The Superiority of Tough Reviewers in a Model of Simultaneous Sales

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Abstract

This paper considers the impact of reviewers on the sale of a product of unknown quality. Sales occur simultaneously after an initial review by an unbiased, pessimistic or optimistic reviewer and we examine the impact on sales in each case. We find that counter-intuitively a pessimistic reviewer is best for the firm's profits regardless of the quality of the product. An endorsement by such a pessimist provides an excellent signal of the product's quality, while consumers expect the reviewer to fail to endorse, so receiving no endorsement will not impact too heavily on the firm's expected profits. This asymmetric impact provides a strong explanation for the stylized fact that reviewers are often viewed as being very critical.

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The Superiority of Tough Reviewers in a Model of Simultaneous Sales

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1. Introduction

Reviewers can be incredibly powerful. For example, in the wine trade the American reviewer Robert Parker can make or break a new vintage. According to the Oxford Companion to Wine: "His judgements have had a significant effect on market demand and the commercial future of some producers" (Robinson, 1999). Despite the powerful effects that reviewers can exert over new products launched onto the market, the literature has paid little or no attention to this important phenomenon. This paper attempts to redress the omission.

We consider a model of sales with heterogeneous consumers, each having some private signal about the value of a product with unknown quality. A monopolist can attempt to tilt sales in its favor through the choice of a reviewer to provide more information before sales begin. We investigate the case where three types of reviewer are available: an unbiased reviewer; a pessimist; and an optimist. The pessimist is a known critic of the firm or type of product and has a higher probability of not endorsing, while the optimist is more likely to endorse than the unbiased reviewer. We find that the pessimist, despite having a much lower probability of endorsement, will be preferred by the firm regardless of the quality of its product. An endorsement by such a pessimist provides an excellent signal of the product's quality, while consumers expect the reviewer to fail to endorse, so receiving no endorsement will not impact too heavily on the firm's expected sales. This can explain why reviewers are keen to build reputations for being overly critical, since doing so makes their endorsements much more valuable to firms, while a failure of such a pessimist to endorse does proportionally less damage to the firm. The idea of a pessimistic reviewer acting as a tough test is more

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general than the specific context of our model - the basic intuition is that a tough initial public test might be useful because the passing of such a test sends out a very strong signal, while failing such a test is not too harmful.

While this paper considers simultaneous sales after a review, an alternative might consider consumers instead acting in strict sequence, observing the actions of their predecessors. Banerjee (1992) and Bikhchandani, Hirshleifer and Welch (1992) examine a sequential herding model appropriate for this setting. In such a sequential set-up, Gill and Sgroi (2003) consider the use of biased reviewers, while Sgroi (2002) examines the use of small groups of consumers who are encouraged to decide early and hence act in a similar way to reviewers, providing additional information for later consumers. Gill and Sgroi (2003) also find that pessimists can be useful, while Sgroi (2002) finds that irrespective of product quality firms would like to use these "guinea pigs".

We abstract from price-setting to focus on the choice of reviewer, but a number of papers analyze the use of initial prices to manipulate sales in a learning environment. Various papers such as Caminal and Vives (1996, 1999) and Vettas (1997) focus on low introductory prices to initiate herd-like behavior from customers. In contrast, Taylor (1999) and Ottaviani (1999) find that high initial prices are optimal. In Ottaviani, the firm wishes to set a high initial price (relative to perceived quality) to encourage the transmission of information. If price is too low, everybody buys, so consumers do not learn from each other's decisions, while if an expensive good becomes successful, this conveys strong positive information to later buyers. Taylor, concentrating on the housing market, considers the sale of only a single item. Taylor allows for the possibility of a herd against the sale of a house, not in favor of purchase, arguing that sellers should therefore set a high early price. If the house is not sold quickly, late consumers can then attribute the failure to sell to the product being overpriced rather than being of low quality. There is also a literature on marketing and advertising which focuses on high early prices to signal quality, see for example Bagwell and Riordan (1991). None of these papers explicitly considers the role of publicly observable reviews, possibly by known biased reviewers, in forming the prior beliefs of consumers. However, the high initial prices in Ottaviani and in Taylor play a qualitatively similar role to the highly critical pessimistic reviewers in this paper: a failure to pass the tough test imposed by either a high initial price or a pessimistic reviewer is not viewed as overly damaging since the test is so unlikely to be passed.

The use of biased methods of evaluation has been considered by a number of authors. Calvert (1985) looks at policy-makers choosing between biased advisors. Sah and Stiglitz

(1986) consider the choice between a bureaucratic "hierarchical" structure and a decentralized "polyarchical" one for accepting or rejecting potential projects, where the former imposes a tougher test. Fishman and Hagerty (1990) analyze the level of discretion that an entrepreneur should be allowed to use in reporting information to potential investors, where greater discretion effectively imposes an easier test. Finally, Meyer (1991) looks at the use of biased contests in deciding which employees to promote. All these papers are concerned with a decision-maker choosing between a number of alternatives, and all come to a similar conclusion: given an initial predisposition towards one of the alternatives, the decision-maker is best off choosing an evaluation procedure which is biased in favor of this predisposition. For example, Meyer finds that firms who are trying to decide which employee to promote should bias contests in favor of the early leader. Just like the firm in our model, the decision-makers in these papers are able to use bias to alter the information partitions to their advantage. Procedures biased in favor of the predisposition are of value because a recommendation that goes against the predisposition is then strong evidence that the predisposition was wrong, while an evaluator who is neutral or biased against the predisposition is unlikely to change the decision-maker's mind if he advises against the predisposition. In contrast, we find that firms (who know product quality with certainty and whose aim is to maximize sales) should choose early evaluators that are biased against their product.[2]

Avery and Meyer (1999) also look at evaluators who suffer from varying degrees of bias, but where the levels of bias are only imperfectly known to a decision-maker. The authors look at the impact of the decision-maker tracking evaluations over time on the toughness of different evaluators' reports, and hence on the decision-maker's payoff.

The next section develops the model of simultaneous sales and notation used throughout the paper. Section 3 examines the effect of different reviewers' decisions on consumers' priors and expected sales. Section 4 compares the impact of different reviewers on sales for firms with high and low quality products. The final section offers some conclusions.

2. A Simple Model of Simultaneous Decision-Making

Consider a group of $N \in \mathbb{N}_{++}$ consumers who act simultaneously deciding upon an action $A_i \in \{Y, N\}$, whether to purchase (Y) or not purchase (N) some product. The cost of purchase is $C = \frac{1}{2}$, and results in the gain of V which has prior probability $q = \frac{1}{2}$ of returning 1 or 0, depending on whether the product is of a high or low quality. The agents

[2]In the final section of Meyer (1991), an example is presented in which the firm has an option to promote nobody and chooses to bias the contest *against* the early leader because it wants to be sufficiently confident before promoting anybody. This has more of the flavor of our result.

each receive a conditionally independent signal about V defined as $X_i \in \{H, L\}$ for agent i. The signals are informative in the following sense.

Definition 1. *Signals are informative, but not fully-revealing, in the sense that:*

$$\begin{aligned}\Pr[X_i = H \mid V = 1] &= \Pr[X_i = L \mid V = 0] = p \in (0.5, 1) \\ \Pr[X_i = H \mid V = 0] &= \Pr[X_i = L \mid V = 1] = 1 - p \in (0, 0.5)\end{aligned}$$

Consumers update their beliefs using their private information, and we assume that, where indifferent, they flip a coin.

Without reviewers to assist in decision-making, consumers have only their own signals to assist them and will therefore choose correctly with probability p, and overall we would expect to see pN consumers buying the product when $V = 1$, and $(1 - p)N$ purchasing when $V = 0$.

2.1. **Modelling Reviewers.** Reviewers are either inherently optimistic, pessimistic or neutral about the product prior to receiving any signals. We model the reviewer as choosing to either endorse or not endorse the firm's product. In reality of course, the reviewer may be able to make a finer distinction than simply endorsing or not. However, we want to think of the review as being quickly and easily disseminated throughout the population of potential consumers, e.g., through word of mouth, written reports concerning the review and so on. Thus we are thinking of a process through which even sophisticated reviews quickly get shortened to an endorse/not endorse distinction through this process of dissemination.[3]

Reviewers are treated as having longer to observe the quality of the product because the firm allows the reviewer to test the product out. We model this in the simplest way possible by allowing reviewers to receive *two* signals. We also assume that their type is common knowledge, perhaps generated through a known history of tough or soft reviews. We define the types of reviewers as follows.

Definition 2. *Optimistic reviewers endorse the product if and only if they get two H signals or a H and a L signal. Pessimistic reviewers endorse the product if and only if they get two H signals. Unbiased reviewers endorse the product if they get two H signals, don't endorse if they get two L signals and flip a coin if they get a H and a L signal.*

[3]Modeling an evaluator as condensing more complex information into a simple binary decision follows for example Calvert (1985) and Sah and Stiglitz (1986). As Calvert puts it: "This feature represents the basic nature of advice, a distillation of complex reality into a simple recommendation."

We do not consider explicitly how reviewers come into existence or take on biases. However, the preference of firms for biased reviewers may justify the existence of biases. Reviewers may differentiate themselves to appeal to firms by building a reputation for being of a certain type. There is a literature on payment structures to certification intermediaries, who play a similar role to reviewers - see for example Lizzeri (1999) and Albano and Lizzeri (2001). In these papers, the intermediary has all the bargaining power as it sets the terms of trade via a price and disclosure rule; instead we are thinking of reviewers as responding to the preferences of the firms regarding their level of bias.

3. Impact of Reviewers on Priors and Expected Sales

In this section, to keep matters as simple as possible we concentrate on the case of $V = 1$, so the product is good. Denote expected sales to the firm as $\pi [x \mid y]$ where $x \in \{P, O, U\}$ corresponding to the choice of pessimistic, optimistic or unbiased reviewer, and $y \in \{E, N\}$ corresponding to the verdict of the reviewer, endorse or not endorse. We can think of the decision by the reviewer as altering the prior from $q = \frac{1}{2}$ (where consumers have no preconceptions) to $q = q^*$ where q^* is the probability that the product quality is high. Alternatively think of q^* directly as a general prior determined explicitly through the review process.

We start by developing the following Remark, which is used implicitly throughout the proofs of the propositions that follow.

Remark 1.

$$\frac{\Pr[V=1|X_i]}{\Pr[V=0|X_i]} = \frac{\frac{\Pr[X_i|V=1]\Pr[V=1]}{\Pr[X_i]}}{\frac{\Pr[X_i|V=0]\Pr[V=0]}{\Pr[X_i]}} = \frac{\Pr[X_i|V=1]\, q^*}{\Pr[X_i|V=0]\,(1-q^*)}$$

This Remark says that agents, when applying Bayes' Rule to calculate their beliefs about whether the product is more likely to be of good or bad quality, simply need to calculate the ratio of the probability of the signal set they have observed if the product were good to the probability if the product were bad, suitably weighted by the updated prior. Using this Remark, we can now determine how customers will behave for any possible updated prior q^* following the reviewer's decision. The following Lemmas partition the set of possible priors into five cases.

Lemma 1. *Where $q^* > p$, all consumers will purchase.*

Proof. A consumer i is least likely to purchase if $X_i = L$. Taking this case, and using Remark 1, we have an odds ratio $\frac{\Pr[V=1|L]}{\Pr[V=0|L]} = \frac{\Pr[L|V=1]q^*}{\Pr[L|V=0](1-q^*)} = \frac{(1-p)q^*}{p(1-q^*)} = \frac{q^*-pq^*}{p-pq^*} > 1$ since $q^* > p$. ∎

A symmetrical argument shows:

Lemma 2. *Where $q^* < 1 - p$, no consumers will purchase.*

The private signal of the consumer yields a posterior probability $\widehat{q} = \Pr[V = 1 \mid X_i]$. Then:

Lemma 3. *Where $q^* \in (1 - p, p)$, following a H signal $\widehat{q} > \frac{1}{2}$, so the customer purchases, while following a L signal $\widehat{q} < \frac{1}{2}$, so the customer does not purchase.*

Proof. Following a H signal, $\frac{\Pr[V=1|H]}{\Pr[V=0|H]} = \frac{\Pr[H|V=1]q^*}{\Pr[H|V=0](1-q^*)} = \frac{pq^*}{(1-p)(1-q^*)} > 1$ as $q^* > (1 - p)$. Thus, $\widehat{q} > \frac{1}{2}$. Following a L signal, $\frac{\Pr[V=1|L]}{\Pr[V=0|L]} = \frac{\Pr[L|V=1]q^*}{\Pr[L|V=0](1-q^*)} = \frac{(1-p)q^*}{p(1-q^*)} < 1$ as $q^* < p$. Thus, $\widehat{q} < \frac{1}{2}$. ∎

Lemma 4. *Where $q^* = p$, following a H signal the consumer purchases, while following a L signal, the consumer flips a coin.*

Proof. Following a L signal, $\frac{\Pr[V=1|L]}{\Pr[V=0|L]} = \frac{\Pr[L|V=1]q^*}{\Pr[L|V=0](1-q^*)} = \frac{(1-p)q^*}{p(1-q^*)} = 1$ as $q^* = p$, so the consumer is indifferent and flips a coin. A H signal is more positive, so the consumer purchases. ∎

By symmetry:

Lemma 5. *Where $q^* = 1-p$, following a H signal the consumer flips a coin, while following a L signal the consumer does not purchase.*

The following Proposition summarizes the information contained in Lemmas 1 to 5:

Proposition 1. *Consumers will respond to an updated prior as follows: (a) if $q^* > p$ then consumer i will buy; (b) if $q^* = p$, following a H signal the consumer buys, while following a L signal, the customer flips a coin; (c) if $q^* \in (1 - p, p)$ then consumer i will buy if and only if $X_i = H$; (d) if $q^* = 1 - p$, following a H signal the consumer flips a coin, while following a L signal the consumer will not buy; (e) if $q^* < 1 - p$ then consumer i will not buy.*

3.1. **The Pessimistic Reviewer.** If the pessimist endorses this is a very strong indication of the quality of the product, while a failure to endorse is certainly not a disaster from the firm's perspective.

Lemma 6. *(a) Endorsement by the pessimist implies $q^* > p$. (b) A failure to endorse implies $q^* \in \left(1 - p, \frac{1}{2}\right)$.*

Proof. See Appendix. ∎

Next we will consider the impact on sales of the decision by the pessimistic reviewer. From Proposition 1 and Lemma 6 we know that when the pessimist endorses then all consumers will buy irrespective of their private signal. This produces sales of $E\pi\left[P \mid E, V=1\right] = N$. With no endorsement from Proposition 1 and Lemma 6 we know that consumer i will purchase if and only if $X_i = H$. Therefore $E\pi\left[P \mid N, V=1\right] = pN$. As $V = 1$, the probability that a pessimist endorses is p^2, yielding a final expected sales figure of:

$$E\pi\left[P \mid V=1\right] = p^2 N + \left(1-p^2\right) pN = N(p+p^2-p^3) \tag{3.1}$$

3.2. **The Optimistic Reviewer.** Next we will consider the impact of endorsement or failure to endorse by the optimistic reviewer.

Lemma 7. *(a) Endorsement by the optimist implies $q^* \in \left(\frac{1}{2}, p\right)$. (b) A failure to endorse implies $q^* < 1-p$.*

Proof. See Appendix. ∎

From Proposition 1 and Lemma 7 we know that when the optimist fails to endorse then no consumers will buy irrespective of their private signal. With an endorsement from Proposition 1 and Lemma 7 we know that consumer i will purchase if and only if $X_i = H$. Therefore $E\pi\left[O \mid E, V=1\right] = pN$. As $V = 1$, the probability that an optimist fails to endorse is $(1-p)^2$, so the probability of endorsement is $1-(1-p)^2$, yielding a final expected sales figure of:

$$E\pi\left[O \mid V=1\right] = \left[1-(1-p)^2\right] pN = N\left(2p^2-p^3\right) \tag{3.2}$$

3.3. **The Unbiased Reviewer.** Finally, we consider the impact of the unbiased reviewer's verdict.

Lemma 8. *(a) Endorsement by the unbiased reviewer implies $q^* = p$. (b) A failure to endorse implies $q^* = 1-p$.*

Proof. See Appendix. ∎

From Proposition 1 and Lemma 8, if the unbiased reviewer endorses, the consumer buys if he gets a H signal and decides based on the flip of a coin if he gets a L signal. In total this results in expected sales of $E\pi\left[U \mid E, V=1\right] = \left[p + \frac{1}{2}(1-p)\right] N$. When the unbiased reviewer fails to endorse, from Proposition 1 and Lemma 8, the consumer flips a coin if he gets a H signal and does not buy if he gets a L signal. In total we then have expected sales of $E\pi\left[U \mid N, V=1\right] = \frac{1}{2}pN$. As $V = 1$, the probability that an unbiased reviewer endorses is

$\Pr[HH] + \frac{1}{2}\Pr[HL] + \frac{1}{2}\Pr[LH] = p$ and fails to endorse is $\Pr[LL] + \frac{1}{2}\Pr[HL] + \frac{1}{2}\Pr[LH] = 1 - p$. The final expected sales figure is therefore:

$$E\pi [U \mid V = 1] = p \left[p + \tfrac{1}{2}(1-p)\right] N + (1-p) \tfrac{1}{2} pN = Np \tag{3.3}$$

3.4. **A Graphical Comparison.** We now summarize the findings in this section in terms of a simple diagram. The impact of reviewers' evaluations on consumers can be modelled as the formation of the prior probability that the product is good. Consumers will observe both the type of reviewer and the decision made and form this prior, before receiving their own private information. It is this that enables us to find the expressions for expected sales given a value for p. The impact of different reviewer types and actions upon the prior and hence on expected sales is shown in the diagram below.

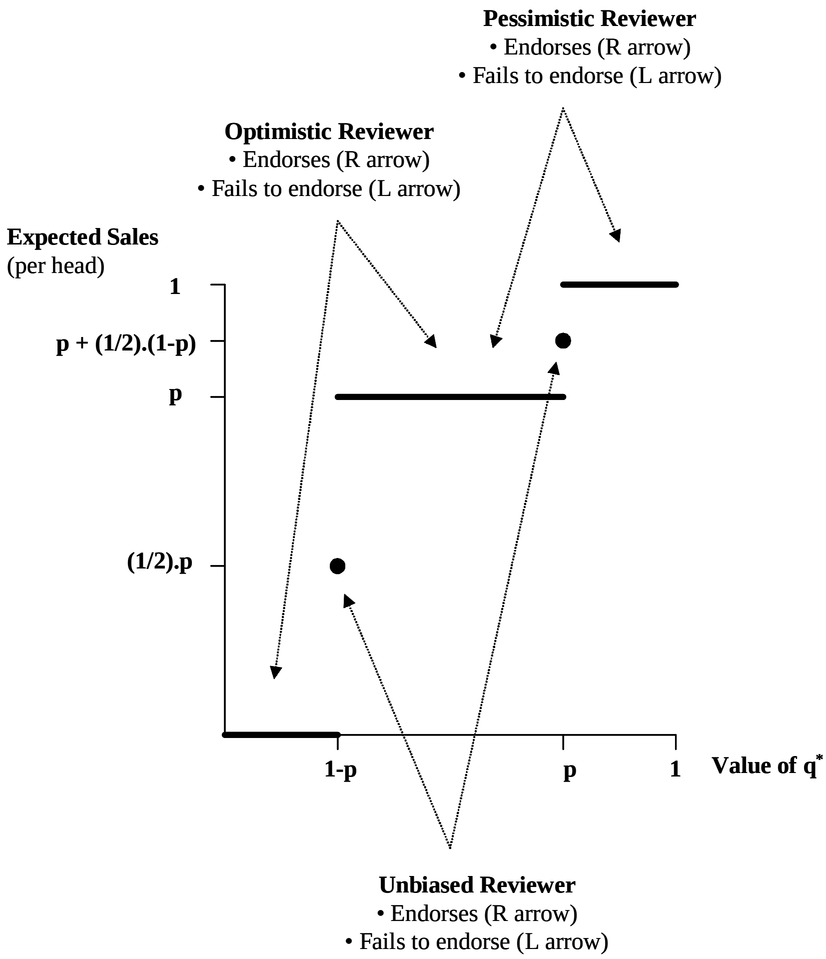

Figure 1: Impact of Reviewers on q^* and Expected Sales ($V = 1$)

The diagram makes clear perhaps the most surprising result so far: even an endorsement decision by the optimist will only produce a prior which is as high as that created when a pessimist *fails to endorse*! In both cases a prior is generated in the $(1-p,p)$ region, within which expected sales are constant as consumers then all purchase if and only if they receive a H signal. The next section shows that despite the pessimist's lower probability of endorsement, the impact on priors is so strong that the pessimist is the firm's best bet for maximizing expected sales.

Gill and Sgroi (2003) also examine the impact of different types of reviewers, but instead consider a sequential model of sales. In Gill and Sgroi a failure to endorse by the pessimist leaves $q^* < 0.5$, but endorsement by the optimist yields $q^* > 0.5$ which, in the sequential setting, makes the firm prefer an endorsement by the optimist to a failure to endorse by the pessimist. For the simultaneous sales model in this paper this is not an issue since all that matters is that in both cases $q^* \in (1-p,p)$. It seems that in the sequential sales model learning from others consumers' actions partially offsets the benefits of a pessimist, though a pessimist remains better overall for expected sales for a good product firm.

4. Choosing the Best Reviewer

The last section gave us expressions for consumers' priors and expected sales under the three different reviewers. We now establish the supremacy of the pessimistic reviewer for sales firstly when $V=1$ and then when $V=0$.

4.1. **The Good Product.**

In this section we establish the superiority of the pessimist for expected sales in the case of the good product, when $V=1$.

Proposition 2. *Let $V=1$. In order the pessimistic reviewer is the best for expected sales, with the unbiased reviewer second and the optimistic reviewer worst for expected sales.*

Proof. See Appendix. ∎

Intuitively, if the pessimist endorses the product this is sufficient to convince all consumers to purchase, whereas a failure to endorse does not dissuade a consumer with a good signal from purchasing. An optimistic reviewer failing to endorse will result in no purchases, whereas an endorsement by an optimist is so likely that it will not convince any consumers with bad signals to purchase. Unlike the optimistic reviewer the unbiased reviewer may result in higher sales if an endorsement occurs, but unlike the pessimist, may result in lower sales if there is no endorsement, and so stands somewhere in the middle.

4.2. **The Bad Product.** Remarkably this section shows that the previous result on the superiority of the pessimistic reviewer still holds in the bad product case, when $V = 0$.

Initially we will alter the values of $E\pi\,[P]$, $E\pi\,[U]$ and $E\pi\,[O]$ for the $V = 0$ case, simply by swapping p for $1 - p$ and vice versa in expressions (3.1), (3.2) and (3.3). This is the case since neither consumers nor reviewers know the true state of the world, so they will continue to act in the same way for any sequence of signals. However H signals now occur with probability $(1 - p)$ rather than p and L signals now occur with probability p rather than $(1 - p)$, hence reversing these in (3.1) to (3.3) gives the new values for expected sales.

$$E\pi\,[P \mid V = 0] = N\,(1 - p)\left(1 + p - p^2\right) \tag{4.1}$$

$$E\pi\,[O \mid V = 0] = N\,(1 - p)\left(1 - p^2\right) \tag{4.2}$$

$$E\pi\,[U \mid V = 0] = N\,(1 - p) \tag{4.3}$$

We now establish the equivalent to Proposition 2.

Proposition 3. *Let $V = 0$. In order the pessimistic reviewer is the best for expected sales, with the unbiased reviewer second and the optimistic reviewer worst for expected sales.*

Proof. First, comparing expressions (4.1) and (4.3) we have

$$E\pi\,[P \mid V = 0] - E\pi\,[U \mid V = 0] = N(1 - p)(p - p^2) > 0$$

Second, comparing expressions (4.3) and (4.2) we have

$$E\pi\,[U \mid V = 0] - E\pi\,[O \mid V = 0] = N(1 - p)p^2 > 0$$

∎

The intuition is much as for the $V = 1$ case. A pessimist can only weakly assist sales, an optimist can only weakly damage them, whereas an unbiased reviewer may enhance or damage sales. Since this is the case regardless of the value of V Propositions 2 and 3 combine to produce a final even stronger result:

Proposition 4. *Regardless of the quality of the product the pessimistic reviewer is the best for expected sales, with the unbiased reviewer second and the optimistic reviewer worst.*

4.3. **Some Comparisons.** While we have shown that the pessimist is in general superior to the unbiased reviewer who is in turn better for expected sales than the optimist, this section gives some idea of the magnitude of the pessimist's superiority, both in general and in terms of some simple examples. Table 1 gives the values of $E\pi\left[P\right]$, $E\pi\left[U\right]$ and $E\pi\left[O\right]$ in terms of $E\pi\left[U\right]$ and table 2 provides a full list of the expected percentage increase in sales for $V=0$ and $V=1$.

	$V=1$	$V=0$
$E\pi\left[P\right]$	$E\pi\left[U\right]+Np^2\left(1-p\right)$	$E\pi\left[U\right]+N(1-p)(p-p^2)$
$E\pi\left[U\right]$	$E\pi\left[U\right]$	$E\pi\left[U\right]$
$E\pi\left[O\right]$	$E\pi\left[U\right]-Np\left(1-p\right)^2$	$E\pi\left[U\right]-N(1-p)p^2$

Table 1: Relative Magnitudes in Terms of $E\pi\left[U\right]$

	$V=1$	$V=0$
Pessimist compared to optimist	$\frac{100(1-p)}{2p-p^2}$	$\frac{100p}{1-p^2}$
Pessimist compared to unbiased	$100p\left(1-p\right)$	$100p\left(1-p\right)$
Unbiased compared to optimist	$\frac{100(1-p)^2}{2p-p^2}$	$\frac{100p^2}{1-p^2}$

Table 2: Expected Percentage Increase in Sales

Note that the percentage increase from using a pessimist over an unbiased reviewer, which is identical in both cases, is decreasing in p across the whole range, and $100p(1-p)\to 0$ as $p\to 1$. The results in this table yield our final proposition.

Proposition 5. *For both a pessimist and unbiased reviewer the improvement in sales over an optimist is higher when $V=0$ than when $V=1$. When moving from an unbiased reviewer to a pessimist the percentage increase in sales is $100p\left(1-p\right)$ irrespective of the value of V.*

Proof. See Appendix. ∎

Some simple examples should demonstrate just how great an advantage it is for a firm when the reviewer is a known pessimist. Firstly, when the product is good we have:

Example 1. *Consider $V=1$. Now let $p=\frac{3}{4}$. In this case we have $E\pi\left[P\mid V=1\right]=\frac{57}{64}N$, $E\pi\left[U\mid V=1\right]=\frac{3}{4}N$ and $E\pi\left[O\mid V=1\right]=\frac{45}{64}N$. In particular a pessimist provides $18\frac{3}{4}\%$ higher expected sales than an unbiased reviewer and $26\frac{2}{3}\%$ higher expected sales than an optimistic reviewer. The unbiased reviewer provides $6\frac{2}{3}\%$ higher expected sales than the optimist. When $p\to\frac{1}{2}$, so private signals are close to uninformative we have $E\pi\left[P\mid V=1\right]\to\frac{5}{8}N$, $E\pi\left[U\mid V=1\right]\to\frac{1}{2}N$ and $E\pi\left[O\mid V=1\right]\to\frac{3}{8}N$. In this case a pessimist provides 25%*

higher expected sales than an unbiased reviewer and an expected $66\frac{2}{3}\%$ *higher expected sales than an optimistic reviewer. The unbiased reviewer provides* $33\frac{1}{3}\%$ *higher expected sales than the optimist.*

Secondly when the product is of low quality we have:

Example 2. *Consider* $V = 0$*. Now let* $p = \frac{3}{4}$*. In this case we have* $E\pi\left[P \mid V = 0\right] = \frac{19}{64}N$*,* $E\pi\left[U \mid V = 0\right] = \frac{1}{4}N$ *and* $E\pi\left[O \mid V = 0\right] = \frac{7}{64}N$*. In particular a pessimist provides* $18\frac{3}{4}\%$ *higher expected sales than an unbiased reviewer and approximately* 171.4% *higher expected sales than an optimistic reviewer. The unbiased reviewer provides* 128.6% *higher expected sales than the optimist. When* $p \to \frac{1}{2}$*, so private signals are close to uninformative we have* $E\pi\left[P \mid V = 0\right] \to \frac{5}{8}N$*,* $E\pi\left[U \mid V = 0\right] \to \frac{1}{2}N$ *and* $E\pi\left[O \mid V = 0\right] \to \frac{3}{8}N$*. In this case a pessimist provides* 25% *higher expected sales than an unbiased reviewer and an expected* $66\frac{2}{3}\%$ *higher expected sales than an optimistic reviewer. The unbiased reviewer provides* $33\frac{1}{3}\%$ *higher expected sales than the optimist.*

With uninformative signals the advantage of a pessimist over the other two types is identical for both $V = 1$ and $V = 0$.

4.4. **Signalling Issues.** Finally, if we allow the firm to select the reviewer then we should consider how customers' priors about the product quality might be affected by the choice of reviewer the firm makes. Any separating equilibrium will result in the firm offering the low quality product receiving a payoff of zero. The bad firm will therefore always have an incentive to copy the actions of the good firm. Therefore, we can expect both types of firm to select the same reviewer, and a pooling equilibrium to ensue. There are clearly three candidate pooling equilibria, one for each type of reviewer, but by applying a mild payoff dominance argument it is clear that both good and bad firms will prefer the pessimistic reviewer based on the findings in the last section. A reasonable set of beliefs supporting this Perfect Bayesian Equilibrium would involve consumers retaining a 50:50 prior in the face of a deviation. Thus, there seems to be little scope for consumers to gain insight into the type of product via the choice of reviewer.

5. Conclusion

This paper presented the simplest possible model of sales which allows the examination of the impact of different types of reviewers. Reviewers were given types corresponding to a broad notion of pessimism, optimism and a lack of bias, and we found that a pessimist is universally superior for expected sales regardless of the quality of the product being sold.

While a pessimist is less likely to endorse a product this does not compensate for the positive impact of an endorsement on sales. On the other hand an optimist is expected to endorse so this adds little to beliefs about a product's quality, but the risk of a failure to endorse, and the strong negative signal such a failure implies, makes the optimist the worst choice for a firm. An unbiased reviewer lies somewhere between the two biased types in terms of impact on expected sales. More generally, the pessimistic reviewer is like choosing an initial tough public test.

The findings in the paper might explain the survival of reviewers with well-known harsh styles, biases and critical approaches. While we might think firms likely to avoid such reviewers the results in this paper show that while these tough reviewers are likely to not offer any endorsement, the tremendous gains when they do endorse actually make them popular with firms.

In order to focus on the heart of the issue, the modelling assumptions have been chosen to make the analysis as tractable as possible. However, interesting extensions might look at generalized beliefs of the firm about the quality of its own product, a more general structure of private information signals to reviewers and customers, or the issue of inter-firm competition.

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Appendix

Proof of Lemma 6. We will begin with (a). Since we know $p \in \left(\frac{1}{2}, 1\right)$ this implies that $2p > 1$. From this we have

$$\begin{aligned} 2p &> 1 \\ &\Rightarrow 2p\,(1-p) > 1-p \\ &\Rightarrow 2p - 2p^2 > 1 - p \\ &\Rightarrow p > 2p^2 - 2p + 1 \\ &\Rightarrow p^2 > \left(2p^2 - 2p + 1\right) p \\ &\Rightarrow \tfrac{p^2}{p^2 + (1-p)^2} > p \end{aligned}$$

From the definition of a pessimist, if we observe endorsement:

$$\begin{aligned} q^* &= \Pr\left[V = 1 \mid \text{Pessimist endorses}\right] \\ &= \Pr\left[V = 1 \mid HH\right] \\ &= \tfrac{\Pr[HH|V=1]\Pr[V=1]}{\Pr[HH|V=1]\Pr[V=1] + \Pr[HH|V=0]\Pr[V=0]} \\ &= \tfrac{p^2}{p^2+(1-p)^2} > p \end{aligned}$$

This proves (a). From the definition of a pessimist, a failure to endorse instead produces

$$\begin{aligned} q^* &= \Pr\left[V = 1 \mid \text{Pessimist does not endorse}\right] \\ &= \Pr\left[V = 1 \mid HL, LH \text{ or } LL\right] \\ &= \tfrac{\Pr[HL, LH, \text{ or } LL|V=1]\Pr[V=1]}{\Pr[HL, LH, \text{ or } LL|V=1]\Pr[V=1] + \Pr[HL, LH, \text{ or } LL|V=0]\Pr[V=0]} \\ &= \tfrac{\left(1-p^2\right)}{(1-p^2)+(2p-p^2)} \end{aligned}$$

Now as before we can use the limits of p to deduce the limits of q^*, once again starting with $2p > 1$, we have:

$$\begin{aligned} 2p &> 1 \\ &\Rightarrow 2p - p^2 > 1 - p^2 \\ &\Rightarrow 2p - 2p^2 + 1 > 2 - 2p^2 \\ &\Rightarrow \tfrac{\left(1-p^2\right)}{(1-p^2)+(2p-p^2)} < \tfrac{1}{2} \end{aligned}$$

Finally we need to show that a failure to endorse still leaves $q^* > 1 - p$.

$$
\begin{aligned}
\frac{\left(1-p^2\right)}{(1-p^2)+(2p-p^2)} &> 1-p \\
&\Leftrightarrow \frac{(1+p)(1-p)}{1+2p-2p^2} > 1-p \\
&\Leftrightarrow 1+p > 1+2p-2p^2 \\
&\Leftrightarrow 2p^2 > p \\
&\Leftrightarrow 2p > 1 \\
&\Leftrightarrow p > \tfrac{1}{2}
\end{aligned}
$$

∎

Proof of Lemma 7. We will begin with (a). From the definition of an optimist, if we observe endorsement:

$$
\begin{aligned}
q^* &= \Pr\left[V=1 \mid \text{Optimist endorses}\right] \\
&= \Pr\left[V=1 \mid HH, HL \text{ or } LH\right] \\
&= \tfrac{\Pr[HH,HL \text{ or } LH|V=1]\Pr[V=1]}{\Pr[HH,HL \text{ or } LH|V=1]\Pr[V=1]+\Pr[HH,HL \text{ or } LH|V=0]\Pr[V=0]} \\
&= \tfrac{p^2+2p(1-p)}{[p^2+2p(1-p)]+(1-p^2)}
\end{aligned}
$$

So,

$$
\begin{aligned}
q^* &> \tfrac{1}{2} \\
&\Leftrightarrow \tfrac{2p-p^2}{1+2p-2p^2} > \tfrac{1}{2} \\
&\Leftrightarrow 4p-2p^2 > 1+2p-2p^2 \\
&\Leftrightarrow 2p > 1
\end{aligned}
$$

Which is clearly true as $p > \frac{1}{2}$. Also,

$$
\begin{aligned}
q^* &< p \\
&\Leftrightarrow \tfrac{2p-p^2}{1+2p-2p^2} < p \\
&\Leftrightarrow 2-p < 1+2p-2p^2 \\
&\Leftrightarrow -1+3p-2p^2 > 0
\end{aligned}
$$

$$\Leftrightarrow (2p-1)(1-p) > 0$$

Which again is clearly the case.

Now consider (b). Since we know $p \in \left(\frac{1}{2}, 1\right)$ this implies that $2p > 1$. From this we have

$$\begin{aligned}
&\Rightarrow \quad 2p - 1 > 0 \\
&\Rightarrow \quad 0 < 2p^2 - p \\
&\Rightarrow \quad 1 - p < 1 + 2p^2 - 2p \\
&\Rightarrow \quad 1 - p < (1-p)^2 + p^2 \\
&\Rightarrow \quad \tfrac{(1-p)^2}{(1-p)^2 + p^2} < 1 - p
\end{aligned}$$

From the definition of an optimist when we do not observe endorsement:

$$\begin{aligned}
q^* &= \Pr\left[V = 1 \mid \text{Optimist does not endorse}\right] \\
&= \Pr\left[V = 1 \mid LL\right] \\
&= \tfrac{\Pr[LL|V=1]\Pr[V=1]}{\Pr[LL|V=1]\Pr[V=1] + \Pr[LL|V=0]\Pr[V=0]} \\
&= \tfrac{(1-p)^2}{(1-p)^2 + p^2} < 1 - p
\end{aligned}$$

This proves (b). ∎

Proof of Lemma 8. We will begin with (a). From the definition of an unbiased reviewer, with endorsement we have:

$$\begin{aligned}
q^* &= \Pr\left[V = 1 \mid \text{Unbiased endorses}\right] \\
&= \tfrac{\left\{\Pr[HH|V=1] + \frac{\Pr[HL|V=1]}{2} + \frac{\Pr[LH|V=1]}{2}\right\}\Pr[V=1]}{\left\{\Pr[HH|V=1] + \frac{\Pr[HL|V=1]}{2} + \frac{\Pr[LH|V=1]}{2}\right\}\Pr[V=1] + \left\{\Pr[HH|V=0] + \frac{\Pr[HL|V=0]}{2} + \frac{\Pr[LH|V=0]}{2}\right\}\Pr[V=0]} \\
&= \tfrac{p^2 + p(1-p)}{[p^2 + p(1-p)] + \left[(1-p)^2 + p(1-p)\right]} \\
&= p
\end{aligned}$$

Which proves (a).

Also from the definition of the unbiased reviewer, if there is no endorsement:

$$
\begin{aligned}
q^* &= \Pr[V=1 \mid \text{Unbiased does not endorse}] \\
&= \frac{\left\{\Pr[LL|V{=}1]+\frac{\Pr[HL|V=1]}{2}+\frac{\Pr[LH|V=1]}{2}\right\}\Pr[V{=}1]}{\left\{\Pr[LL|V{=}1]+\frac{\Pr[HL|V=1]}{2}+\frac{\Pr[LH|V=1]}{2}\right\}\Pr[V{=}1]+\left\{\Pr[LL|V{=}0]+\frac{\Pr[HL|V=0]}{2}+\frac{\Pr[LH|V=0]}{2}\right\}\Pr[V{=}0]} \\
&= \frac{(1-p)^2+p(1-p)}{\left[(1-p)^2+p(1-p)\right]+[p^2+p(1-p)]} \\
&= 1-p
\end{aligned}
$$

Which proves (b). ∎

Proof of Proposition 2. First, from (3.1) and (3.3), we have $E\pi[P \mid V=1] = N(p+p^2-p^3)$ and $E\pi[U \mid V=1] = Np$, therefore:

$$
\begin{aligned}
E\pi[P \mid V=1] &= N\left(p+p^2-p^3\right) \\
&= Np + N\left(p^2-p^3\right) \\
&= E\pi[U \mid V=1] + N\left(p^2-p^3\right)
\end{aligned}
$$

Now since $p^2-p^3 = p^2(1-p) > 0$ for $p \in \left(\frac{1}{2},1\right)$ we have $E\pi[P \mid V=1] > E\pi[U \mid V=1]$ as required.

Second, using expressions (3.2) and (3.3) yields:

$$E\pi[U \mid V=1] - E\pi[O \mid V=1] = N\left(p-2p^2+p^3\right)$$

We simply need to show $p-2p^2+p^3 > 0$:

$$
\begin{aligned}
p-2p^2+p^3 &= p(p^2-2p+1) \\
&= p(1-p)^2 > 0
\end{aligned}
$$

Which yields $E\pi[U \mid V=1] > E\pi[O \mid V=1]$ as required. ∎

Proof of Proposition 5. The first part of the proposition states that for both a pessimist and unbiased reviewer the improvement in sales over an optimist is higher when $V=0$ than when

$V = 1$. From Table 2, we simply need to show that $\frac{p}{1-p^2} > \frac{1-p}{2p-p^2}$ and that $\frac{p^2}{1-p^2} > \frac{(1-p)^2}{2p-p^2}$. Both hold immediately as $p > 1 - p$, $1 - p^2 < 2p - p^2$ and $p^2 > (1-p)^2$, given $p \in \left(\frac{1}{2}, 1\right)$.

The second part of the proposition is immediate from the values of expected sales under $V = 0$ and $V = 1$. ∎