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Label Confusion: The Groucho Effect of Uncertain Standards

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Labels certify that a product meets some standard for quality, but often consumers are unsure of the exact standard that the label represents. Focusing on the case of ecolabels for environmental quality, we show how even small amounts of uncertainty can create consumer confusion that reduces or eliminates the value to firms of adopting voluntary labels. First, consumers are most suspicious of a label when a product with a bad reputation has it, so labels are often unpersuasive at showing that a seemingly bad product is actually good. Second, label proliferation aggravates the effect of uncertainty, causing the informativeness of labels to decrease rather than increase. Third, uncertainty makes labeling and nonlabeling equilibria more likely to coexist as the number of labels increases, so consumers face greater strategic uncertainty over how to interpret the presence or absence of a label. Finally, a label can be legitimitized or spoiled for other products when a product with a good or bad reputation displays it, so firms may adopt labels strategically to manipulate such information spillovers, which further exacerbates label confusion. Managers can reduce label confusion by supporting mandatory labeling or by undertaking investments to make certain labels "focal."

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1. Introduction

When product quality is unobservable, quality labels are an important mechanism for firms to prove their quality to consumers. However, consumers are often unsure of the exact quality standard that a label represents—is it a relatively easy or difficult standard? This is particularly important for "ecolabels" that certify environmental quality, because environmental impact is often a credence good that consumers cannot observe directly and because there has been a proliferation of different labels by different organizations. Despite attempts by governments, industry groups, and nongovernmental organizations (NGOs) to clarify label standards, confusion by consumers is widely blamed for undermining the credibility of ecolabels, thereby reducing the incentive for firms to adopt them.[1] We examine this issue of how consumer uncertainty about label standards affects the managerial decision to have a product of given environmental quality certified with an ecolabel.

When label standards are uncertain, consumers face a joint estimation problem. If they see a label on a product, they must estimate whether the label is more indicative of a high-quality product or of an undemanding standard for the label. For instance, when a car buyer sees a Low Emission Vehicle ecolabel, she will update both her estimate of the car's environmental quality and of the meaning of the ecolabel. If the car is a large sports utility vehicle, then the updating on both dimensions is likely to be very different than if the car is a small hybrid. Just as an employer must jointly estimate the ability of a job applicant and the value of his degree, or a tourist must jointly estimate the quality of a hotel and the toughness of the local rating system, a consumer cannot rely on the

[1] The website Ecolabelling.org lists more than 300 different ecolabels in use, many with widely different standards for different products. As a report prepared for the World Bank noted, "The diversity of ecolabels (which reflect the multitude of certification schemes) can be confusing to consumers and weaken the credibility of all labels" (Fischer et al. 2005). The impact of label confusion on adoption incentives is seen for the European Union (EU) Flower label, where for some product categories none of the major manufacturers have certified their products (see *European Eco-label Catalogue* at http://www.eco-label.com) and surveys indicate that understanding of the label is far lower than of other regional and national ecolabels (Sto and Strandbakken 2005).

mere presence of an ecolabel to determine a product's environmental quality.

We investigate how this joint estimation problem affects the power of labels to reduce information asymmetries about product quality. We find that concern over the effects of uncertain labeling standards is well founded. In addition to the direct information loss due to the uncertainty, the optimal responses of consumers and firms lead to further information losses that can greatly undermine the value of voluntary labeling. First, labeling should be most valuable when consumers expect a product to be bad but in fact it is certifiably good. However, when standards are uncertain, if a product is expected to be of low quality, then there is a "Groucho effect" in which consumers infer that the labeling standard is probably weak if such a product can meet it. Just as Groucho Marx famously joked that he did not want to join a club with standards so low as to accept him as a member, a firm with a bad reputation gains little from labeling. Therefore, the incentive for labeling is undermined when the problem of information asymmetry, and hence the potential gain from labeling, is greatest.

Second, the presence of multiple labels with different standards should create more opportunity for firms of different quality levels to certify themselves and thereby reduce information asymmetries. But when standards are uncertain, the proliferation of labels has the opposite impact. Because consumers do not know which standards are easy and which are difficult, a label only proves that a firm has met the easiest of the different standards, even if the firm has met a higher standard. This reduces the informativeness of labeling and also reduces the incentive to be certified. As the number of different standards rises, we find that the informativeness of labeling goes to zero and that a "nonlabeling" equilibrium always exists for a sufficiently high number of standards.

Third, uncertain standards aggravate the problem of strategic uncertainty because of the coexistence of labeling and nonlabeling equilibria. Multiple equilibria can arise with voluntary labeling because if consumers expect a firm to have a label, then lack of one is particularly damaging to the firm's estimated quality, whereas if labeling is not expected, then the firm loses less from not having a label and can save on certification costs. When standards are known, this multiplicity of equilibria disappears under a regularity condition as the number of standards increases. But with uncertain standards we find instead that the multiple equilibrium problem is aggravated by more labels and that labeling and nonlabeling equilibria always coexist for a sufficiently large number of labels unless certification costs are so high that only nonlabeling is an equilibrium.

Finally, we find that uncertainty over standards generates information externalities between firms that can lead to strategic behavior that further reduces the informativeness of labels. A firm can "legitimize" or "spoil" a label for use by other firms depending on whether the firm has a good or bad reputation. Therefore, disreputable firms have an incentive to adopt the same label as reputable firms, but reputable firms instead have an incentive to avoid labels adopted by disreputable firms. Such managerial strategizing makes it difficult for consumers to rely on the existing reputations of firms as a simple way to learn about different standards and gives certifiers an incentive to promote early adoption among firms of recognized high quality.

A key factor in consumer uncertainty over labeling standards is that the source of a label or certificate is often unclear. For instance, the similar-appearing "FSC" and "SFI" labels are two of the main ecolabels for forest products, but one is controlled by an environmental NGO and the other by an industry-backed NGO. The potential for such confusion is widespread—of the 363 different labeling schemes tracked by ecolabelling.org, 209 are run by NGOs, 59 are run by industry groups, 53 are run by governments, and 42 are run by for-profit firms. Moreover, even when the source of a label is clear, the objectives of certifiers, and hence the likely difficulty of their standards, are often unclear (see, e.g., Shaked and Sutton 1981, Maxwell 2010).

To capture these uncertainties, we model consumers as having a prior distribution of the labeling standard(s) that can be arbitrarily precise or diffuse and arbitrarily skewed toward higher or lower levels. For instance, consumers might believe that an ecolabel standard is likely to be easy or difficult but be unsure of exactly how easy or difficult, or they might be completely uncertain of the difficulty. This distinguishes our approach from most of the literature in which the labeling standards are assumed to be common knowledge. Our model is most appropriate for consumer product markets, where buyers are unlikely to be well informed, rather than for markets for raw materials or intermediary products, where buyers have strong incentives to acquire exact information on the source and meaning of different standards.

Because label confusion reduces the value of labeling as a strategy to inform consumers about product quality, investments in clarifying label standards can enhance both the informativeness and likelihood of labeling, thereby allowing consumers to make more informed decisions. For instance, the ISEAL Alliance of certifiers has tried to make standards for ecolabels more transparent to reduce consumer confusion (http://isealalliance.org). Industry groups, governments, for-profit labelers, or NGOs interested in promoting label adoption can also try to make a particular standard "focal" in the sense of publicizing it and making consumers expect that firms will adopt the standard if they meet it. This can reduce or eliminate the information losses caused by label proliferation and by strategic uncertainty over which equilibria are being played by firms. "Look for the label" campaigns can be interpreted as encouraging consumers to focus on particular labels among the multiplicity of possible labels. Government and industry attempts to reduce the number of labels or "harmonize" or standardize different voluntary standards also have this effect. Of course, not all firms benefit from stronger incentives to label due to harmonization and transparency. Firms that cannot meet labeling standards clearly benefit from more label confusion. And even firms that can meet the standards are sometimes better off in a nonlabeling equilibrium from saving labeling costs.

These results on label confusion add to the literature on verifiable message "persuasion" or "disclosure" games (see the survey by Dranove and Jin 2010), and in particular to the debate on mandatory versus voluntary disclosure. The classic "unravelling" result finds that mandatory disclosure is unnecessary because even those with bad information have an incentive to prove they do not have worse information.[2] However, as recognized early on, voluntary disclosure might be insufficient if disclosure is costly (Viscusi 1978, Jovanovic 1982, Verrecchia 1983). Our analysis contributes to this debate by showing that the combination of costly disclosure and uncertainty is particularly disruptive to voluntary disclosure, and that the effects are exacerbated when there are multiple labels.

The idea that the imperfect nature of labels can have an important effect on disclosure strategies appears in other papers that differ from ours in other key respects. Sinclair-Desgagne and Gozlan (2003) consider binary tests of environmental quality that are known by consumers to vary in accuracy and allow firms to choose whether to take the more accurate or less accurate test. Lerner and Tirole (2006) and Farhi et al. (2008) consider standards that are known to be of differing difficulty and assume the firm is uncertain of its own quality, so that from the firm's perspective there is uncertainty over whether a particular standard will turn out to be too difficult. These papers focus on how firms can best "show off" their quality by choosing standards that are known to be either more or less difficult and find that multiple standards increase the ability of firms to provide information about their quality. But for ecolabels we believe that our assumption that consumers are unaware of the underlying standard embodied in a certification label is more appropriate. Because of this difference in assumptions, other papers have not addressed the main issues that we examine, including confusion caused by label proliferation, legitimizing and spoiling of labels, and the role for mandatory disclosure or "focal" equilibria in reducing confusion. As discussed later, the exception is Fishman and Hagerty (1990), who consider costless disclosure of one of multiple noisy signals of "high" or "low" quality and whose results are closely related to our findings regarding focal equilibria.

Our analysis is for the case where labels certify that a standard has been met and provide no more detailed information. Voluntary labels typically take this "pass-fail" form, in which a certificate or label is awarded or not, even in cases where more detailed information could be provided. For instance, of the 10 nongovernment ecolabels for carbon emissions listed at the ecolabelling.org website, all but one provide a simple label of approval without more detailed information about the product's carbon footprint. The prevalence of simple labels could reflect the need to reduce information processing by consumers. Or, consistent with the theoretical literature, it could reflect the incentive of certification intermediaries to withhold more detailed information when labeling is voluntary (Lizzeri 1999). Given the prevalence of the pass-fail form and the multiple reasons for it, we take the form as given in our analysis.

We discuss our results in the context of ecolabeling, but they apply to any certification or labeling scheme about which uncertainty over a pass-fail standard exists. More broadly, the issues we investigate arise in any situation in which observers must jointly update their beliefs about an agent's quality and an uncertain quality standard. For instance, consistent with Groucho Marx's concerns, our analysis shows that a disreputable individual might indeed find little benefit from joining a club because the very fact of his membership downgrades the perceived standards of the club.

This paper proceeds as follows. In §2 we develop the basic model with one standard, define the conditions for the existence of both labeling and nonlabeling equilibria, show the existence of the Groucho effect, and analyze its impact on informativeness. In §3 we analyze the multistandard case, showing that the qualitative results of §2 continue to hold and that the impact of the Groucho effect is worsened.

[2] Mandatory disclosure is distinct from the imposition of minimum quality standards that can exclude firms from the market (Leland 1979). The application to environmental quality standards is considered by Arora and Gangopadhyay (1995) and Lutz et al. (2000), and the application to ecolabeling is analyzed by Amacher et al. (2004) and Mattoo and Singh (1994).

In §4 we consider strategic interactions between firms when there are multiple standards and information spillovers. In §5 we present our conclusions.

2. Base Model

We consider a firm's decision to have its product certified that it meets a quality standard for an ecolabel. The product's exogenously given (environmental) quality Q is distributed according to distribution F with full support on $[0, 1]$ and with corresponding density function f. The firm knows the realized value q of Q, but consumers only know its distribution F. There exists a label with standard S, which is distributed according to the distribution G with full support on $[0, 1]$ and with corresponding density function g. The firm knows the realized value s of S. If consumers also know the realized value s, we say the standard is "certain," and if they only know the distribution G, we say the standard is "uncertain." For simplicity we assume Q and S are independent. In this section we assume that there is only one label.

If $q \geq s$, the firm has a choice to obtain a label or not; i.e., a firm that meets the labeling standard need not choose to be certified for the label. If $q < s$, the firm does not meet the standard so it has no choice. Certification has a fixed cost $c > 0$ that is independent of q or s and captures any fees to the certifier and any other costs, e.g., the expense of documenting quality control processes, auditing and testing costs by the certifier, and the opportunity cost of providing space on the product packaging for the label.[3] We assume the payoff to the firm is the expected quality of its product as estimated by consumers less the certification cost if it chooses to certify. Because we allow for general F, all the results hold as long as the firm's payoff is a strictly increasing function of quality as estimated by consumers. Consumer concern for environmental quality could capture direct financial gains to the consumer, e.g., savings from lower energy use, or internalized social benefits, e.g., knowing that forests are protected.

[3] Because quality q is exogenous, we are not considering costs to improve the product. Vitalis (2002) notes that certification costs can be a substantial fraction of total costs. These costs may be paid by a manufacturer or a retailer (Guo 2009). We assume that c is the same for any s, but in some cases the testing component of certification costs might be more expensive when the standard is tougher. As long as any such variation in c is not known by the consumer and therefore cannot be used to infer the difficulty of a standard, consumers will have even more reason to be suspicious that a label represents a low standard, and the negative effect of standard uncertainty on labeling incentives will be aggravated.

The expected quality of a product conditional on quality Q exceeding the standard S, where the value of S is distributed according to G, is

$$E[Q \mid Q \geq S] = \frac{\int_0^1 \int_s^1 q\, dF(q)\, dG(s)}{\int_0^1 \int_s^1 dF(q)\, dG(s)}, \tag{1}$$

and similarly the expected quality conditional on not meeting the standard is

$$E[Q \mid Q < S] = \frac{\int_0^1 \int_0^s q\, dF(q)\, dG(s)}{\int_0^1 \int_0^s dF(q)\, dG(s)}. \tag{2}$$

When s is known, these conditional expectations reduce to $E[Q \mid Q \geq s] = \int_s^1 q\, dF(q) / \int_s^1 dF(q)$ and $E[Q \mid Q < s] = \int_0^s q\, dF(q) / \int_0^s dF(q)$.

Before analyzing the equilibrium behavior of firms, first consider the effect of uncertainty about the standard on consumer information, supposing that all firms meeting the standard obtain a label. Because the label provides information about both Q and S, it provides less information about Q alone than when S is known. For instance, for the case of uniform F and G, the expected mean-squared-error of consumer estimates of Q falls from 1/12 to 1/24 when S is certain but falls only to 1/18 when S is uncertain. As the following proposition confirms, this pattern holds for general F and G. For particular realizations s of S, e.g., for very high or low s, certain standards can be less informative than uncertain standards, but on average a certain standard is more informative.

Proposition 1. *Suppose all eligible firms are labeled. The expected informativeness of the label is lower if the standard is uncertain than if it is certain.*

Proof. All proofs are in the appendix. □

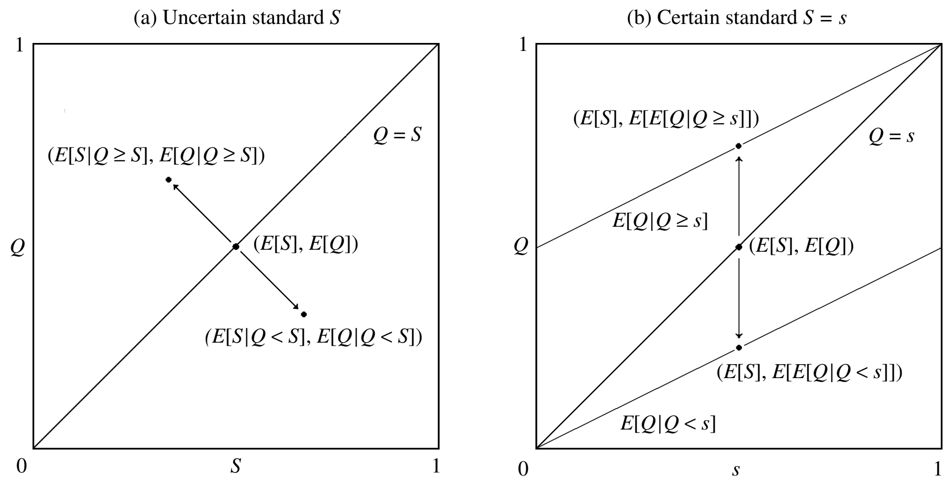
As expected, uncertainty over the meaning of a label reduces the ability of the label to convey information about quality to consumers. Our objective in this paper is to explore how the equilibrium labeling decisions of firms aggravate the uncertainty problem to create further confusion among consumers.

Our equilibrium concept is perfect Bayesian equilibrium subject to a belief-refinement introduced below. In a *labeling equilibrium* a firm whose product meets or exceeds the labeling standard always obtains a label, so the lack of a label implies failure to meet the standard. Consumer beliefs used to update product quality are consistent with this firm strategy in equilibrium, so the equilibrium condition is simply that the benefit from labeling is higher than the cost,[4]

$$E[Q \mid Q \geq S] - E[Q \mid Q < S] \geq c. \tag{3}$$

[4] If a labeling equilibrium exists, a continuum of equilibria also exist where only types in some subset $X \subset [S, 1]$ obtain a label, with the knife-edge result that $E[Q \mid Q \in X] - E[Q \mid Q \notin X] = c$. We do not analyze these equilibria in which all types are indifferent between labeling and nonlabeling.

Figure 1 **Updated Quality and Standard Estimates**



Because $E[Q \mid Q \geq S] > E[Q \mid Q < S]$ such an equilibrium exists for c sufficiently small and does not exist for c sufficiently large. In a *nonlabeling equilibrium* a firm does not certify product quality even if it can, so lack of a label represents no news at all, implying the prior estimate $E[Q]$ is unchanged. Labeling in the nonlabeling equilibrium is an unexpected, out-of-equilibrium action. As discussed by Banks and Sobel (1987), there is no variation in the incentives of types to certify, so standard forward induction arguments do not indicate one type or another is a more plausible source of the unexpected action. We refine the perfect Bayesian equilibrium set by assuming that consumers believe that such an action is equally likely to have been by any type that meets the standard, so an unexpected label is good news that generates the updated estimate $E[Q \mid Q \geq S]$. Therefore, the equilibrium condition for the nonlabeling equilibrium is

$$E[Q \mid Q \geq S] - E[Q] \leq c. \tag{4}$$

Because $E[Q \mid Q \geq S] > E[Q]$, such an equilibrium does not exist for c sufficiently small and does exist for c sufficiently large. Comparing the two conditions, because $E[Q \mid Q < S] < E[Q]$ the left-hand side of (3) is greater than the left-hand side of (4), implying for any given c one or the other of these two equilibria exists. Both conditions are satisfied simultaneously, indicating the existence of multiple equilibria, when

$$\begin{aligned} &E[Q \mid Q \geq S] - E[Q] \\ &\qquad \leq c \leq E[Q \mid Q \geq S] - E[Q \mid Q < S], \end{aligned} \tag{5}$$

which is possible again by the fact that $E[Q \mid Q < S] < E[Q]$. Regarding when one of the equilibria is unique, the labeling condition (3) cannot be satisfied for c sufficiently large and the nonlabeling condition (4) cannot be satisfied for c sufficiently small. We state these results as the following proposition, where the proof verifies the inequalities stated above.

Proposition 2. *With certain or uncertain labeling standards, there exists $0 \leq \underline{c} < \bar{c} \leq 1$ such that a nonlabeling equilibrium exists iff $c > \underline{c}$, a labeling equilibrium exists iff $c < \bar{c}$, and both equilibria exist iff $c \in [\underline{c}, \bar{c}]$.*

To see the differential effects of certainty and uncertainty, first consider Figure 1(a), where F and G are uniform so that the priors are $(E[S], E[Q]) = (1/2, 1/2)$. The updated expectations of S and Q for $Q \geq S$ and $Q < S$ are given by the centers of mass of the upper and lower triangles, respectively, so $E[Q \mid Q \geq S] = 2/3$ and $E[S \mid Q \geq S] = 1/3$, and $E[Q \mid Q < S] = 1/3$ and $E[S \mid Q < S] = 2/3$. Therefore, meeting the standard is good news about Q and bad news about S, and failing to meet the standard is the opposite. We term the downward adjustment of the estimate of S due to a label the "Groucho effect"—achieving the goal diminishes the goal itself. And we term the upward adjustment to the estimate of S due to lack of a label the "reverse Groucho effect"—failing to meet the goal enhances the goal itself. These adjustments lead to a moderating effect on the estimates of Q, where consumers are both less impressed by a label and less discouraged by lack of a label.

This can be seen by comparison with Figure 1(b), where F and G are still uniform and the realized value s of the standard is known to consumers. The updated quality estimates based on meeting the standard or not, $E[Q \mid Q \geq s] = (1+s)/2$ and $E[Q \mid Q < s] = s/2$, are given respectively by the upper and lower lines in the figure. Integrating these estimates of Q over the different values of s we get the ex ante expected qualities for a certain standard of $E[E[Q \mid Q \geq s]] = 3/4$ and $E[E[Q \mid Q < s]] = 1/4$. These are the average expected qualities for the certain standard case where s is known, and they are the expected qualities that would result for the uncertain standard case if the conditional distribution of S did not become less favorable when $Q \geq S$ and more favorable when $Q < S$. Comparing these expectations with those in Figure 1(a), the example illustrates the general rule, verified in the proof of the following proposition, that

$$E[E[Q \mid Q < s]] < E[Q \mid Q < S] < E[Q] < E[Q \mid Q \geq S] < E[E[Q \mid Q \geq s]], \qquad (6)$$

so meeting the labeling standard is better news on average if the standard is known for sure than if it is uncertain, and not meeting it is worse news on average if the standard is known for sure than if it is uncertain.

The relationship in (6) implies that condition (3) for a labeling equilibrium is more strict with an uncertain standard than it is on average for a certain standard, and that condition (4) for a nonlabeling equilibrium is less strict with an uncertain standard than it is on average for a certain standard. Thus, the Groucho effect makes the condition for the labeling equilibrium harder to meet, and the reverse Groucho effect makes the condition for the nonlabeling equilibrium easier to meet.

Proposition 3. *The expected range of certification costs supporting a labeling (nonlabeling) equilibrium is smaller (larger) if the standard is uncertain rather than certain.*

To gain further insight into these differences, consider Figure 2, where G is uniform and F follows the Beta distribution $B(q; a, b)$. For the figure we restrict either $a = 1$ and $b \geq 1$, or $a \geq 1$ and $b = 1$, so that the distribution is respectively for a "bad reputation firm" with low expected quality or for a "good reputation firm" with high expected quality and the distribution is uniquely determined by its mean $E[Q] = a/(a+b)$. Figure 2(a) shows the cost cutoff $\bar{c} = E[Q \mid Q \geq S] - E[Q \mid Q < S]$ for the boundary of the labeling region (L) from the equilibrium condition (3), the cost cutoff $\underline{c} = E[Q \mid Q \geq S] - E[Q]$ for the boundary of the nonlabeling region (N) from the equilibrium condition (4), and the resulting multiple equilibrium region (LN). Figure 2(d) shows the certain standard case where the corresponding regions are determined by the expected values $E[\bar{c}] = E[E[Q \mid Q \geq s]] - E[E[Q \mid Q < s]]$ and $E[\underline{c}] = E[E[Q \mid Q \geq s]] - E[Q]$ based on averaging out the exact values for different realizations of $S = s$. The figures illustrate the result from Proposition 2 that uncertainty over the standard makes label adoption less likely in that, relative to the case of certain standards, the equilibrium range for the labeling equilibrium is always smaller and the equilibrium range for the nonlabeling equilibrium is always larger.[5]

Consider the effect of prior expectations about firm quality on labeling incentives. The Groucho effect is strongest for firms with bad reputations because consumers are suspicious of any standard that such a firm can meet; similarly, the reverse Groucho effect is strongest for firms with good reputations, because consumers infer that failure to obtain a label implies that the standard for the label was very difficult. Because the Groucho and reverse Groucho effects are weakest for intermediate firms whose quality is most uncertain, the impact of certification on expected quality is the strongest, and such firms have the most incentive to obtain a label.[6] This is seen in Figure 2(a), where the labeling region is at a minimum and the nonlabeling region is at a maximum for $E[Q]$ approaching 0 or 1.

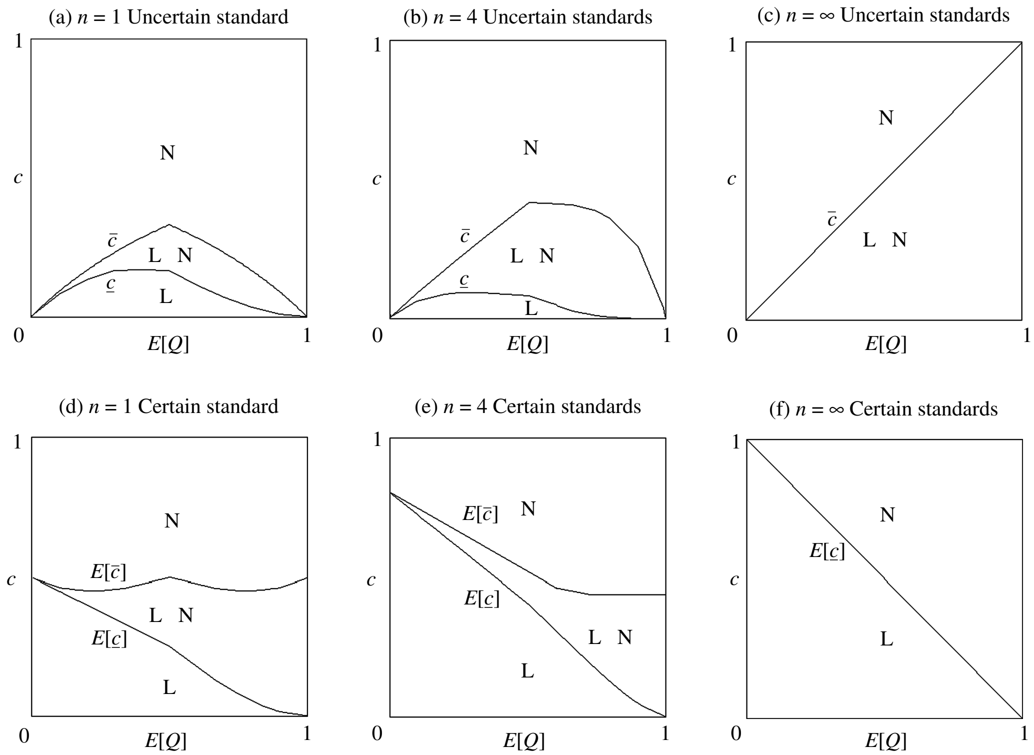
When standards are certain there is no joint updating about both quality and standards, so bad reputation firms that are actually of high quality can effectively certify their quality, and good reputation firms that fail to certify their quality when expected to can be heavily penalized by consumers. Therefore, as seen in Figure 2(d), the labeling equilibrium region is comparably large for all firms. The nonlabeling region is smallest for bad reputation firms because they have a strong incentive to certify their quality even when not expected to, whereas good reputation firms can rely on their good reputations and save the certification costs.

These results on the role of prior expectations imply that firms with bad reputations for environmental quality that can in fact meet relatively stringent standards have the most to gain from more transparent labeling standards. As will be seen in the following section, and as illustrated in the remaining panels of Figure 2, the divergence in labeling incentives between the certain and uncertain cases, and the differential effect on incentives based on prior expectations, becomes increasingly stark as the number of standards increases.

[5] The effects of intermediate degrees of uncertainty over the standard G are also interesting. If F is uniform, then higher variance in G reduces labeling incentives, but in general the relationship between variance in G and labeling incentives need not be monotonic.

[6] The functional form of F in the figure implies that F is most diffuse for $E[Q] = 1/2$. Regarding mean-preserving spreads in F, for the case of uniform G it can be shown that they increase the incentive to disclose both for certain and uncertain standards. From a sociological perspective, Phillips and Zuckerman (2001) find that middle status types have the most incentive to meet social norms, given the uncertainty of their status.

Figure 2 Labeling (L) and Nonlabeling (N) Equilibrium Regions



3. Multiple Labels

We now consider how label confusion is affected by the availability of multiple labels with different standards. As noted in the introduction, the proliferation of different labels for some products is quite extreme. For instance, the website ecolabelling.org lists more than 30 different labels for forest products, more than 40 different labels for textiles, and more than 100 different labels for food products. It might seem that more options should offer firms more ways to show off their quality, so that label usage increases. But the proliferation of standards is often blamed for creating confusion among consumers that weakens the credibility of all labels and reduces label adoption (Fischer et al. 2005). This suggests that an increase in labels can aggravate the underlying problem of uncertain standards.

To gain insight into how the proliferation of labels interacts with standard uncertainty, we now assume that there are $n \geq 1$ labels with different standards drawn independently from the same distribution G with the same cost c. Following standard notation for order statistics we denote the random variable representing the ith lowest realized standard by $S_{i:n}$ and its distribution by $G_{i:n}$, so that $G_{1:n}$ represents the distribution of the worst standard and $G_{n:n}$ the distribution of the best standard. The firm's quality and the realized difficulties of the different standards are only known by the firm, but F, G, c, and n are also known by consumers.

For simplicity we assume that if a firm meets the standards for multiple labels it can only adopt one of them. As long as attaining and displaying extra labels is costly, this assumption does not affect our main qualitative results.[7] We also restrict attention initially to a "symmetric" labeling strategy, where the firm adopts the toughest label that it meets independent of any arbitrary properties of the ex ante identical standards. Any other equilibrium strategy that is similarly symmetric, such as always adopting the second toughest standard when possible, provides equivalent information about firm quality to consumers. For now we do not consider "focal" equilibrium strategies where it is assumed that a particular label will always be adopted if the standard for it is met.

Because consumers do not know which of the labels has a more difficult standard, a label under a symmetric labeling strategy only proves that a firm has met the easiest standard, even if the firm has in fact met the best standard. Hence the incentives to obtain

[7] The restriction of displaying one label does not affect the conditions for existence of labeling and nonlabeling equilibria if there are constant or diminishing returns to labels. This holds, for instance, for uniform F and G. But if returns are increasing over some range, then it might be worthwhile to be certified by multiple labels, even if it would not be worthwhile to be certified by one label; e.g., a restaurant might display multiple labels in its window. Because the marginal value of any label goes to 0 as the number of labels increases, the limiting results of this section are unaffected by the possibility of showing multiple labels.

a label or not are exactly the same as in the previous section, with the only exception being that we replace the random variable S with the random variable $S_{1:n}$, representing the weakest of the n standards. Therefore, following conditions (3) and (4), for uncertain standards a *symmetric labeling equilibrium* exists if and only if

$$E[Q \mid Q \geq S_{1:n}] - E[Q \mid Q < S_{1:n}] \geq c, \tag{7}$$

and a nonlabeling equilibrium exists if and only if

$$E[Q \mid Q \geq S_{1:n}] - E[Q] \leq c. \tag{8}$$

For certain standards the conditions are quite different because consumers know the difficulty of the standard that was met and the difficulty of standards that were not met. We define a labeling equilibrium for certain standards as an equilibrium in which any of the different labels are adopted. For instance, a firm might find a label with a high standard worth the certification cost, but not a label with a lower standard (e.g., Viscusi 1978, Jovanovic 1982). A labeling equilibrium exists if and only if some firm types find it more profitable to pay the certification cost and prove that they meet a particular standard (and none higher) than to be thought of as coming from the whole range below that standard, i.e., if and only if

$$\max_{i=1,\ldots,n} \{E[Q \mid s_{i:n} \leq Q \leq s_{i+1:n}] - E[Q \mid Q < s_{i:n}]\} \geq c, \tag{9}$$

where we define $s_{n+1:n} = 1$.

The condition for a nonlabeling equilibrium is simpler because lack of a label always gives a payoff of $E[Q]$, implying that the incentive to unexpectedly adopt a label is always highest for those meeting the highest standard. In particular, under our belief refinement a nonlabeling equilibrium exists if and only if

$$E[Q \mid Q \geq s_{n:n}] - E[Q] \leq c. \tag{10}$$

As shown in Figure 2, these conditions imply that behavior with uncertain standards diverges dramatically from that with certain standards. As the number of labels n increases, consumers become increasingly suspicious of the value of a label and the expected quality conditional on having a label $E[Q \mid Q \geq S_{1:n}]$ falls. Therefore, comparing panel (a) with panels (b) and (c), as n increases the nonlabeling equilibrium region based on Equation (8) expands. In the limit condition (8) converges to $E[Q] - E[Q] \leq c$ so a nonlabeling equilibrium always exists for $c > 0$, which is particularly damaging to bad reputation firms, which lose the opportunity to disprove consumer expectations. Regarding the labeling equilibrium, if consumers expect a firm to obtain a label and the firm does not, then the expected quality conditional on not having any label $E[Q \mid Q < S_{1:n}]$ also falls as the number of labels increases. Because both $E[Q \mid Q \geq S_{1:n}]$ and $E[Q \mid Q < S_{1:n}]$ are decreasing in n, the labeling equilibrium region based on (7) can expand or contract, and as seen in the figure in this example the region expands. In the limit condition (7) converges to $E[Q] - 0 \geq c$, so a labeling equilibrium only exists if firm reputations are sufficiently good.[8] This labeling equilibrium provides almost no information on firms, but good reputation firms still feel compelled to obtain a label to avoid being thought of as very low quality. In contrast, comparing panel (d) with panels (e) and (f), for certain standards as n increases the labeling incentive for bad reputation firms becomes increasingly strong because of the absence of the Groucho effect and the greater availability of different standards. At the same time, the labeling incentive for good reputation firms decreases, because they can rest on their reputations and save the labeling costs.

The following proposition shows that these patterns hold generally for uncertain standards and, following Lizzeri (1999, Theorem 1), hold for certain standards as long as the distribution of F is log-concave.[9]

Proposition 4. *Suppose there are n labels with i.i.d. standards. If standards are uncertain,* (i) *the support of a nonlabeling equilibrium is increasing in n; and in the limit as n increases,* (ii) *nonlabeling is an equilibrium for all $c > 0$,* (iii) *symmetric labeling is an equilibrium if and only if $E[Q] \geq c$, and* (iv) *the symmetric labeling equilibrium is uninformative. If standards are certain, in the limit as n increases,* (v) *nonlabeling is almost surely an equilibrium if and only if $E[Q] \geq 1 - c$, and* (vi) *for F log-concave, labeling is almost surely an equilibrium if and only if $E[Q] \leq 1 - c$.*

Recall that Proposition 1 showed that certification is always less informative when standards are uncertain. Proposition 4(iv) shows that for large n this result is even stronger in that, even though labeling can still be an equilibrium for large n, the informativeness of a label when standards are uncertain goes to zero; i.e., estimates of Q are no better than the prior estimates without a label. Managers find themselves

[8] Note that at $E[Q] = 1$ the firm's quality is perfectly revealed and the incentive to label disappears, but our analysis assumes Q has full support on $[0, 1]$ so the analytic results and the figure are for the range $E[Q] \in (0, 1)$.

[9] As a step in a more general analysis, Lizzeri (1999) analyzes the case where certification costs are given and each quality level can be certified. In our case in the limit as the number of labels increases there is essentially a different label for every quality level, so the problem converges to that analyzed by Lizzeri. Note that log-concavity is equivalent to a decreasing reversed hazard rate and is satisfied by most commonly used distributions, including the Normal, Uniform, and Beta distributions (Bagnoli and Bergstrom 2005).

in a labeling paradox. Labeling is completely wasteful because in equilibrium the firm proves that it is not of the lowest type, but the firm does not benefit relative to prior expectations, and consumers do not learn any information because the firm being of the lowest type is a zero probability event anyway. This contrasts with the result for certain standards, where as n increases a label becomes highly informative and the only residual uncertainty arises from firms that do not have a label because of the certification costs. This suggests that as the number of labeling organizations expands, organizations interested in promoting ecolabels should try to limit the number of labels or better educate consumers about label standards.

That labeling provides no new information as n increases is related to the finding by Lizzeri (1999) that a certification intermediary that is interested in maximizing profits from certification will often choose the lowest possible standard, with the result that there is no net gain in information to consumers. Because a firm that does not meet the standard will be thought of as extremely low quality, firms are willing to pay a high cost for the certificate; because the certificate is so easy to earn, almost all of them are able to pay for the certificate and receive it. Therefore, a profit-maximizing certification intermediary uninterested in informing consumers benefits the most from a low standard. Our model differs in the assumption that there are multiple exogenous labeling standards rather than an endogenous standard chosen by a profit-maximizing certification intermediary, and that there is a fixed cost to certification rather than a profit-maximizing price set by the intermediary. Nevertheless, we find the same result that as the number of labels grows, consumers learn little from certification even as firms feel forced to expend substantial resources on it.

With multiple standards, one standard is sometimes "focal" or "salient" in that consumers expect firms to adopt the standard if they are able to, even if they also meet another potentially more demanding standard. For instance, in many European countries, regional or national ecolabels appear to be focal relative to the EU Flower label; e.g., the Nordic Swan label and German Blue Angel labels are more widely adopted for almost all product categories. Given the focality of these labels and the fact that consumers do not know which labeling standards are tougher, consumers might infer that a firm that displayed the EU Flower label was only able to attain it and not the focal label.

It might seem that information flows will decrease if firms are expected to choose a focal standard rather than the one they know to be toughest. To see how a focal standard can increase rather than decrease information flows, we now consider focal labeling strategies based on arbitrary properties of the labels that are unrelated to their difficulty. In such a strategy there is one label, say label X, that a firm is expected to adopt if it can. If the firm adopts another label, say label Y, then it is assumed that it could not meet label X and that label Y was the best of the other labels it did meet. For certain standards, a firm will clearly certify whichever label is toughest so any equilibrium based on focal strategies will break down. But for uncertain standards, consumers do not know which label is tougher so such a focal labeling equilibrium is possible. Such an equilibrium can be more informative than a symmetric labeling equilibrium, as the following proposition shows.[10]

Proposition 5. *Suppose there are n labels with i.i.d. standards.* (i) *If standards are uncertain and c is sufficiently low, there exists a focal labeling equilibrium that is more informative than the symmetric labeling equilibrium.* (ii) *If standards are certain, a focal labeling equilibrium cannot exist.*

The focality of a standard eliminates the problems caused by multiplicity of voluntary standards. The result is then similar to the $n = 1$ case in that there is no degradation of the expected difficulty of the standard, but it is actually better because firms that do not meet the focal standard can still provide information to consumers by meeting a different standard. As discussed in the introduction, this result provides a role for industry groups, governments, and NGOs in not just setting and clarifying standards, but in attempting to make particular standards focal. "Look for the label" campaigns can help induce an equilibrium where consumers expect a particular standard to be used and look less favorably on adoption of other labels. The key is not necessarily that the focal label has a higher standard, or that the standard be certain, but simply that there is a single standard that consumers expect firms to try to attain.

This result has important implications for the debate over the role of industry-sponsored labels aimed at environmental and/or social aspects of product quality. It is common for NGOs to criticize the introduction of industry-sponsored labels, often citing them as embodying lower-quality standards than existing NGO labels. However, if the industry labels are introduced as a response to label proliferation, and if the industry succeeds in making its label

[10] Proposition 5 looks at the case where c is sufficiently low that it is an equilibrium for the firm to adopt another label if it cannot meet the standard for the focal label. It can also be an equilibrium for a firm to adopt the focal label if it can and otherwise not adopt any label. For sufficiently many standards such a strategy is also more informative than the symmetric disclosure equilibrium, but for low costs the firm has an incentive to deviate to the equilibrium strategy we examine.

focal, then there can be a gain in information to consumers. Therefore, it might be strategic for NGOs to settle for less-demanding labels that have a greater chance of becoming focal.

Our result on focal certification equilibria is closely related to a finding by Fishman and Hagerty (1990), who analyze a persuasion game with costless disclosure where there are multiple noisy signals about whether an investment project is profitable and assume that a firm can only reveal one of them. Similar to our result, they find that a "lexicographic" equilibrium is most informative; a firm releases the first signal that is favorable in accordance with a set order that is anticipated by receivers, so that releasing another favorable signal is therefore evidence that the first signal was not favorable.

An alternative to the use of campaigns to establish focal standards is to simply make it mandatory for a firm to disclose whether it meets a particular standard. In this case bad news regarding this mandatory disclosure on one standard can still be supplemented with good news on other standards, so the result is essentially the same as in the focal equilibrium if the certification costs for the mandatory standards are taken as sunk costs. Therefore, the informativeness result of Proposition 5 also provides an argument for mandatory certification of a particular label, even if consumers do not know the exact standard for the label, and suggests that firms may benefit from partnering with government or dominant NGOs to promote a specific label as a marketing strategy.

4. Multiple Firms

We now consider how the presence of multiple firms affects label confusion. It might seem that, by observing which firms obtain which labels, consumers should be able to learn about different labeling standards and thereby reduce the information problems analyzed above. Indeed, if there is only one label and all firms that can meet the label standard adopt it, then as the number of firms increases, the fraction of the firms obtaining the label is an increasingly precise estimate of the label standard. However, we find that two factors limit such learning. First, the nonlabeling equilibrium is unaffected by an increase in the number of firms, so the potential for no learning, and also the potential for strategic uncertainty about how to interpret lack of a label, remains. Second, in the realistic case where there are both multiple firms and also multiple labels, we find that firms have an incentive to choose standards strategically in a way that interferes with consumer learning.

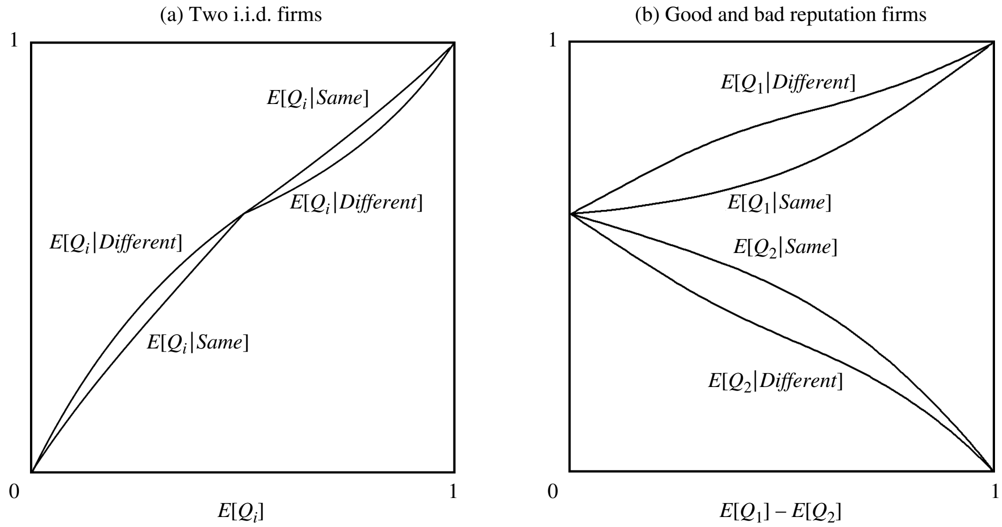
First consider the simpler case where m firms with i.i.d. qualities $Q_1, \ldots, Q_m$ simultaneously choose whether to adopt a single label with standard S. As discussed at the end of this section, we do not model product market competition between firms; we just assume that each firm wants to be perceived as higher quality rather than lower quality. Each firm knows the realized value of its own quality and each other's qualities $q_1, \ldots, q_m$ and the realized difficulty of the standard s, but consumers only know F, G, c, and m. The first part of the following proposition uses a standard Law of Large Numbers result to confirm that the fraction of firms obtaining the label can be an asymptotically precise estimate of the standard, so the situation for each firm is equivalent to that of a single firm facing a certain standard, as examined in §2. The second part shows that this logic does not extend to the nonlabeling equilibrium, because the gain from deviating by a single firm is $E[Q_i \mid Q_i \geq S] - E[Q_i]$, so the condition for a nondisclosure equilibrium remains exactly the same as that of a single firm facing an uncertain standard. The third part confirms that for a certain standard the number of firms has no effect on the support of either equilibrium.

Proposition 6. *Suppose m i.i.d. firms face a single label. If the label standard is uncertain*, (i) *the expected support of a labeling equilibrium converges to that of a single firm facing a certain standard as m increases, and* (ii) *the expected support of a nonlabeling equilibrium is the same as for $m = 1$.* (iii) *If the label standard is certain, the expected support of either equilibrium is the same as for $m = 1$.*

Looking back at Figure 2, this proposition implies that with uncertain standards a large number of firms expands the region where labeling and nonlabeling equilibria coexist from the "L, N" areas in the separate panels of (a) and (d) to encompass the area above $\underline{c}$ in panel (a) and underneath $E[\bar{c}]$ in panel (d). Therefore, even though the presence of multiple firms can potentially reduce uncertainty over the standard by the first part of the proposition, it need not do so by the second part, and the combination of these results implies that there is increased strategic uncertainty from the larger range of c that supports multiple equilibria.[11] Therefore, this result reinforces the argument that firms and organizations interested in promoting ecolabel adoption need to consider how to promote ecolabels in an environment where both labeling and nonlabeling are equilibria. Similarly, it supports a role for mandatory labeling to avoid the multiple equilibrium problem.

[11] This is seen for the EU Flower label, which has different standards for different product categories, and where label adoption rates for the categories vary greatly. For instance, consumers could interpret the absence of adoption by any major laundry detergent products either as reflecting a nonlabeling equilibrium or as strong evidence that the labeling standard for detergents is very strict. In this case the former interpretation appears to be correct (Rubik and Frankl 2005).

Figure 3 Strategic Choice of Labels



Now considering the case where there are both multiple firms and multiple labels, learning about label standards is more difficult because adoption of one label by a firm creates an information externality or spillover that can affect the incentives for other firms to certify. If a firm follows the strategy of adopting the toughest label that it meets, and if the firm is a good reputation firm, then adoption of a label might be good news about the label standard, which counteracts the Groucho effect. Because of this selection effect, a good reputation firm can "legitimize" a standard and make it more attractive to other firms, but because of the Groucho effect, a bad reputation firm can "spoil" a standard and make it less attractive to other firms. Firms therefore have an incentive to choose standards strategically in a way that interferes with consumer learning.

To gain insight into this incentive, first suppose there are two labels with i.i.d. standards and two i.i.d. firms. If one firm follows the strategy of adopting the toughest label it meets and the prior F is very favorable, then the label that it adopts is likely to be the better one. This gives the other firm an incentive to adopt the same label, regardless of whether the label is really the toughest. Conversely, if the prior F is very unfavorable, then the label that is adopted is still likely to be the worse one. This gives the other firm an incentive to adopt the opposite label, regardless of whether it really is the toughest. Therefore, in both cases firms have an incentive to deviate from the symmetric certification strategy of adopting the label with the toughest standard.[12]

[12] Jovanovic (1982) notes in passing that the disclosure incentives of one firm can be affected by those of another if firm quality is correlated. Here firm quality is independent, but conditional correlation is generated by the same uncertain standards being available to each firm.

This is seen in Figure 3(a) for two firms with i.i.d. quality given by the Beta distribution as before and for two standards with i.i.d. uniform distribution. Define $E[Q_i \mid Same]$ as the expected quality of firm i's product when the toughest standard that each firm meets is the same,

$$E[Q_i \mid S_{1:2} \leq Q_1, Q_2 < S_{2:2} \cup S_{1:2} < S_{2:2} \leq Q_1, Q_2], \quad (11)$$

and $E[Q_i \mid Different]$ as the expected quality of firm i's product when one firm meets a higher standard:

$$E[Q_i \mid S_{1:2} \leq Q_1 < S_{2:2} \leq Q_2 \cup S_{1:2} \leq Q_2 < S_{2:2} \leq Q_1]. \quad (12)$$

Because the firms are i.i.d., $E[Q_1 \mid Same] = E[Q_2 \mid Same]$ and $E[Q_1 \mid Different] = E[Q_2 \mid Different]$, so if (11) > (12), both firms will prefer to adopt the same standard even if one meets a higher standard, and if (11) < (12), both firms will prefer to adopt a different standard even if they both meet the higher standard. Only in the knife-edge case where (11) equals (12) and the firms are just indifferent is it an equilibrium for firms to always follow the symmetric labeling strategy. This is seen in the figure where, unless $E[Q_i] = 1/2$, firms have an incentive to either pool with each other or separate from each other by choosing standards strategically. Such strategic behavior aggravates label confusion and makes it more difficult for a firm with a bad reputation to prove itself to be good.

Now consider more generally m firms with i.i.d. qualities choosing simultaneously whether to adopt one of n labels with i.i.d. standards, where again the realized qualities and standards are known by the firms but only F, G, c, m, and n are known to consumers. Let $a = (a_1, \ldots, a_m)$, where a_j equals the label 1 to n adopted by firm j with 0 representing no label. Then in a candidate symmetric labeling equilibrium $E[Q_i \mid a]$ is expected quality conditional on the observed a and on the equilibrium strategy of adopting the toughest label attainable. If $E[Q_i \mid a]$ is constant for all a that are attainable for a given realization of $(Q_1, \ldots, Q_m)$, then no firm has an incentive to deviate. But if this knife-edge condition does not hold, as in the two-firm and two-label example above, at least one firm has an incentive to deviate by adopting a lower standard.

This problem does not arise for a focal equilibrium. Suppose that there is a particular label that each firm is expected to adopt or not if it meets the standard for it. Then the incentive to adopt the label is exactly the same as if there was only one label,[13] including the result from Proposition 6, that with many firms consumers will become increasingly certain of the standard for the focal label. Therefore, the focal equilibrium can approximate the case of a mandatory label, allowing consumers to learn about the meaning of the standard for the label from their experiences with different products. Again this result supports a role for marketing efforts aimed at the development or adoption of a focal labeling standard.

The proof of the following proposition follows directly from the above arguments.

Proposition 7. *Suppose $m > 1$ i.i.d. firms choose among $n > 1$ labels with i.i.d. standards.* (i) *If the label standards are uncertain, then a symmetric labeling equilibrium does not exist generically, but a focal labeling equilibrium always exists under the same condition as for $n = 1$.* (ii) *If the label standards are certain, then the support of any equilibrium is the same as for $m = 1$.*

This incentive to choose standards strategically can be aggravated if consumers have different prior distributions about the different firms' products. Figure 3(b) shows the case where "good reputation" firm 1 has convex Beta distribution parameterized by $(\theta, 1)$ and "bad reputation" firm 2 has the symmetric concave independent Beta distribution parameterized by $(1, \theta)$, so $E[Q_1] - E[Q_2] = (\theta - 1)/(\theta + 1)$. When $\theta = 1$, both firms have uniformly distributed quality ($E[Q_1] = E[Q_2] = 1/2$ in the figure) and there is no incentive to be strategic, but as soon as a gap emerges, the good reputation firm always wants to choose a different label than the bad reputation firm, and the bad reputation firm always wants to choose the same label as the good reputation firm. If both firms adopt the same label, it is likely that only the weaker standard was met, which is bad news for the good reputation firm but still good news for the bad reputation firm. If both firms adopt different labels, it is likely that the good reputation firm met the tougher standard and the bad reputation firm met the weaker standard, so the good reputation firm gains and the bad reputation firm loses. Hence there cannot be an equilibrium in which each firm always adopts the toughest label it meets. Instead, if both firms meet both standards, there must be a mixed-strategy equilibrium where the bad reputation firm tries to choose the same label as the good reputation firm and the good reputation firm tries to avoid such an outcome.

The above analysis assumes that the choice of standards is simultaneous, but the analysis can also be applied to the case of sequential adoption. In the sequential case, a "labeling cascade" can emerge in which firms choose the same label strategically. For instance, in the two-firm and two-label example in Figure 3(a), if both firms have good reputations so that $E[Q_i \mid \mathit{Same}] > E[Q_i \mid \mathit{Different}]$, then the second firm raises its expected quality by herding with the first firm and adopting the same label, even if it meets an even tougher standard for another label. Similarly, if both firms have bad reputations, so that $E[Q_i \mid \mathit{Same}] < E[Q_i \mid \mathit{Different}]$, then antiherding can arise, in which the second firm chooses a different label than the first firm. These effects are amplified if the firms have different reputations, as in the example in Figure 3(b), in which case herding will arise if the good reputation firm goes first and antiherding will arise if the bad reputation firm goes first. In each case, the uncertainty of standards creates interdependence in the perceived quality of products that leads to a strategic choice of labels.[14]

As mentioned in the introduction, a common strategy when introducing a new ecolabel is to try to induce the most reputable companies to adopt the label with the hope that other companies will then adopt it. Similar strategies occur in many other contexts; e.g., new journals try to start with articles by respected authors. The above analysis implies that information spillovers may be one reason for this strategy. If a good reputation firm moves first, then the bad reputation firm can always choose the same label if it is capable of doing so. Therefore, the good reputation firm has no incentive to deliberately choose an easier label, and if it faces any uncertainty at all over whether the bad reputation firm will meet the tougher label, it has a strict incentive to choose

[13] If firms that do not meet the standard for the focal label adopt another label, this is good news that the firm at least meets the easiest standard. Which of the other labels firms choose depends on the same coordination issues regarding the symmetric labeling equilibrium, so generically there will be a mixed-strategy equilibrium for the other labels. But this does not affect the incentive to adopt the focal label.

[14] This discussion applies to choices between different labels, rather than the choice to obtain a label at all. If choices are sequential and a firm unexpectedly deviates from the nonlabeling equilibrium, then consumer beliefs might reasonably change and other firms might face pressure to also deviate. Our belief refinement does not apply in this case.

the tougher label. However, because there is a second-mover advantage, a good firm needs to be given some incentive to move first.

We have assumed that firms do not care directly how other firms are regarded by consumers, but only care if the label itself is diminished or enhanced because of the actions of other firms. In many situations firms will be in the same industry and therefore have a competitive incentive to look good relative to other firms by undermining their competitors' perceived quality. The above analysis shows that, even without such product market externalities, firms need to worry about the strategic effects of labeling decisions.[15]

5. Conclusion

The literature on ecolabels and other quality certification schemes has long recognized that consumer confusion is a major hurdle to their adoption and effective use. Our analysis provides a theoretical basis for such concerns when consumers have even slight uncertainty about the difficulty of labeling standards. Because consumers must jointly update the estimated quality of the product and the estimated difficulty of the standard, there are not only direct information losses but also substantial indirect losses as firms decide whether it is worthwhile to be certified and, if so, which of multiple labels to adopt. We find that a "Groucho effect" due to uncertainty discourages labeling when it is most beneficial to consumers and firms, that the effects of uncertainty are aggravated by the proliferation of labels with different standards, that strategic uncertainty from multiple equilibria becomes particularly problematic as the number of labels increases, and that information spillovers give firms an incentive to choose strategically among different labels to make learning about labeling standards more difficult for consumers.

Mandatory adoption of ecolabels can also suffer from direct information losses due to uncertainty over certification standards, but it precludes the additional indirect losses due to firm labeling decisions and can also facilitate consumer learning about standards. Therefore, these results provide an additional consideration in the debate over voluntary versus mandatory disclosure of product quality. We find that actions aimed at making one standard "focal" can also reduce the indirect information losses. "Look for the label" promotional campaigns that induce consumers and firms to focus on a particular label, even if the standard for it remains uncertain, can increase certification incentives, reduce the problem of strategic uncertainty due to multiple equilibria, and improve consumer learning by eliminating firm incentives to choose among labels strategically.

Our results assume that consumers are unsure of both the absolute and relative difficulty of different standards, but sometimes the relative difficulty of different standards is known even when the exact standards are not. For instance, consumers might know that one ecolabel is an industry label while another is an NGO label and infer that the latter represents a more difficult standard. Clearly, such relative information can reduce some of the problems identified in this paper. Therefore, another strategy for organizations to reduce label confusion is to focus on providing a clear ranking of different labels, even if the exact standards remain difficult to communicate to consumers. One option is for a single certifier to provide multiple labels representing different ranked standards, e.g., gold, silver, and bronze labels for LEED certification of buildings. However, as discussed in the introduction, the vast majority of ecolabels take the simple pass-fail form analyzed in this paper, so better understanding of why certifiers do not provide richer information to consumers is an important area of future research.

If ecolabels can help consumers successfully identify more environmentally friendly products, they may also be able to induce firms to improve the environmental quality of products over time. In the context of restaurant hygiene labels, Jin and Leslie (2003) show that restaurants improve their hygiene in response to public disclosure of hygiene ratings. We assume for our analysis that quality is fixed, so the issue of endogenous quality response to labels with uncertain standards remains open for further research. Given that consumers do not know the difficulty of labeling standards, it seems that firms have an incentive to save costs by only attaining the quality needed to meet the easiest standard. We conjecture that this makes attainment of a particular standard an even worse signal of the standard's likely difficulty, thereby strengthening the Groucho effect and aggravating the problem of label confusion.

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[15] Note that competition does not always lead to more disclosure. Guo and Zhao (2009) show that there is less disclosure in a competitive than in a monopolistic environment and that the amount of disclosure depends on whether it is sequential or simultaneous. See also Hotz and Xiao (2011), Board (2009), and Levin et al. (2009) for the effect of competition on disclosure.

Management Meeting of the French Economic Association at the Toulouse School of Economics, the Conference on Public Economics at the University of the Mediterranean, the University of Guelph, the University of Lausanne, the University of Michigan, the University of Toronto, and the University of Western Ontario.

Appendix

Proof of Proposition 1. Let $\underline{q} = E[Q \mid Q < S]$ and $\bar{q} = E[Q \mid Q \geq S]$, and for the realized value $S = s$, let $\underline{q}(s) = E[Q \mid Q < s]$ and $\bar{q}(s) = E[Q \mid Q \geq s]$. Then the mean-squared error (MSE) for the uncertain case is

$$\begin{aligned}
&\int_0^1 \left(\int_0^s (q-\underline{q})^2\, dF(q) + \int_s^1 (q-\bar{q})^2\, dF(q) \right) dG(s) \\
&\quad = \int_0^1 \left(\int_0^s (q^2 - 2q\underline{q} + \underline{q}^2)\, dF(q) \right. \\
&\qquad \left. + \int_s^1 (q^2 - 2q\bar{q} + \bar{q}^2)\, dF(q) \right) dG(s) \\
&\quad = E[Q^2] + \int_0^1 (F(s)(\underline{q}^2 - 2\underline{q}\underline{q}(s)) \\
&\qquad + (1-F(s))(\bar{q}^2 - 2\bar{q}\bar{q}(s)))\, dG(s), \qquad (13)
\end{aligned}$$

and the expected MSE for the certain case is

$$\begin{aligned}
&\int_0^1 \left(\int_0^s (q-\underline{q}(s))^2\, dF(q) + \int_s^1 (q-\bar{q}(s))^2\, dF(q) \right) dG(s) \\
&\quad = E[Q^2] + \int_0^1 (F(s)(\underline{q}(s)^2 - 2\underline{q}(s)^2) \\
&\qquad + (1-F(s))(\bar{q}(s)^2 - 2\bar{q}(s)^2))\, dG(s) \\
&\quad = E[Q^2] - \int_0^1 (F(s)\underline{q}(s)^2 + (1-F(s))\bar{q}(s)^2)\, dG(s). \qquad (14)
\end{aligned}$$

Comparing, (13) minus (14) equals

$$\begin{aligned}
&\int_0^1 F(s)(\underline{q}^2 - 2\underline{q}\underline{q}(s)) + (1-F(s))(\bar{q}^2 - 2\bar{q}\bar{q}(s))\, dG(s) \\
&\quad + \int_0^1 F(s)\underline{q}(s)^2 + (1-F(s))\bar{q}(s)^2\, dG(s) \\
&= \int_0^1 F(s)(\underline{q}^2 - 2\underline{q}\underline{q}(s) + \underline{q}(s)^2) \\
&\qquad + (1-F(s))(\bar{q}^2 - 2\bar{q}\bar{q}(s) + \bar{q}(s)^2)\, dG(s) \\
&= \int_0^1 F(s)(\underline{q} - \underline{q}(s))^2 + (1-F(s))(\bar{q} - \bar{q}(s))^2\, dG(s) > 0, \qquad (15)
\end{aligned}$$

so the MSE is larger for the uncertain case. □

Proof of Proposition 2. Given that the support of q is restricted to $[0, 1]$, we just need to verify for the uncertain case that $E[Q \mid Q \geq S] > E[Q < S]$, $E[Q \mid Q \geq S] > E[Q]$, and $E[Q \mid Q < S] < E[Q]$, and for the certain case that $E[Q \mid Q \geq s] > E[Q < s]$, $E[Q \mid Q \geq s] \geq E[Q]$, and $E[Q \mid Q < s] \leq E[Q]$ for all s. The last group of inequalities is standard for conditional expectations. Checking the first group of inequalities, note that $E[Q \mid Q \geq S] - E[Q]$ is proportional to

$$\begin{aligned}
&\int_0^1 \int_s^1 q\, dF(q)\, dG(s) - E[Q] \int_0^1 \int_s^1 dF(q)\, dG(s) \\
&\quad = \int_0^1 \left(\int_s^1 q\, dF(q) - \int_s^1 dF(q) E[Q] \right) dG(s) \\
&\quad \propto \int_0^1 (E[Q \mid Q \geq s] - E[Q])\, dG(s) > 0, \qquad (16)
\end{aligned}$$

where the inequality follows because $E[Q \mid Q \geq s] \geq E[Q]$ for all s with strict inequality for $s > 0$. By similar calculations, $E[Q \mid Q < S] < E[Q]$ also holds. Thus, combining the two inequalities, $E[Q \mid Q \geq S] > E[Q < S]$. □

Proof of Proposition 3. Substituting (1) and (2) into (3), for the labeling equilibrium we need to show that

$$\begin{aligned}
&\frac{\int_0^1 \int_s^1 q\, dF(q)\, dG(s)}{\int_0^1 \int_s^1 dF(q)\, dG(s)} - \frac{\int_0^1 \int_0^s q\, dF(q)\, dG(s)}{\int_0^1 \int_0^s dF(q)\, dG(s)} \\
&\quad \leq \int_0^1 \frac{\int_s^1 q\, dF(q)}{\int_s^1 dF(q)}\, dG(s) - \int_0^1 \frac{\int_0^s q\, dF(q)}{\int_0^s dF(q)}\, dG(s), \qquad (17)
\end{aligned}$$

and substituting (1) and (2) into (4), for the nonlabeling equilibrium we need to show that

$$\frac{\int_0^1 \int_s^1 q\, dF(q)\, dG(s)}{\int_0^1 \int_s^1 dF(q)\, dG(s)} \leq \int_0^1 \frac{\int_s^1 q\, dF(q)}{\int_s^1 dF(q)}\, dG(s). \qquad (18)$$

Considering the nonlabeling equilibrium first, (18) is equivalent to

$$\begin{aligned}
&\int_0^1 \left(\frac{\int_s^1 q\, dF(q)}{\int_0^1 (\int_t^1 dF(q))\, dG(t)} - \frac{\int_s^1 q\, dF(q)}{\int_s^1 dF(q)} \right) dG(s) \leq 0 \\
&\iff \int_0^1 \left(\int_s^1 q\, dF(q) \right) \left(\frac{\int_0^1 F(t)\, dG(t) - F(s)}{(1 - \int_0^1 F(t)\, dG(t))(1-F(s))} \right) dG(s) \leq 0 \\
&\iff \int_0^1 E[Q \mid Q \geq s] \left(\int_0^1 F(t) dG(t) - F(s) \right) dG(s) \leq 0 \\
&\iff \int_0^1 E[Q \mid Q \geq s] \left(1 - \frac{F(s)}{\int_0^1 F(t)\, dG(t)} \right) dG(s) \leq 0. \qquad (19)
\end{aligned}$$

Letting $P(s) = \int_0^s F(t)\, dG(t) / (\int_0^1 F(t)\, dG(t))$, then (19) is equivalent to $\int_0^1 E[Q \mid Q \geq s]\, dP(s) \geq \int_0^1 E[Q \mid Q \geq s]\, dG(s)$, or integrating by parts, $-\int_0^1 ((d/ds)E[Q \mid Q \geq s])(P(s) - G(s))\, ds \geq 0$. Therefore, because $(d/ds)E[Q \mid Q \geq s] > 0$, the inequality holds if $G(s) \geq P(s)$ for all s, i.e., if $P \succ_{\text{FOSD}} G$. Note that $G(s) \geq P(s)$ is equivalent to $\int_0^1 F(t)\, dG(t) \geq (\int_0^s F(t)\, dG(t))/G(s)$. The right-hand side is an increasing function of s and the inequality holds weakly for $s = 1$, so the inequality holds for all s.

Now considering the labeling equilibrium, given that (18) holds, (17) holds if

$$\frac{\int_0^1 \int_0^s q\, dF(q)\, dG(s)}{\int_0^1 \int_0^s dF(q)\, dG(s)} \geq \int_0^1 \frac{\int_0^s q\, dF(q)}{\int_0^s dF(q)}\, dG(s), \qquad (20)$$

which always holds by the same arguments as above. □

Proof of Proposition 4. (i) We first want to show that $G_{1:n} \succ_{\text{MLR}} G_{1:n+1}$, i.e., for all $x < y$,

$$\frac{g_{1:n}(x)}{g_{1:n+1}(x)} \leq \frac{g_{1:n}(y)}{g_{1:n+1}(y)}. \qquad (21)$$

Noting that

$$g_{k:n}(x) = \frac{n!}{(k-1)!(n-k)!} G(x)^{k-1} (1-G(x))^{n-k} g(x), \qquad (22)$$

(21) simplifies to $G(x) \le G(y)$, which holds for all $x < y$. Now we want to show that if $G \succ_{\text{MLR}} H$ for any two distributions G and H, then it is better news when the firm meets a standard with distribution G than H. So we need to prove that

$$\frac{\int_0^1 \int_s^1 q\,dF(q)\,dG(s)}{\int_0^1 \int_s^1 dF(q)\,dG(s)} \ge \frac{\int_0^1 \int_s^1 q\,dF(q)\,dH(s)}{\int_0^1 \int_s^1 dF(q)\,dH(s)}, \tag{23}$$

which can be rewritten as

$$\frac{\int_0^1 E[q \mid q \ge s](1-F(s))g(s)\,ds}{\int_0^1 (1-F(s))g(s)\,ds} \ge \frac{\int_0^1 E[q \mid q \ge s](1-F(s))h(s)\,ds}{\int_0^1 (1-F(s))h(s)\,ds}. \tag{24}$$

Define the densities $p(s) = (1-F(s))g(s)/\int_0^1 (1-F(t))g(t)\,dt$ and $q(s) = (1-F(s))h(s)/\int_0^1 (1-F(t))h(t)\,dt$ and let $P(s)$ and $Q(s)$ represent the respective distributions. Because $E[q \mid q \ge s]$ is increasing in s, the above condition holds if $P \succ_{\text{FOSD}} Q$. By the assumption that $G \succ_{\text{MLR}} H$, for all $x < y$,

$$\begin{aligned}
&\frac{g(x)}{g(y)} \le \frac{h(x)}{h(y)} \\
&\iff \frac{(1-F(x))g(x)}{(1-F(y))g(y)} \le \frac{(1-F(x))h(x)}{(1-F(y))h(y)} \\
&\implies \frac{\int_0^y (1-F(x))g(x)\,dx}{(1-F(y))g(y)} \le \frac{\int_0^y (1-F(x))h(x)\,dx}{(1-F(y))h(y)} \\
&\iff \frac{\int_0^y (1-F(x))g(x)\,dx}{p(y)\int_0^1 (1-F(x))g(x)\,dx} \le \frac{\int_0^y (1-F(x))h(x)\,dx}{q(y)\int_0^1 (1-F(x))h(x)\,dx} \\
&\iff \frac{\int_0^y p(x)\,dx}{p(y)} \le \frac{\int_0^y q(x)\,dx}{q(y)} \\
&\iff \frac{P(y)}{p(y)} \le \frac{Q(y)}{q(y)},
\end{aligned} \tag{25}$$

so P reverse hazard rate dominates Q, which implies $P \succ_{\text{FOSD}} Q$ and hence (23) holds. Letting $G = G_{1:N}$ and $H = G_{1:n+1}$, this establishes that $E[Q \mid Q \ge S_{1:n}] \ge E[Q \mid Q \ge S_{1:n+1}]$. Therefore, from (8), the support of a nonlabeling equilibrium is increasing in n.

(ii) By the Glivenko-Cantelli theorem, the empirical distribution $G_n(s)$ of n standards converges uniformly to the theoretical distribution G as n goes to infinity, implying that for any $\varepsilon > 0$, the minimum of these standards is almost surely less than ε in the limit. Hence the expected quality from unexpected labeling converges to $E[Q]$ in the limit, and the necessary and sufficient condition (8) for a nonlabeling equilibrium reduces to $E[Q] - E[Q] \le c$ or $c \ge 0$.

(iii) By the same argument as in (ii), the expected quality from nonlabeling converges to 0 and from labeling converges to $E[Q]$ in the limit as n increases, so the necessary and sufficient condition (7) for a symmetric labeling equilibrium reduces to $E[Q] - 0 \ge c$.

(iv) By the same argument as in (ii), in the limit as n increases a firm meets the worst of the n standards almost surely and expected quality conditional on meeting the standard equals $E[Q]$, so the expected MSE in the labeling equilibrium just equals the variance of F.

(v) For any firm of type q, consider the largest realized standard $\underline{s}$ such that $q \ge \underline{s}$ and the smallest realized standard $\bar{s}$ such that $\bar{s} \ge q$. Given $\underline{s}$ and $\bar{s}$, in a nonlabeling equilibrium, if the firm certifies, then it has expected quality $E[Q \mid \underline{s} \le Q < \bar{s}]$ and if it does not certify, then it still has expected quality $E[Q]$, so nonlabeling is an equilibrium if and only if $E[Q \mid \underline{s} \le Q < \bar{s}] - E[Q] \le c$. By the Glivenko-Cantelli theorem, the empirical distribution $G_n(s)$ of n standards converges uniformly to the theoretical distribution G as n goes to infinity, so for any $\varepsilon > 0$, for any q, $\max\{q - \underline{s}, \bar{s} - q\} < \varepsilon$ for sufficiently large n. Therefore, because $E[Q \mid \underline{s} \le Q < \bar{s}] \in [\underline{s}, \bar{s}]$, for any firm of type q, in the limit $E[Q \mid \underline{s} \le Q < \bar{s}] = q$ almost surely. So the condition for a nonlabeling equilibrium is $q - E[Q] \le c$ for all q, or $1 - E[Q] \le c$.

(vi) Following the same argument as in (v), the condition for a symmetric labeling equilibrium is $E[Q \mid \underline{s} \le Q < \bar{s}] - E[Q \mid q \le \underline{s}] \ge c$ for some q, which converges to $q - E[Q \mid Q \le q] \ge c$ almost surely. Following Lizzeri (1999, Theorem 1), the left-hand side is increasing in q if F is logconcave (Bagnoli and Bergstrom 2005), so this condition is met for some q if and only if it holds for $q = 1$, or $1 - E[Q] \ge c$. □

Proof of Proposition 5. (i) Consider a focal labeling equilibrium in which a firm that does not meet the focal standard instead adopts the highest other standard it meets. The estimation of the focal standard is not affected by the number of standards present on the market, so such a focal labeling equilibrium exists if

$$E[Q \mid Q \ge S] - E[Q \mid Q < S_{1:n}] \ge c \tag{26}$$

and

$$E[Q \mid S_{1:n} \le Q < S] - E[Q \mid Q < S_{1:n}] \ge c. \tag{27}$$

The latter condition is clearly binding and holds for sufficiently low c. In such an equilibrium consumers learn that the firm did not meet even the lowest standard, $Q < S_{1:n}$, or that the firm met the lowest standard but not the focal standard, $S_{1:n} \le Q < S$, or that the firm met the focal standard, $Q \ge S$. In a symmetric labeling equilibrium they learn only that the firm met or did not meet the lowest standard, $Q < S_{1:n}$ or $Q \ge S_{1:n}$. The former partition is finer so it reveals more information.

(ii) Suppose the firm is following a focal certification strategy of always adopting a standard X even if standard Y is tougher. Because consumers know which standard is tougher, this is only possible if consumer beliefs "punish" the firm for choosing Y out of equilibrium. But under our belief refinement, we assume that any type is equally likely to have deviated, so the expected quality of adopting Y is higher and the proposed strategy is not an equilibrium. □

Proof of Proposition 6. (i) Suppose each firm follows the labeling equilibrium strategy of certifying when possible and that k of m firms meet the standard and $m-k$ do not. From the Glivenko-Cantelli theorem, the empirical distribution $F_m(q)$ of m firm qualities converges uniformly to the theoretical distribution F so $\lim_{m\to\infty} Q_{\lceil qm \rceil:m} = F^{-1}(q)$ for any q, where $\lceil x \rceil$ denotes the smallest integer at least as large as x. Hence, the expected value conditional on being in the group of k firms that certify converges to the expected value conditional on having quality $Q_i \ge s$, $\lim_{m\to\infty} \sum_{j=m-k+1}^{m} Q_{j:m}/k = \lim_{m\to\infty} \int_s^1 Q_{\lceil qm \rceil:m}\,dq/(1-F(s)) = \int_s^1 F^{-1}(q)\,dq/(1-F(s)) = \int_s^1 q\,dF(q)/(1-F(s)) = E[Q_i \mid Q_i \ge s]$ for any s. Similarly, the expected value conditional on being in the group of $m-k$ firms that do not certify converges to the expected value conditional on having quality $q < s$, $\lim_{m\to\infty}\sum_{j=1}^{m-k} Q_{j:m}/(m-k) = E[Q_i \mid Q_i < s]$ for any s. Noting that a single deviation from the equilibrium strategy has vanishing impact on the expected value of either group, the limiting condition for each firm to follow the labeling strategy is $E[Q_i \mid Q_i \geq s] - E[Q_i \mid Q_i < s] \geq c$ for any s. The expected support for the equilibrium over the distribution of possible standards is then $c < E[\bar{c}]$, where

$$E[\bar{c}] = E[E[Q_i \mid Q_i \geq s]] - E[E[Q_i \mid Q_i < s]], \qquad (28)$$

which is the same as that for a single firm facing a certain standard.

(ii) Suppose each firm follows a strategy of not labeling. The expected payoff for a single firm is just $E[Q_i]$. If a single firm deviates, then as discussed our belief refinement is that the label is treated as good news that concentrates the posterior distribution of Q_i on $[s, 1]$, where s is distributed according to G. Therefore, the payoff to a single firm from deviating is $E[Q_i \mid Q_i \geq S] - c$, so the equilibrium condition for nonlabeling is

$$E[Q_i \mid Q_i \geq S] - E[Q_i] < c, \qquad (29)$$

which is the same as that for a single firm facing an uncertain standard.

(iii) If the standard is certain then consumers by definition learn nothing about the distribution of standards from which firms adopt which labels. Hence, the equilibrium conditions are the same as in the case of a single firm. $\square$

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