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Certification Mechanisms for Credence Attributes of Foods: Does It Matter Who Provides Diagnosis?

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Abstract

Credence goods markets are subject to failure because consumers are unable to punish fraudulent experts who diagnose and supply treatment, and they lack the technical expertise with which to verify the quality of treatment actually offered. The focus of research in agricultural economics has been almost entirely on how labeling and certification of food products that contain credence attributes resolve the lemons problem. This ignores the crucial role that firms, nongovernmental organizations, or government regulatory agencies, acting either independently or jointly as experts, play in the process of diagnosis and treatment in credence goods markets. This is important if experts fail to act in good faith through their diagnosis and treatment.

INTRODUCTION

Sexton (2013) notes that there has been a significant increase in demand over recent decades for the provision of a range of attributes in food products, many of which cannot be verified either ex ante or ex post by consumers. These attributes, which are typically interpreted as representing higher-quality products, reflect a range of consumer preferences for food and related products. For example, they meet dietary requirements (low sodium); cover food safety (pesticide residues) and ethical production concerns (animal welfare); satisfy the right-to-know about food production methods (genetic modification) and their location (geographic indicators); and contribute to resolving known externalities associated with food production (shade-grown coffee) and marketing arrangements that promote better trading conditions for marginalized producers in developing countries (fair trade). Food products that contain these types of attribute and create a severe asymmetric information problem are part of a broader class of goods known as credence goods.

In the economics literature, the term credence good refers to a situation in which consumers are never able to discover how much of the good they actually need or to establish the quality of the good even after consumption (Emons 2001). Importantly, sellers not only provide the good to consumers, but they also act as experts who determine the needs of consumers. As pointed out originally by Darby & Karni (1973) and discussed at length in Dulleck & Kerschbamer (2006), there is considerable potential for fraud when experts have an incentive to exploit informational asymmetries at both the diagnosis and treatment stages in markets for credence goods. The canonical example of this is an expert, for example, a doctor (car mechanic), who diagnoses a medical (mechanical) problem and provides treatment (repairs). The problem facing the consumer is that they have insufficient information to judge whether the diagnosis is actually correct and also whether they have actually received the appropriate level of treatment. In other words, experts know more about the type of good that a consumer needs (diagnosis) and may exploit that informational asymmetry by defrauding the consumer in terms of the quality of the good actually provided (treatment).

With an increased presence of credence goods in the food sector, an evolving body of literature focuses on analyzing their market and welfare-economic impacts. Some of these studies include, inter alia, Bonroy & Lemarié (2012), Caswell & Mojduszka (1996), Marette et al. (1999), McCluskey (2000), Roe & Sheldon (2007), Segerson (1999), and Zago & Pick (2004). The analysis presented has focused almost exclusively on the treatment stage of credence goods and how third-party certification and labeling may be used to ensure that consumers are not cheated on claimed food product quality. In other words, consumers are assumed to have full knowledge in forming their preferences about quality (the diagnosis is correct), but they are unable to verify quality both before and after consumption (they may get the wrong treatment). Over this entire time, they ignore the possibility that firms or other agents may either defraud or deliberately mislead consumers because the latter have insufficient information to judge whether they needed the claimed quality in the first place.

For many credence goods, expert claims are part of the normal marketing process, where the impact on consumers of an incorrect diagnosis is likely minimal. For example, claims are regularly made by independent experts about the quality of specific wines, based on where the wine is produced and the grape variety used. Certification occurs via labeling regimes, such as France's Appellations d'Origine Contrôlées (Hadj Ali & Nauges 2007, Swinnen 2017). However, a consumer experiencing the recommended wine may simply decide that it is not to their taste and will not drink it again; i.e., there is little cost of an incorrect diagnosis and subsequent treatment.

In the case of market failures associated with food production, presenting the correct diagnosis may be critical to their resolution. This is especially true when the diagnosis stage is the outcome

of explicit interaction between firms and other agents, the latter including regulatory agencies and nongovernmental organizations (NGOs). This may result in the correct diagnosis by firms and these other agents but with different levels of proposed treatment (Baron 2011). One example is interaction between the tuna industry, the US government, and environmental NGOs concerning the protection of dolphins whose population was declining and the eventual use of certification of a credence attribute through application of the dolphin-friendly label (Körber 1998). Here, the diagnosis and recommended treatment were correct: Too many dolphins were being killed incidentally in the process of commercial tuna fishing. The appropriate treatment was a significant reduction in such deaths and certification that tuna purchased by consumers in the United States was caught through dolphin-friendly fishing methods.

For nutritional dimensions of food and their relationship to human health, the role of doctors as experts is often assumed by the government acting on the advice of nutritional experts. For example, since 1980, the US government has provided nutritional advice to consumers through publication of the US Dietary Guidelines for Americans. Issued every five years, the Dietary Guidelines Advisory Committee, composed of 11–15 nutritional experts, evaluates current science to make nutrition recommendations that promote human health and reduce incidence of disease. The development and implementation of such guidelines by the government necessarily represent the diagnosis stage of credence goods for consumers as they make their consumption choices. For example, excess sodium consumption can increase blood pressure and the risk of heart disease and stroke, the latter being the most significant cause of mortality among the US population (Kochanek et al. 2009). Given the presence of sodium in many food products, the current US Dietary Guidelines recommend that the US population consume less than 2,300 mg of sodium per day. Combined with the mandated label indicating sodium content per serving of any US food product, this suggests provision of the correct diagnosis, and treatment does matter in the case of nutritional characteristics of food products.

However, such interaction between the government and nutritional and health care experts may result in an incorrect diagnosis followed by inappropriate treatment. For example, it has been suggested that the most recent expert report of the Dietary Guidelines Advisory Committee failed to consider all the relevant scientific evidence related to saturated fats and the effect of low carbohydrate diets because members of the committee had potential conflicts of interest (Teicholz 2015). In other words, diagnosis provided by experts concerning a healthy diet, signaled to consumers through a mandated label, may either be incorrect or at least slow to adapt to new scientific findings.

It may even be the case that self-appointed experts can add noise to diagnoses from acknowledged experts. For example, consumption of gluten, a protein found in wheat, barley, and rye and commonly found in bread, pasta, and other processed foods containing these grains, triggers celiac disease in 0.71% of the US population (Rubio-Tapia et al. 2012). The recommended treatment for those diagnosed with the disease is a totally gluten-free diet. Prior to 2014, labeling of food products as gluten free was voluntary, but in 2013, the US Food and Drug Administration (FDA) finalized a standard definition of gluten free, to which all food manufacturers had to comply after August, 2014.

For the small percentage of actual sufferers from celiac disease, there is a clear diagnosis offered by the medical profession, and a regulatory agency has stepped in to ensure that a credence characteristic is labeled appropriately. However, a growing number of the US population, encouraged by articles in popular media and elsewhere, have self-diagnosed as gluten sensitive (Kim et al. 2016), even though there is no scientific evidence that gluten poses any health risk to them. Unfortunately, there are risks associated with the growing popularity of a gluten-free diet: Diagnosing celiac disease becomes harder due to the lack of biomarkers in the blood by which the

disease is typically detected. Therefore, reducing consumption of whole grains may increase the risk of heart disease, cancer, diabetes, and other diseases. In addition, consumers who currently self-diagnose but later reject a gluten-free diet potentially generate negative spillovers to those actually diagnosed with celiac disease if the availability and range of gluten-free food products is then significantly reduced (Worosz & Wilson 2012).

The preceding discussion suggests that, in many instances, it does matter who provides diagnosis for credence attributes of foods. In this context, the purpose of this article is twofold: (*a*) to review some of the main findings in the agricultural economics literature concerning the economic effects of labeling and certification of food products with credence attributes and (*b*) to consider whether it matters who provides the diagnosis and treatment associated with credence attributes when the consumer knows what treatment they actually get due to labeling and certification. The remainder of the review proceeds as follows. First, it presents an outline of how credence goods have been analyzed in the economics literature. Second, the article selectively reviews some key findings in the agricultural economics research literature concerning credence goods. Third, some issues related to diagnosis in the case of credence attributes in food are described and discussed.

CREDENCE GOODS

In his original classification of goods, Nelson (1970) introduced the concept of search and experience goods to the economics lexicon. Consumers are able to establish the quality of the former ex ante through search, whereas consumers can only establish quality ex post among the latter. In the case of experience goods, asymmetric information may result in market failure: Absent credible signals by firms or the offer of quality guarantees, consumers expect to be cheated if firms make claims of high quality, when only low-quality goods are supplied in equilibrium, i.e., in a market for lemons (Akerlof 1970). An extensive literature has evolved to analyze circumstances under which experience goods are supplied in equilibrium; the seminal articles are those by Allen (1984), Bagwell & Riordan (1991), Klein & Leffler (1981), Riordan (1986), and Shapiro (1983), which focus on mechanisms such as credible reputation building, price signaling and repeat purchase, and the role of informed consumers.

Darby & Karni (1973) added credence goods to Nelson's (1970) classification, spawning a literature extensively reviewed by Dulleck & Kerschbamer (2006, p. 5), who define credence goods as

> a situation where an expert knows more about the type of good or service the consumer needs than the consumer himself. The expert seller is able to identify the quality that fits a customer's need best by performing a diagnosis. He can then provide the right quality and charge for it, or he can exploit the informational asymmetry by defrauding the consumer.

This type of information asymmetry gives rise to two specific market inefficiencies: over (under) treatment, where the consumer requires a complex (simple) treatment but instead receives a simple (complex) treatment; and overcharging, where a consumer receives a simple treatment but is instead charged for a complex treatment. Dulleck & Kerschbamer (2006) list three conditions under which market mechanisms will discipline experts from acting fraudulently: (*a*) expert sellers face a set of homogeneous consumers; (*b*) there are economies of scope between diagnosis and treatment, and consumers proceed with the recommended treatment after diagnosis; and (*c*) treatment is verifiable ex post, and/or liability rules exist to protect consumers from receiving simple treatment when complex treatment is required.

In their review, Dulleck & Kerschbamer (2006) use a simple model structure to highlight the information problems endemic to markets for experts' services and also to rationalize the majority

of key results presented in the literature once conditions *a–c* are successively relaxed. On the basis of their notation, the typical credence goods game has the following structure: On the supply side, there are $n \geq 1$ risk-neutral experts, where each expert can serve many consumers, $i = 1, \ldots, n$, and experts simultaneously post prices $\underline{p}_i$ and $\bar{p}_i$ for the simple and complex treatments, respectively. Each expert earns a profit consisting of total revenue minus the costs of treatment actually provided, where $\underline{c}$ and $\bar{c}$ are the costs of supplying the simple and complex treatments, respectively. On the demand side, there is a continuum of risk-neutral consumers, where ex ante, consumers know that they have a problem requiring treatment, where h is the probability that they need complex treatment. On consulting an expert, each consumer incurs a diagnosis cost d, and if they accept treatment, their net payoff is $u - p - d$, where $u \in [v, 0]$ and $p \in [\underline{p}_i, \bar{p}_i]$, v being the consumer's utility if the treatment provided is sufficient.

In its simplest form, a single expert ($n = 1$) seeks the patronage of a single consumer; the variables v, h, $\underline{c}$, and $\bar{c}$ are known to both players, and the expert offers prices $\underline{p}$ and $\bar{p}$, respectively. The game then proceeds as follows: (*a*) The consumer observes prices p and decides whether to visit the expert; (*b*) if the consumer visits the expert, nature randomly determines the nature of their problem; (*c*) the expert then diagnoses the consumer, and in so doing, learns the consumer's problem and recommends either the simple or complex treatment; (*d*) the consumer can then reject or accept the recommended treatment, and if they accept, the expert provides some type of treatment and charges for the recommended one. By extending the game to many consumers and many experts ($n > 1$), where h is the fraction of consumers who require the complex treatment, consumers observe posted prices p and decide whether to seek a diagnosis from an expert and from which expert. Payoffs now allow a consumer to reject the diagnosis of one expert and seek (a) second opinion(s), the cost being rd, where r is the number of experts visited. When consumers are committed to accepting treatment, the solution to the game is subgame perfect, but if they decide to seek a second diagnosis when uncertain about whether the initially prescribed treatment is correct, the game has a perfect Bayesian equilibrium.

Dulleck & Kerschbamer (2006) show that if conditions *a–c* do hold, credence goods are provided efficiently, with the markets solving the problem of fraudulent experts at no cost. Specifically, in equilibrium, each expert posts and charges prices such that the markup for the complex treatment is lower than that for the simple treatment, $\bar{p} - \bar{c} \leq \underline{p} - \underline{c}$. Verifiability prevents overcharging; the expert cannot claim that complex treatment has been provided when in fact simple treatment was provided. Liability prevents undertreatment; i.e., the expert cannot provide simple treatment when the consumer needs complex treatment. The incentive to overtreat is addressed by the fact that price-cost margins are higher for simple treatment.

Interestingly, most of the literature assumes that either the liability condition or verifiability holds in the analysis, while relaxing conditions *a* and *b*. There are several main effects of doing so. First, in the case of a single expert, if consumers are heterogeneous in terms of their expected cost of efficient treatment, and there is no liability condition, price discrimination occurs (Dulleck & Kerschbamer 2007). Essentially, the complex diagnosis and appropriate treatment are offered to consumers with a low expected cost of treatment, whereas consumers with a high expected cost of treatment are induced to consume a complex treatment that is not actually required. Second, suppose there is a rule that fixes prices for complex treatment, but there is no commitment by consumers to buy the complex treatment and no verifiability. In this case, experts may overcharge consumers some of the time in credence goods markets (Pitchik & Schotter 1987). This follows from the fact that recommending the simple treatment guarantees a positive profit, whereas earning a positive profit from recommending the complex treatment when only the simple one is required depends on whether the consumer accepts the diagnosis. Alternatively, with flexible prices and several experts, there will be specialization with duplicate search and diagnosis costs (Wolinsky

1993). This result is driven by the assumption that there are cheap and expensive experts: The former always recommends appropriate treatment, and the latter always recommends complex treatment. If a consumer first visits a cheap expert and is recommended the simple treatment, they accept, but if they are recommended the complex treatment, they then visit the expensive expert and get the complex treatment. In other words, there is no longer any overcharging, as the cheap expert has no incentive to overcharge consumers, but there is costly double advice. With verifiability, specialization disappears as experts set prices closer to costs, such that consumers have less incentive to seek a second opinion.

However, even when conditions *a* and *b* hold, if consumers cannot observe and verify the type of treatment they receive and are unable to punish the expert if they establish ex post that they were undertreated, experts have an incentive to act fraudulently, and the market for credence goods can even break down; i.e., an expert provides low quality and charges for high quality (Akerlof 1970). Specifically, if consumer utility v is sufficiently high, and $n > 1$, each expert charges a constant price $\tilde{p} = \underline{c}$ and always provides the simple treatment (i.e., a lemons market), and if v is too low, the credence goods market does not exist. Of course, if complex treatment has the same cost as simple treatment, $\underline{c} = \bar{c}$, experts have no incentive to act fraudulently. Dulleck & Kerschbamer (2006) suggest that a legal rule could be put in place, requiring that experts be held liable for supplying inappropriate treatment, but proving liability ex post is potentially difficult. Therefore, if punishment of fraudulent experts is ruled out, and reputation-building by experts does not work, then either a complete lack of verifiability of treatment or a lack of technical expertise on the part of consumers to establish verifiability will result in fraudulent behavior by experts.

It is precisely the latter possibility that led Caswell & Mojduszka (1996) to introduce credence goods into analysis of food attributes, such as safety and nutrition, in which the typical consumer is simply unable to verify claimed quality. Thus, it is impractical for them to test, for example, the protein content of food or contamination from food-borne pathogens such as *Escherichia coli*. The proposed solution for this market failure is either government-mandated labeling of credence attributes or circumscription of voluntarily supplied information in combination with third-party certification. Reference is made by Caswell & Mojduszka (1996) to the US Nutrition Labeling and Education Act, which went into force in 1990.

THE ECONOMICS OF CERTIFICATION AND LABELING

Virtually all of agricultural economics analysis focuses on resolution of the lemons problem via labeling and third-party certification, ignoring the role of experts in the provision of credence goods. This literature offers no detailed discussion about who provides diagnosis and treatment in the case of food products, essentially assuming that, as long as labeling resolves the asymmetric information problem, consumers receive the appropriate form of treatment. This ignores the possibility that experts may differ in their ability to perform diagnoses and also that the ability and effort of experts are unobservable by consumers (Dulleck & Kerschbamer 2009, Pesendorfer & Wolinsky 2003). In addition, it is typically assumed that in seeking treatment, consumers know what they want, and the only problem they face is imperfect information regarding the type of treatment they will receive when purchasing a food product (Bonroy & Constantos 2015).

Notwithstanding, the literature has developed to the point where substantive survey articles have reviewed the main findings concerning credence goods labeling and certification (Bonroy & Constantos 2015, Roe et al. 2014) and the impact of labeling on consumers, especially with respect to nutrition labeling (Kiesel et al. 2011). Essentially, the authors of the first two surveys ask the same question: What are the potential economic benefits and costs of credence goods labeling in the food and agricultural sector? Given the greater emphasis of this review on the diagnosis stage

of the credence goods problem, no attempt is made here to replicate the detail of these surveys. Instead, the focus is on some of the main takeaway points from this literature as they relate to treatment, with an emphasis on what is perhaps relevant to a discussion of diagnosis and the role of experts.

Selectively following Bonroy & Constantos (2015), the remainder of this section highlights three issues as they relate to the costs and benefits of labeling of credence attributes in food: (*a*) How might labeling interact with market structure and its associated effects on producers and consumers? (*b*) How does the choice of labeling mechanism affect the treatment level of credence attributes? (*c*) What is the role of NGOs in setting credence goods labels? Importantly, the latter two questions provide a link to the subsequent section that focuses on diagnosis.

Market Structure

To highlight the potential impact of labeling on market structure, the credence goods model developed in a series of articles by Roe & Sheldon (2007) and Sheldon & Roe (2009a,b) is briefly outlined, and some of their key results are discussed. A model of vertical product differentiation originally published by Shaked & Sutton (1982, 1983) shows that consumers have unit demand for a quality differentiated good. Consumers derive the same surplus from a good of a specific quality but differ in their ability to pay. Firms produce a single differentiated product with a technology characterized by zero marginal production costs and a fixed quality–dependent cost, where all firms incur a sunk entry cost irrespective of quality. Firms maximize their profits in a three-stage game. First, firms choose to enter, incurring a sunk cost. Second, firms that have entered simultaneously choose quality, incurring additional fixed costs and then label their quality levels and pay appropriate certification costs. Third, the firms simultaneously set prices following Bertrand-Nash strategies.

Assuming perfect information about quality and a uniform distribution of income with a restriction on the width of that distribution, equilibrium market structure is a natural duopoly consisting of one firm that supplies a low-quality good and a second firm that supplies a high-quality good; there is no credence goods problem. With asymmetric information about quality, the equilibrium market structure collapses to one firm selling the low-quality good. This follows from the fact that if two (or more) firms were to enter, they can only offer the low-quality good at a zero price because of Bertrand-Nash competition, thereby making a loss due to sunk entry costs. Consequently, the perfect equilibrium of the game is when one firm enters and sells the low-quality good at the monopoly price. If labeling and certification of the high-quality good are the only policy instruments available, they have the potential to resolve the market failure due to imperfect information as well as to mitigate the monopoly distortion. Labeling of the high-quality good allows a second firm to enter the market, with consumers getting a greater choice of goods, and Bertrand-Nash duopoly drives down prices, thereby raising consumer welfare.

As Bonroy & Constantos (2015) point out, this latter result is sensitive to the assumption that sunk costs are incurred upon entry, ensuring that only one firm enters without labeling. In the absence of sunk entry costs, the authors assume that only two firms survive in the market with or without labeling, with one producing high quality and the other producing low quality. In this case, introducing a label turns the market from a homogeneous product duopoly, with both firms pricing at zero marginal cost, to a differentiated product duopoly, where the firm selling the high-quality good raises the price, thereby lessening competition on the firm selling the low-quality good who also raises the price. In this case, both firms benefit from labeling, while consumers at the lower end of the income distribution now consume the low-quality good at a higher price, foregoing the 50/50 chance they previously had of obtaining the high-quality good at a lower price

under asymmetric information. In this case, the single-policy instrument of labeling resolves the credence goods market failure but introduces a duopoly distortion. Of course, if market structure is instead assumed to be one of monopoly, it is well known that a firm can also utilize quality differences to exercise second-degree price discrimination (Maskin & Riley 1984, Mussa & Rosen 1978, Varian 1989). Therefore, labeling allows the firm to widen the range of qualities it offers, and with an appropriate pricing scheme, it can effectively discriminate between consumers.

These types of result are rather common in the extant agricultural economics literature on credence goods, which typically assumes imperfect horizontal and vertical market structures. For example, Zago & Pick (2004) draw on the approach to vertical product differentiation of Mussa & Rosen (1978) and establish that labeling and certification may not be welfare enhancing if the market for the high-quality good becomes less competitive. Following Gabszewicz & Grilo (1992), Bonroy & Constantos (2008) assume that the basis for product differentiation is one in which consumers have subjective beliefs about which firm supplies low as opposed to high quality, such that when labeling and certification are introduced, depending on costs, only one firm survives in equilibrium. There is reverse differentiation that may actually be resisted by both firms.

Finally, Bonroy & Lemarié (2012) consider a vertical market structure consisting of two upstream firms selling an intermediate input to a continuum of firms downstream who process the input into a final food product. Key to the analysis is that downstream firms are ranked by cost efficiency, and therefore their preference for more productive intermediate inputs is also ranked. However, such inputs may not be ranked in the same way by consumers, for example, genetically modified (GM) ingredients. Labeling results in consumers' ability to choose food products based on the inputs used, such that vertical product differentiation is created in the downstream market (GM versus non-GM inputs), which reduces price competition upstream. At the same time, downstream firms may switch their ranking of intermediate inputs. The net effect is that for the high-quality non-GM supply chain, the differentiation and ranking effects push up both intermediate input and final product prices. In contrast, these effects work in opposite directions for the intermediate input in the low-quality GM supply chain; thus, differentiation pushes up its price, whereas the ranking effect lowers it. This outcome also suggests an interesting result: Upstream firms produce an intermediate GM input that has been considered safe by one set of experts, but downstream firms also acting as experts offer a food product that contains non-GM intermediate inputs.

This discussion highlights two important features of the literature examining market structure and labeling. First, as is typically the case in industrial organization analysis, the range of results from introducing labeling and certification is very sensitive to the underlying assumptions of the modeler. Second, when there are multiple market failures (imperfect competition and asymmetric information), but there are constraints on the number of available policy instruments (labeling only), the welfare outcomes have to be set in the context of the theory of second best. Solving the asymmetric information problem through labeling and certification may or may not mitigate the distortion due to imperfect competition.

Labeling and Treatment Level

The result derived by Roe & Sheldon (2007) that labeling and certification of a credence good will generate the same equilibrium as under perfect information turns out to be quite sensitive to the institutional details of labeling, a point also emphasized in the reviews by Roe et al. (2014) and Bonroy & Constantos (2015). For example, in comparing public to private labeling, the latter review carefully lays out the circumstances under which an industry will under- or overprovide quality (treatment) as compared to the socially optimal public level. For example, drawing on

Spence (1975), it is shown that if the marginal willingness to pay for improved quality diminishes, the demand effect may result in a monopoly firm setting a standard lower than the social optimum. By contrast, in a duopoly setting, where labeling allows for product differentiation and a decrease in price competition, the firm selling the high-quality good has a strategic incentive to seek a higher standard than is socially optimal, given that a social planner would have an incentive to set a lower standard to increase price competition if they are unable to regulate firms' prices. Drawing on Motta (1993), it is shown that the demand effect can outweigh the strategic effect, with the private standard being less than socially optimal.

In the same vein, Sheldon & Roe (2009b) evaluate public versus private standards in an international setting where two developed economies agree to harmonize their mandatory environmental credence goods labeling regulations. If the authorities have exclusive authority to certify and label a discrete level of environmental quality, they risk pushing out the high-quality good if the harmonized standard is too high or too low to yield positive profits for the firm producing that good, thereby lowering aggregate environmental benefits. If, however, private certification is also permitted, the welfare gains from economic integration are maximized if regulators permit private certification of a standard different from the harmonized standard-private certification, thus lowering the risk that a higher-quality good is pushed out of the market if public environmental standards are set too low or too high. It should be noted that, with mutual recognition of standards, one country's standard may already be closer to what is privately optimal for a firm to supply the higher-quality good.

Sheldon & Roe (2009b) also extend their analysis to the case in which both a developed country and developing country consider economic integration, such that their joint income distribution is wider than for each individual country under autarky, and with perfect information, three goods are viable in equilibrium: low, medium, and high quality. If the authorities have exclusive authority to certify and label a discrete level of environmental quality, they risk pushing out either one or both of the medium- and high-quality goods, which may also lower aggregate environmental benefits. Again, private certification has the potential to prevent this outcome.

The latter results also have implications for the so-called "race to the bottom" in environmental standards. In the absence of any environmental credence goods regulations, only the low-quality good is produced in equilibrium, and de facto, standards never leave the bottom. In contrast, once there is mandatory labeling, as long as private certification of discrete labeling is permitted, there will be no race to the bottom. This is because firms have an incentive to produce higher than minimum environmental-quality goods in equilibrium. Thus, even if the regulatory authorities harmonize down environmental standards in a race to the bottom, private certification ensures that increased aggregate environmental benefits are still realized.

These results hint at the possibility that the level of treatment offered in credence goods markets is sensitive to who is acting as the expert. In particular, depending on their incentives, firms acting as experts may choose to privately label and certify credence attributes at a lower or higher level than a regulator acting as an expert would. The latter outcome also suggests that, if private certification is permitted, firms might also act to raise quality either to establish a reputation for corporate social responsibility or because they come under external pressure from NGOs.

NGOs and Credence Goods

NGOs have become increasingly active with respect to provision of credence attributes in food products (Baron 2009, 2011). Typically, NGOs are confined to organizations advocating stricter standards with respect to negative externalities in either food production or consumption, but there are also NGOs promoting other credence attributes in food, such as the ethical treatment of

animals. Fedderson & Gilligan (2001) examine the impact of an information-supplying activist on outcomes in a credence goods market where consumers care about the operating practices of firms operating in a duopoly. Their model assumes that activists randomly monitor the specific operating characteristics of one firm, where these are neither good or bad nor observable to consumers. Through monitoring, activists learn that firm's quality choice and then signal that knowledge to consumers who then make their purchasing decision. Activists can support an equilibrium where at least one firm supplies the high-quality good, even though consumers cannot observe quality even after consumption. In addition, depending on the degree of substitutability between goods, activists can support equilibria where both firms supply high quality, or low- and high-quality goods are supplied. Therefore, activists may improve the workings of a credence goods market, although as Fedderson & Gilligan (2001) point out, information-supplying activists do not necessarily guarantee a socially optimal outcome.

NGOs may also operate in a setting where government is involved in standard setting. Heyes & Maxwell (2004) examine the impact of an NGO in a competitive market where government sets a mandatory minimum standard, and the NGO can confer a label on firms that voluntarily conform to their standard. Without third-party certification, only the low-quality good is supplied, with the latter surviving in equilibrium if an NGO sets a voluntary standard. By comparison, a mandatory minimum standard ensures that only a single quality can survive in equilibrium. It is shown that the voluntary label is more attractive to firms than the minimum standard; the average quality is higher under the minimum standard, although it is ambiguous which instrument is socially optimal. Given this result, Heyes & Maxwell (2004) show that a minimum standard is optimal when combined with a voluntary standard set by the NGO.

If private labels set by firms are lower than minimum quality standards set by the government, which in turn are lower than voluntary standards set by NGOs, there is the potential that the actual standards implemented will be the outcome of a political-economic game (Bonroy & Constantos 2015). In the Heyes & Maxwell (2004) setting, firms may resist both minimum and voluntary quality standards if it reduces their profits, such that government reduces the minimum standard to increase the chance of it being implemented. By contrast, if the voluntary standard already exists, it may reduce resistance by firms to reduction of the minimum standard.

Alternatively, if the industry initially sets a standard and the NGO then pushes to increase the standard, Baron (2011) shows that the industry standard will be higher than in the absence of pressure from the NGO. In this model, firms can produce either a low-quality good or a high-quality good with credence attributes, with the standard set by an industry credence organization and credibly certified by a third party. The level of the standard is a function of the number of firms in the organization, and once collectively set, these firms compete in the high-quality segment of the market, whereas firms outside the organization sell the low-quality good. Preferences for the credence attribute are drawn from a uniform distribution of consumers. Baron (2011) models the problem as a four-stage game. First, the NGO demands that the industry set a standard, after which the credence organization sets a standard. Second, the NGO directs social pressure on the organization. Third, the NGO and its target organization contest a campaign. Fourth, given the outcome of the campaign, there is Cournot-Nash competition in the product market.

There is a trade-off for the credence organization: A higher standard decreases the chance of a successful NGO campaign, but a higher standard also reduces profits if the NGO campaign fails. This results in the credence organization setting a standard that lies between what would be optimal in the absence of an NGO campaign and what the NGO seeks in a standard. This optimal standard increases in the strength of the demand of the NGO, the strength of public sentiment for the NGO's campaign, and the size of the market and strength of preferences for the credence

good. It decreases in the fixed costs of supplying high-quality goods and the marginal costs of meeting the credence standard.

A key point about the political economy view of standards is that it highlights how relative political power between firms and NGOs may determine which type of standard is set to resolve the credence goods problem. It also assumes that if the government participates as a social planner, it always seeks to maximize social welfare, ignoring the possibility of regulatory capture. This also reinforces the argument made earlier that more attention should be given to who the experts are and how they influence the level of treatment embodied in credence goods.

DIAGNOSIS AND TREATMENT

Several features of the game outlined the section titled Credence Goods can be adapted to the case of food: Consumers face firms selling food product(s) at various prices, where the treatment offered is a labeled and certified credence characteristic(s); consumers may be uncertain about the claimed benefits of the treatment and seek diagnosis from an expert; and the expert and supplier of treatment may either be the same agent or separate agents. For example, a non-GM food product supplied by a food firm is an example of the first situation, whereas a food product with low-sodium content is an example of the second one, where nutritional scientists acting as expert(s) advise consumers that a low-sodium diet is beneficial, and the treatment is supplied by a food firm.

This section focuses on whether it might matter who provides diagnosis in the case of food products with credence attributes. Specifically, two contrasting cases of firms providing the relevant diagnosis are presented. In the first case, a reduction of externalities is associated with food production where both firms and NGOs may interact as experts to provide a diagnosis to consumers. In the second case, firms supply the treatment, novel foods, and production methods where regulators are potentially subject to capture by expert firms. Motivation for the former situation draws on the case of Starbucks and how it has collaborated with NGOs on selling and promoting fair-trade coffee beans (Argenti 2004). The latter scenario draws on the case of aspartame, which was eventually approved for commercial release, despite a report by the FDA indicating that the firm G.D. Searle misrepresented the carcinogenic effects of the artificial sweetener and held back incriminating evidence from the FDA (Iuliano 2010).

Corporate Social Responsibility, Credence Goods, and NGOs

In examining the influence of NGOs in credence goods markets, Fedderson & Gilligan (2001) assume that firms passively react to activist behavior. In contrast, in Heyes & Maxwell (2004), interaction between firms and NGOs affects the extent to which firms will resist standards set by government. However, this ignores the possibility that firms may actually choose to supply credence goods due to some sense of corporate social responsibility (Baron 2001, Siegel & Vitaliano 2007). Firms engage in an environmentally friendly production activity that goes beyond what is required by law.

Baron (2009) develops an approach to this possibility accounting for corporate social performance: the private provision of public goods, motivated by either a sense of moral duty or self-interest on the part of firms, and which may be either voluntary or a response to external influence. The latter could come from public politics in the form of government regulation (Maxwell et al. 2000) or from private politics, when private parties such as NGOs, funded by private citizens, seek to influence other private parties such as firms (Baron 2003).

Baron (2009) assumes a setup comprising a continuum of citizens, two firms, and an activist. Citizens make both consumption and investment decisions and may also contribute to the activist.

One firm is morally motivated, mitigating an externality ex ante, even if this does not maximize its market value. Thus, the costs of moral management are not necessarily fully offset in either the product or capital market; if they were, then all firms would act morally. A second firm is self-interested and will only mitigate an externality to maximize its market value. The activist prefers greater mitigation of the externality than the morally required response, as they care about any remaining harm being borne by citizens. The model generates an equilibrium for the product market, the market for social pressure, and the capital market, the last of which prices moral management and corporate social performance.

Focusing on the product market, both firms produce identical products that can be vertically differentiated under Bertrand-Nash competition through corporate social performance, given that citizens have preferences for reduction in a production externality, a credence attribute. In equilibrium, the morally managed firm produces the higher-quality good at a higher price for citizens who have a high valuation of corporate social performance, whereas the self-interested firm sells a lower-quality good to consumers with a low valuation of corporate social performance. Whether the morally managed firm is more profitable depends on the difference in marginal costs of low- and high-quality production and the price premium and whether most citizens have a preference for corporate social performance.

Interestingly, Baron (2009) is able to rationalize why a firm such as Starbucks, which had already established a reputation for corporate social responsibility in the 1990s, was threatened with a boycott in 2000 by the NGO Global Exchange if they did not sell and promote fair-trade coffee (Argenti 2004). By introducing a parameter measuring whether consumers distinguish in the product market between ex ante and activist-induced corporate social performance, Baron (2009) can predict who will be targeted by activists. If consumers do make the distinction, a morally managed firm will avoid external pressure only if it has built up a reputational advantage over the self-interested firm. If no distinction is made, morally managed firms become softer targets for activists and are more likely to be subject to external social pressure. In other words, a firm exhibiting corporate social responsibility acts as an expert in providing the correct diagnosis, the level of which may be affected by external pressure from NGOs that are also acting as experts.

Novel Foods and Production Methods

In many countries, food products that are considered novel due to the product itself, an ingredient, or the food production process, and that may or may not be harmful to consumers, are evaluated by a regulatory agency prior to their commercial release. Obviously, if the regulator has perfect information about a novel food that it is presented for evaluation and also acts in the best interests of the consumer, the diagnosis stage is straightforward. Thus, only safe novel foods will be permitted for commercial release, and the credence goods problem collapses to the treatment stage whereby any claimed benefits of the novel food will be certified and labeled accordingly. Two things militate against this outcome. First, the complexity and extent of innovations mean that firms seeking approval for their novel foods will necessarily be experts at the diagnosis stage. Second, regardless of whether the regulator is well informed about novel foods, there is always the possibility that they will be subject to regulatory capture in the approval process. Importantly, if there are economies of scope between the extent of innovation by firms and the degree of influence they can exert over the regulator, there is clear potential for what has been termed deep capture of the regulator, which is distinct from shallow capture (Hanson & Yosifon 2003).

Prior to Stigler (1971), the presumption of a public interest theory of economic regulation was that a benevolent social planner would behave as a rational actor, and their preferences for regulatory outcomes and other economic policy choices were consistent with the public interest. Stigler's

(1971) contribution drew from his observation that firms may have an incentive to seek regulation and that politicians are willing to supply that regulation if it allows them to maintain or augment their power. A problem with this approach is that it applies broadly to a class of political economy problems involving rent seeking and is not very specific to the notion of regulatory capture. It also has two key methodological limitations. First, because the approach ignores informational asymmetries, regulated firms are unable to extract rents and therefore have no incentive to try to influence regulators; i.e., there is no agency problem. Second, the supply side of policies is a black box, ignoring the agency relationship between the government and appointed regulator (Laffont & Tirole 1993).

Introducing an explicit regulatory body in a principal-agent setting allows for the idea that a political principal wants to manage the possibility that an agent (the firm) may have an incentive to capture the regulator (Bó 2006). In the credence goods setting, a firm in the food industry (the expert) seeks approval of a novel food (diagnosis) from a regulatory body such as the FDA. There are two key components in such a setting. First, a firm has private information about the novel food, so that there is uncertainty about its properties. Because consumers may value the innovation, and there is a positive probability that the product is truly novel, it is possible that the contract offered to the firm will allow them to capture rents, when in fact, the product is not actually novel. Second, because of the information asymmetry, the government has appointed the FDA as a regulator (supervisor), whose function is to specialize in learning as much as possible about the extent of the firm's novel product. The problem facing the principal (government) is that the agent (firm) has an incentive to bribe the regulator (supervisor) into not revealing when their product is not innovative, with the amount of the bribe being just equal to the value of the informational rent. Of course, actual bribes are typically illegal, but they do not have to be explicit for regulatory capture to occur. For example, financial ties between members of FDA advisory committees and the firm(s) seeking approval may bias the recommendations of such committee members in favor of approval of a novel food, even if they have information/concerns about the potential for the novel product to be either unsafe or not as novel as claimed (Camara & Kyle 2015). There may also be revolving doors, whereby regulators may bias their decisions to enhance their chances of future employment in the very industry they are regulating. Essentially, the public concern is that there may be a conflict of interest on the part of the regulator (Che 1995).

Hanson & Yosifon (2003), however, suggest that this is only part of the story. Specifically, they make a distinction between shallow and deep capture. Key to understanding the difference are the concepts of dispositional attribution and situational influences. The former explains behavior in terms of the internal characteristics within an individual, as opposed to situational influences external to that individual. In other words, regulators are not motivated to serve the public interest; rather, they are subject to external influences and therefore subject to capture. To use the language of social psychologists, the notion of regulators as benevolent social planners is subject to the bias of fundamental attribution error.

Members of advisory committees appointed by regulatory agencies may have incentives to collude with firms from the industry that they are regulating, and this is denoted as shallow capture. Specifically, this is assumed to mean that members of advisory committees may learn about the actual safety of novel food products, but due to conflicts of interest, they will not always reveal that information to the regulatory agency. As a result, unsafe food product innovations can enter the market, reflecting incorrect diagnosis and treatment.

Deep capture is when firms seek to influence institutions beyond the regulator, including the media, public education, and academic research, to ultimately influence the broader public. This definition has already found traction in an early application in agricultural economics by Smith & Tasnádi (2014) in their analysis of how the US food industry has attempted to influence the public

debate concerning the causes of obesity. Here, deep capture is assumed to mean that firms will present biased information in their applications for approval of novel foods in an effort to nudge members of the advisory board. Once approved, firms will continue to disseminate this biased information to influence consumers and other groups who maintain an interest in the safety of novel foods.

The regulatory and influence structure is as follows. The government sets the rules for the regulatory body and any advisory committees they employ. For example, a novel food may be presumed unsafe until studies show otherwise, and a standard is then applied for approving that novel food for commercial release. Alternatively, a novel food may be generally regarded as safe, unless evidence presented suggests otherwise. At this point, it is assumed that the government itself is not subject to capture due to the lobbying activities of the firm, consumers, or other interest groups who may have an interest in the rules and standards applied for approval of novel foods. There is potential for shallow capture of the advisory committees due to members' conflict of interest. In other words, the committee member may either vote for approval of a novel food product if they have a financial tie to the firm sponsoring that product, or they may vote against approval of that product if they have a financial tie to an incumbent firm with a competing product (Lurie et al. 2006).

The advisory committees are also subject to deep capture by the firms whose novel foods they evaluate for approval. Treating presentation of the information as the diagnosis stage for a credence good, the innovating firm is assumed to be the expert. The innovator knows more than the advisory committee about its product, such that the novel food actually meets claims made about it and is safe. Essentially, innovations are novel by definition, and experts hold asymmetric information about their innovations. As a consequence, food firms expend resources to nudge the regulator into approving their novel food product by providing biased information to advisory committee members.

Deep capture occurs because the advisory committee members, given their existing knowledge of food products and the biased information they receive from firms, are subject to fundamental attribution error when approving novel food products that might actually prove harmful to consumers: They believe they are making the correct decision based on their disposition to act in the public interest, when in fact, they are subject to situational influence. In addition, the cost of deep capture falls with the extent of innovation by firms; there are economies of scope between innovation and influence. The more novel a food product is, the more complex is its diagnosis stage. The less skilled advisory committees can seek a second opinion, and the system is therefore committed to moving to the treatment stage.

Sheldon et al. (2015) consider how members of an advisory committee might be captured by an expert firm. The firm submits data b to the regulatory agency concerning the quality and safety of its novel food i in application a, for which it is seeking approval. The regulatory agency initially conducts an internal review of these data, which it may then refer to an advisory committee of scientists who have some knowledge of the field relating to the novel food. After presentation of these data, the advisory committee members vote for or against approval of the application. The regulatory agency then follows the recommendation of the advisory committee on whether the novel food can be commercially released.

A useful approach to analyzing the voting behavior of members of an advisory committee draws on the analysis of Iaryczower & Shum (2012) on the voting behavior of US Supreme Court judges, which has been adapted and applied to voting behavior of FDA advisory committees on new drug applications (Camara & Kyle 2015). An advisory committee comprises a set of scientists who have to vote on novel food applications. For each application, a committee member can vote for or against approval, $\upsilon \in \{0, 1\}$; $\upsilon = 0$ is a vote against approval, and $\upsilon = 1$ is a vote for approval.

The advisory committee then aggregates the votes of all committee members by a rule such as majority rule.

Prior to voting on an application, each committee member observes a private signal, $s = \omega + \sigma\psi$, where $\psi \sim \mathrm{N}(0, 1)$. The unobservable variable $\omega \in \{0, 1\}$ indicates the correct decision about the safety of a novel food, i.e., the correct decision that it is safe, $\omega = 1$, and the correct decision that it is unsafe, $\omega = 0$. The scale parameter $\theta = 1/\sigma$ measures the information content of the signals received by a committee member. In addition, $\rho \equiv \Pr(\omega = 1)$ is the common prior probability of state ω.

Each committee member cares about the information contained in the signal, as their payoffs are state dependent. Specifically, it is assumed that, given the ideological beliefs of a committee member about novel foods, $\pi \in (0, 1)$, their payoff depends on both the correct decision about a novel food, ω, and their actual vote on the application for approval, υ. Specifically, there are two possible negative payoffs to a committee member if they get the decision about safety of a novel food wrong. First, the cost to a committee member for recommending an unsafe novel food for commercial release is $-\pi$, given that they vote in favor of the application, $\upsilon = 1$, but the correct decision is actually that the novel food is unsafe, $\omega = 0$. Second, the cost to a committee member of blocking a safe novel food for commercial release is $-(1 - \pi)$, given that they vote against the application, $\upsilon = 0$, but the correct decision is actually that the novel food is safe, $\omega = 1$.

These negative payoffs for an incorrect decision are adjusted to allow for the possibility of conflicts of interest on the part of the advisory committee member; thus, there is the potential for shallow capture. If a committee member has a tie to the firm sponsoring an application, SC, they receive λ for voting in favor of the application, and if they have a tie to a competing firm, CC, they receive κ for voting against the application.

Information E consists of the private scientific information of the committee member, which is subject to influence by the expert firm through b. Assuming initially that there are no conflicts of interest, $\lambda = \kappa = 0$, an advisory committee member will vote in favor of approval of a novel food product if $\Pr(E|\omega = 1) \geq \pi$; i.e., the correct decision is safe. Equivalently, and allowing for conflicts of interest, an advisory committee member will only vote in favor of approval if

$$\lambda SC - \pi \Pr(E|\omega = 0) \geq \kappa CC - (1 - \pi)\Pr(E|\omega = 1).$$

From this model structure, it is possible to make some predictions about the influence of shallow and deep capture on the votes of advisory committee members, and hence the outcome of committee voting. If committee members' beliefs are neutral, $\pi \approx 1/2$, if the common prior is uninformative, $\rho \approx 1/2$, and if the information content of the signal is "good," the scaling parameter θ is high, and there are no conflicts of interest, $\lambda = \kappa = 0$. The advisory committees will then come to unanimous decisions and be evenly split between approving and rejecting novel foods. This is the case when there is neither shallow nor deep capture. In this situation, committee members are not subject to bribes, and good information is not subject to bias. The expert firm does not try to convince a neutral committee member that their novel food is actually safe when it is in fact unsafe.

If these assumptions are relaxed individually, suppose that committee members have strong ideological beliefs. For example, the class of novel food may contain GM ingredients. The advisory committee member is either predisposed to be in favor of GM ingredients, $\pi \approx 1$, or against GM ingredients, $\pi \approx 0$. In this case, individual committee members will exhibit a lower variability in their votes, voting more consistently for or against the novel food. If there is shallow capture due to conflict of interest, $\lambda > 0$ and $\kappa > 0$, committee members are more likely to vote for the novel food of a sponsor and more often vote against the product of their sponsor's competitor. Finally, if the sponsoring firm supplies biased information to committee members via deep capture

investments, there will be less variability in their voting, and they will more often vote with the majority in favor of approving novel foods.

In terms of policy implications, there are two obvious steps that governments could take in their approach to the supervisory role of regulatory agencies. The first, which comes directly from the orthodox literature on regulatory capture, is to minimize the impact of conflicts of interest, which would exclude FDA advisory committee members with a conflict of interest from voting on novel food applications (Iuliano 2010, Lurie et al. 2006). Second, deep capture might be minimized through removing industry from safety trials through the independent conduct of safety trials (Iuliano 2010). For example, either the regulatory agency itself could act as the expert by employing its own scientists to conduct such trials, or the trials could be outsourced to scientists at universities and other research centers. Of course, the cost of the former option may be prohibitive, and the latter institutions are themselves open to deep capture by experts.

SUMMARY AND CONCLUSION

As defined by the economics literature, credence goods markets are subject to failure due to consumers' inability to punish fraudulent experts diagnosing and supplying treatment and because consumers lack the technical expertise with which to verify the quality of treatment actually offered. Surprisingly, in agricultural economics, the focus of research has been almost entirely on how labeling and certification of food products containing credence attributes will resolve the problem of consumers being charged for high quality when in fact they receive low quality. This ignores the diagnosis stage for credence goods and whether it matters which experts provide the diagnosis.

In this context, this review has focused on three areas: (*a*) the credence goods problem as analyzed in the mainstream economics literature, (*b*) some key findings of the extant literature in agricultural economics on credence goods, and (*c*) the ways in which firms acting as experts may provide the correct (incorrect) diagnosis and treatment to consumers of credence goods under different circumstances. The key conclusion to be drawn is that, by assuming consumers know what they want (complex versus simple treatment) and focusing only on resolution of the asymmetric information problem, agricultural economics ignores the crucial role played by firms, NGOs, or government regulatory agencies, acting either independently or jointly as experts, in the process of diagnosis and treatment in credence goods markets. This is important, given that experts may either act in good faith by seeking to be socially responsible or by trying to influence regulatory agencies. However, in doing so, they may provide diagnoses and treatment that are potentially unsafe to consumers.

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