Lawsuits, regulation and product quality: A fragile balance

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Abstract

When consumers purchase experience goods, typically they cannot observe the effort firms invest in their production, but they may reveal the product quality after purchase. Observing a low-quality product may provide an imperfect signal on the firm's effort, because low-quality may be caused either by malpractice or by chance (even if the firms excel effort). In the case of experience goods, one of the basic goals of government intervention is to prevent malpractice (or induce firms to exert a certain level of effort) in order to reduce potential risks to consumers. In this article, we show that an ex-post government inspection of malpractice may indeed be a useful tool to achieve this goal but not in all circumstances. Specifically, we assume that in the absence of government intervention, consumers who encounter low quality products may discipline firms through costly lawsuits (being compensated only in the occurrence of malpractice). In this framework, we show how adding government inspection may alter the incentives of consumers to pursue lawsuits. Specifically, the reliance of consumers on the government inspection may discourage them from pursuing lawsuits, which in turn, changes the incentive of firms to excel effort. On the one hand, if the government

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inspection is sufficiently effective in detecting malpractice, then firms' effort is guaranteed. On the other hand, if its effectiveness is sufficiently low, then the government intervention basically encourages malpractice because consumers rely on the government to act on their behalf and thereby avoid lawsuits. In this framework, we argue that less information may be somewhat beneficial for the economy in the sense that when consumers are uninformed about how effective the government inspectors are, they entail more discipline on firms through malpractice lawsuits, which may in turn promote high effort by firms.

1 Introduction

This article examines how the incentives of firms to excel effort are affected by the chance that a potential malpractice behavior may be followed by lawsuits or government inspection. We discover that in some cases the chance of being inspected by a government agency may practically encourage malpractice by firms. The reason is that the introduction of government inspection may alleviate consumers' incentives to pursue malpractice lawsuits against firms. On the other hand, when consumers are uninformed about how efficient the government inspectors are, they entail more discipline on firms through lawsuits, and therefore may promote high effort of firms.

In many instances, the information about products is asymmetrically (or disproportionally) distributed between firms and consumers. That is, it is difficult for consumers to assess the product quality before purchase (and specifically, whether products adhere to certain quality standards) in a wide array of domains including vaccinations, therapeutic drugs, food, baby products, cars, and medical treatment, just to name a few. This asymmetric information between consumers and firms naturally entails potential risks to consumers.[1]

[1]To name several examples, home appliances may malfunction and cause damages, and automobile defects may expose passengers to injurious crashes. In the food industry, there is an ongoing debate surrounding the issue of not only the nutritional value of certain products, but also their quality and safety.

Despite the potential risks, people consume these products constantly.

While typically the effort of firms is unobservable to consumers, they may learn the quality of products from experience (for a review on experience goods see Dulleck and Kerschbamer (2006) and Shapiro (1983)[2]). Consequently, based on their experience, consumers may pursue a lawsuit if they suspect malpractice. Alternatively, as many of the markets for experience goods are heavily regulated, consumers may rely on the official authorities to provide the necessary information on the products and investigate malpractice.[3]

To understand the incentives of firms to exert effort (and increase the share of high quality products) in the context of experience goods, our model analyzes the interaction between three players, firms, consumers and a government agency that monitors the product market. First, providers (firms or individuals) choose their level of effort invested in producing goods or services. For example, doctors invest effort when they treat patients. Insufficient effort of doctors, or malpractice, is potentially harmful to their patients, but even if the effort level is sufficient, there is still some probability that the treatment will be harmful.[4]

The second player is consumers (or patients) that purchase products or services and reveal their quality through experience. In the example of doctors, patients discover whether their condition has improved or deteriorated after the treatment. Then, they decide whether to pursue a costly lawsuit for medical malpractice, considering that their lawsuit will succeed (and they will be compensated) only if malpractice indeed occurred. The threat of being sued may encourage doctors to invest sufficient effort when treating patients.

The first two players, providers and consumers, interact with a third player, a government

[2]'Credence goods', on the other hand, are products where consumers, regardless of their experience, never realize their true quality (see the vast literature dating back at least to Nelson (1970) and Darby and Karni (1973).

[3]Dranove and Jin (2010) review the growing volume of literature on the market response to certification and quality disclosure programs. These programs provide systematic information about the quality and safety in specific markets, including, for example, restaurant hygiene grade cards (Jin and Leslie, 2003) and nutritional labeling requirements (Mathios, 2000).

[4]In Hörner (2002), consumers also act as a disciplinary body, inducing firms to excel high effort. The discipline is not through lawsuits, however. When consumers realize they had bought a low-quality product, they shift their purchases to other firms pushing the transgressed firm out of the market.

agency (e.g., a Ministry of Health or another official authority), interested in malpractice in order to reduce potential risks to consumers. This agency regulates the market, monitors providers and may find evidence for malpractice ex-post (with some degree of efficiency).

An example for such a worldwide heavily regulated market is the market for baby formula. Baby formula must meet strict dietary requirements of the FDA, UNICEF, or the European Commission, depending on the country (see, for example, the detailed tables of the Commision, 2006). If the infant formula falls below the standards, then a recall is issued.[5]

The most notorious baby formula scandal was the Melamine incident in China in 2008. A Melamine contaminated formula caused the death of 6 infants and kidney damage to 300,000 others (see Gossner et al., 2009). Another incident occurred in Israel in 2003. Remedia ltd. had distributed an impaired soy-based formula that lacked Thiamine, a mineral essential for infant development. A sequence of errors caused this tragedy, including insufficient checkups and mistaken analysis of lab tests. The consequences were death of 4 infants and various long-term motorial, neurological and cognitive damages to others. After the recall, in the civil process the company and the victims' families reached a financial settlement.[6]

The chance of being compensated following a government investigation may discourage consumers, or patients, from pursuing lawsuits, relying on the government agency to pinpoint malpractice with some positive probability, which in turn may augment malpractice by firms, or doctors.

Therefore, if the government agency is not effective in detecting malpractice, its goal toprevent malpractice may be futile, because its existence may actually encourage malpractice. This undesirable result may be prevented if either the government agency is suffi-

[5]In the last decade, recalls of baby food produced by major companies in the United States occur every one or two years as a consequence of contamination, intestinal infections, spoilage, foreign body or choking hazard. Some examples are Baby's Bliss Gripe water in 2007, Similac and Happy baby formula recalls in 2010, Baby Move dietary supplement and Gerber formula recalls in 2012, Plum Organics pouches in 2013, Stonyfield yogurt and world baby pouches in 2014, Gerber pouches, Sammy's milk infant formula and HEB in 2016, PC Organics pouches and Garden of life supplement in 2017, respectively. See the FDA website for a review of recalls in the United States, http://www.fda.gov/Safety/Recalls/ArchiveRecalls/default.htm.

[6]In the criminal process Remedia's chief technology officer was convicted of wrongful death and was sentenced to jail. Officials in the Ministry of Health were sentenced to public service.

ciently effective in identifying malpractice or if consumers are uninformed about its degree of efficiency (which reduces consumer reliance on the government agency and induces more malpractice lawsuits on their behalf).[7]

This result suggests that providing consumers with additional information on the efficiency of the government agency may lead to a lower effort level of firms (see Moav and Neeman, 2010 for a similar result in a different context).

2 The Model

2.1 A model without regulation

Let F be a firm (a provider) which produces some product or service, and denote by C a customer who buys the product. The firm F chooses to either exert effort (e) or not (ne), where the action chosen is a private knowledge of F. The effort may manifest in different stages of production, through e.g., the choice of production technologies, inputs, or its level of inspection throughout the production process. We assume that if no effort is made, the product is of low quality. Otherwise, the product is of high quality with probability α, $0 < \alpha < 1$, and of low quality with probability $1 - \alpha$. If the quality is high, the game ends, F obtains a payoff x, $0 < x < 1$, and the customer obtains a payoff 1. If the quality is low, then the customer C decides whether to pursue a malpractice lawsuit against the firm (s) or not to sue the firm (ns).

The consumer payoff increases with the quality of the product. Specifically, while a high-quality product generates a maximal payoff 1 to the consumer, a low-quality product obtains a payoff 0 to the consumer in case she does not pursue a lawsuit. If the consumer decides to sue, then she pays a lawsuit cost c, $0 < c$, that include the cost of lawyers and additional

[7]The Remedia's scandal provides some anecdotal evidence in this context. After the scandal, the Israeli Ministry of Health has forbidden to add captions mentioning that products were 'approved by the Ministry of Health' neither to food packages nor to advertisements of any kind, in order to avoid misleading the consumers.

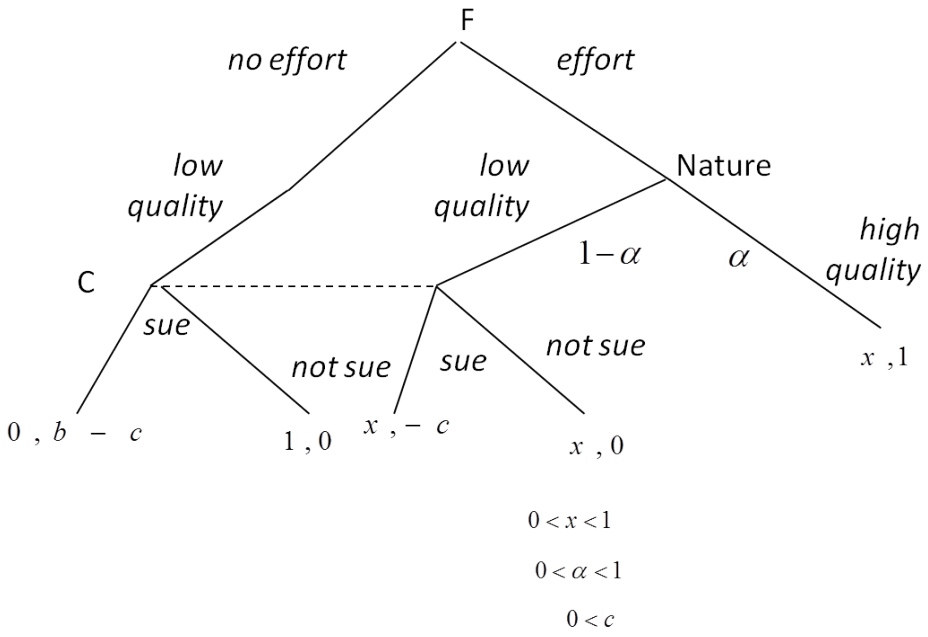

Figure 2.1: Γ_1. In each pair of payoffs the first number denotes the payoff of the firm F, and the second one is a payoff of the consumer C.

court fees. We assume that a lawsuit reveals the occurrence of malpractice (or the effort level of the firm).[8] Accordingly, if the firm chose (ne), the consumer C obtains a compensation of b for the malpractice, namely, the net payoff of C is $b-c$. If the firm well-behaved (or e was chosen), then the consumer malpractice lawsuit is rejected by the court and the consumer is not compensated (but still pays the lawsuit cost c).

The payoff of the firm F depends on the occurrence of malpractice and whether it is discovered. Accordingly, the firm receives the largest payoff 1 if no effort was made and it was not sued by the consumer (ne, ns). A lawsuit reduces its payoff to 0. If the firm well-behaved, however, (e was chosen), then its payoff is always x (whether it is sued of not). It follows that the cost of effort for the firm is $1-x$, if not sued. This defines a game Γ_1. See Figure 2.1 Denote by P_e the probability that F chooses e and by P_s the probability that given the product is of low quality, the consumer C chooses s. Then, the equilibrium of this

[8]While not in the model, in reality the courts use several processes for the purpose of extracting the truth (such as the investigation of experts and witnesses).

game is unique and depends on whether the net payoff of the consumer in case of a justified lawsuit (on the basis of malpractice), $b - c$, is positive or not. Formally,

Proposition 2.1. 1. If $b < c$, the equilibrium of Γ_1 is unique and satisfies $P_e = 0$ and $P_s = 0$.

2. If $b > c$, ihe equilibrium of Γ_1 is unique and satisfies $0 < P_e < 1$ and $0 < P_s < 1$.

All proofs appear in Appendix.

According to Proposition 2.1, if the net payoff of consumers is negative in case they file a justified lawsuit (the compensation, b, is lower than the cost, c), then consumers never pursue lawsuits, and as a result firms always choose ne, or malpractice.[9] However, when the net payoff from lawsuits is positive, it is worthwhile for consumers to pursue lawsuits (in a positive probability) and consequently, there is a positive probability that firms excel effort.[10] In other words, the chance of being sued by consumers encourages firms to well-behave.

An attendant question is how the implementation of a government agency that searches malpractice may affect the incentives of firms to well-behave. We argue in the sequel that such an institution, if ineffective, may be harmful to the economy in the sense that it encourages malpractice.

2.2 A model with regulation

In this section, we add a government agency (or a regulator) responsible to inspecting firms in order to prevent malpractice and reduce potential risks to consumers. We define the game Γ_2, as an extension of Γ_1. Let R be a regulator. The regulator moves first and commits to

[9]This case applies to affirmative action, where per consumer the benefit of lawsuit is lower than the cost.

[10]Note that the probability of consumers to sue increases in the cost of effort, $1 - x$. When the cost of effort rises, firms become reluctant to excel effort. The increase in the probability to sue maintains the indifference of firms between e and ne. Additionally, the probability of the firms to excel effort rises in b–c. When the net payoff of consumers in case of a justified lawsuit, b–c, rises, it becomes worthwhile to sue. The increase in the probability to excel effort maintains the indifference of consumers between s and ns. A similar argument applies to an increase in α, which augments $P(ne|l)$ (the chance of malpractice given that the product is of low-quality).

inspects[11] the firm F with probability P_i, if it produces a low-quality product. We assume that the probability to be inspected, P_i , is known to firms F but not known to the consumer C.

Then, F chooses whether to excel effort (e) with a probability $P_e(P_i)$. If the quality of the product is high, the game ends. In this case, the payoffs of F and C are as in the game Γ_1 and R obtains a payoff 1. If the quality is low, the government agency inspects F with a probability P_i. The inspection is costly for R, namely, if the inspection is performed, R pays c_R, $0 < c_R$, and 0 otherwise.

The regulator R promotes public health. Alleviating malpractice serves this goal, because more effort of firms reduces potential risks to consumers. For example, the effort of doctors affects the expected quality of the treatment they provide to their patients, which in turn affects their health. Accordingly, the regulator's payoff function equals the expected product quality net of the inspection cost, namely, expected utility of R is

$$EU_R = \alpha P_e(P_i) - c_R(1 - \alpha P_e)P_i. \tag{1}$$

Given that inspection is performed by R, she detects malpractice (ne) with a positive probability r, $0 < r < 1$. The parameter r can be viewed as measuring how effective, or professional, the government agency is in detecting malpractice. We assume, for now, that r is a common knowledge in the economy. In the following section we alter this assumption. Then, after the regulator R plays, if malpractice was detected, then R announces publicly about this finding. In this case, the game ends, the consumer C obtains a compensation b, and the firm F receives 0.

However, the regulator R may not detect malpractice (given that the product is of low quality) in two cases. First, there is a chance of $1-P_i$ that R has not performed an inspection on the firms. Second, an inspection was performed by R but did not detect malpractice

[11] A model with an inspector as a first mover appears in Andreozzi, 2004.

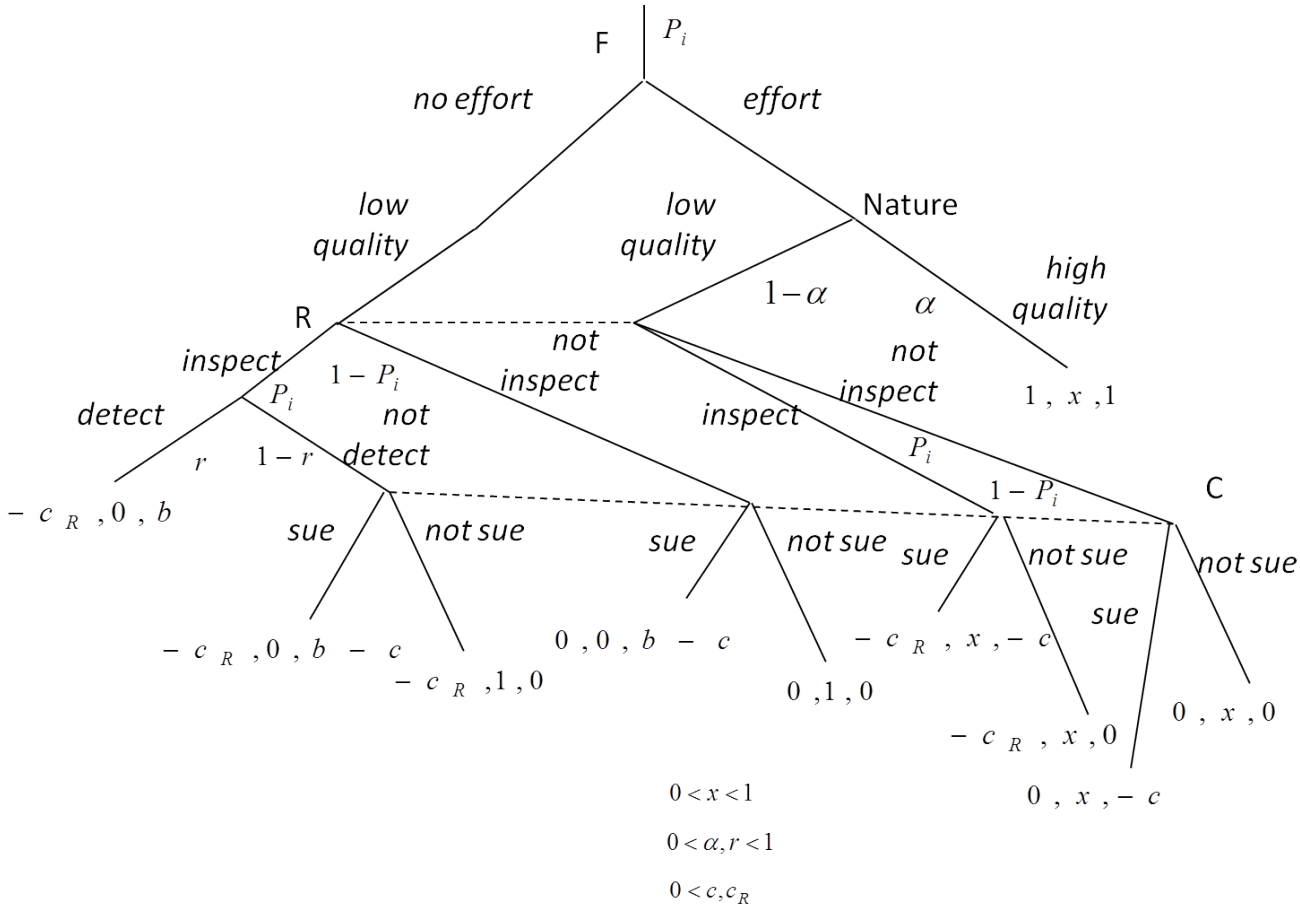

Figure 2.2: Γ_2. In each triple of payoffs the first number is the payoff of R, the second one is the payoff of F, and the third one is the payoff of C.

(because either F had chosen e or F had chosen ne but was not detected). We assume that C cannot distinguish between these two cases. Consequently, as she is not compensated, she may decide then to sue the firm F, and the game proceeds as Γ_1. See Figure 2.2 Then, the equilibrium of this game depends not only on whether the net payoff of the consumer in a justified lawsuit, $b - c$, is positive or not (like the case without regulation), but also on the cost (c_R) and efficiency (r) of the regulator. Let us define the regulator as effective if its probability to detect malpractice is sufficiently high, and as costly if the inspection cost is sufficiently high.

Definition 1. 1. The regulator is effective if $r > 1 - x$. Otherwise, the regulator is

ineffective.

2. The regulator is costly if $c_R > \frac{\alpha r}{(1-x)(1-\alpha)}$. Otherwise, the regulator is not costly.

Assume that $r \neq 1-x$, $c_R \neq \frac{\alpha r}{(1-x)(1-\alpha)}$. If equality holds, there is a multiplicity of equilibria.

According to the following propositions, the government involvement prevents malpractice completely if it is effective and not costly. In this case, the government agency fully takes the place of the consumers as a disciplinary body, and consumers decide not to pursue lawsuits. Therefore, a well-performed government agency (with respect to its effectiveness and cost) improves the expected quality of products .

However, if the regulator is inefficient and not costly, then its intervention may encourage malpractice. In other words, the economy may deteriorate to an equilibrium where less discipline is entailed on firms through malpractice lawsuits, and as a result the occurrence of malpractice rises. Formally,

Proposition 2.2. If the regulator is effective and not costly, there exists a unique equilibrium where R inspects F (in case of a low-quality product) with probability $P_i = \frac{1-x}{r}$, F chooses pure e and C chooses pure ns.

Therefore, an effective and not costly regulator guarantees the effort of firms with certainty, and thereby consumers deter from pursuing lawsuits.

Next, we examine the case where the regulator is ineffective and costly. In this case, not only that implementing inspection cannot induce firms to excel more effort but also the presence of a regulator may encourage malpractice.

In case the regulator is ineffective and costly, the equilibrium depends on the other way to discipline firms, malpractice lawsuits. Therefore, it is straightforward that if pursuing lawsuits is not worthwhile for consumers (their net payoff, $b-c$, is negative), then consumers never sue (ns), in turn the regulator never inspects the firms ($P_i = 0$), and thereby similar to the equilibrium without a regulator, malpractice occurs with certainty,

Proposition 2.3. Let $b < c$. If the regulator is ineffective and costly, in the unique equilibrium of Γ_2, F chooses pure ne, and C chooses pure ns..

The proof is straightforward by being ns a dominant strategy of C.

In contrast, when a lawsuit may be worthwhile for consumers, (the compensation is higher than the cost, $b > c$), and the cost of regulation is sufficiently low, there exists an equilibrium where consumers pursue lawsuits with a positive probability and the regulator inspects the firms with certainty.

Nevertheless, the regulator is ineffective, and as a result cannot induce firms to exhibit pure e ($P_i = \frac{1-x}{r} > 1$ is not feasible). Moreover, malpractice occurs in a higher probability compared to the equilibrium without a regulator

Denote

$$c_R^* = \alpha \frac{b - c - r(b-c)}{(1-\alpha)(b - r(b-c)}$$

Proposition 2.4. Let $b > c$, the regulator is ineffective and $c_R < c_R^*$. Then, there exists an equilibrium, where $P_s = 1 - x$, $P_i = 1$ and $P_e(1) < \frac{b-c}{b-\alpha c}$.

According to Proposition 2.4, the presence of an ineffective regulator induces malpractice (a lower chance that firms exert effort) compared to the equilibrium without a regulator. Moreover, by (6), as r is higher (but still lower than $1 - x$, and $c_R < c_R^*$), the lower is the probability that the firm makes the effort and the lower is the probability that the consumer pursue a lawsuit This result seems surprising at a first glance. The explanation lies in the consumer response to the government intervention. The consumer relies on the inspection by the government agency to detect (ne), and thus sues the firm with a lower probability than in the absence of inspection As a result, the chance of malpractice rises.

Note that the economy may benefit from the existence of the regulator not only because the effort of firms is augmented, but also by saving the cost of lawsuits. The expected payoff of C in Γ_1 is

$$EU_C = \alpha P_e, \tag{2}$$

and the expected payoff in Γ_2, in equilibrium characterized in Proposition 2.4 is

$$EU_C = \alpha P_e(1) + br(1 - P_e(1)). \tag{3}$$

In Figure 2.3 we compare numerically (2) and (3) show that it may be a case that if b is low, the consumer is better off in the model without regulation, but this is not true if b is high. We assume that the expected payoff of the consumer if the firm well-behaves (or excels effort e), α, is always larger than the payoff of the consumer if compensated for malpractice, b. Namely, $\alpha > b$. This is justified by the well-known principal in law systems, that the payoff achieved by a malpractice lawsuit at most compensates for the damage, or returns the consumer to her position if the malpractice had not occurred.

In the following section, we add asymmetric information with respect to the effectiveness of the regulator and analyze the resulting equilibrium.

2.3 A model with regulation and asymmetric information

Suppose next only R and F know the value of the effectiveness of inspection, r. C does not know r, and has a prior on the distribution of r, $G : [0, 1] \to [0, 1]$. This game is denoted as Γ_{asym}. In this section, we assume $b > c$.

The following propositions show that lack of ex-ante information about the level of r may be harmful (encourage malpractice) when the regulator is discovered less effective than expected, or beneficial (discourage malpractice) when the realization of r exceeds expectations. The intuition is straightforward. On the one hand, if consumers believe that there is a sufficiently low chance that the government agency is ineffective and costly, they behave as though this chance is zero. Accordingly, consumers rely on the regulator to inspect the firm and thereby do not pursue lawsuits assuming that in most cases firms excel effort. Naturally, when the realization of r is low, the reliance of the consumers on the regulator is not justified and (given that consumers do not sue and firms take that into account) malpractice occurs

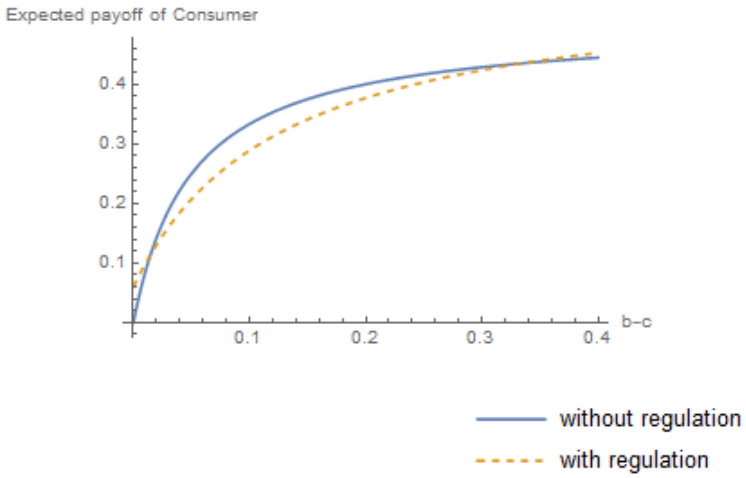

Figure 2.3: Expected payoff of C for $\alpha = 0.5$, $c = 0.1$, $r = 0.6$, $c_R < c_R^*$, $x < 1 - r$.

with certainty.

On the other hand, when consumers believe that there is a high chance that the realization of r is low (firms are more costly and ineffective), they step in and pursue lawsuits in a positive probability. When the realization of r is higher than the consumers expected, firms are induced to excel effort with certainty, reducing the occurrence of malpractice to zero. These conclusions are summarized formally in Propositions 2.5-2.6.

Proposition 2.5. Let the probability that the regulator is ineffective and costly be sufficiently low, $G(r \leq \max[1-x, \frac{c_R(1-\alpha)}{\alpha}(1-x)]) < \frac{c}{b}$. Then in an equilibrium of Γ_{asym}:

$$P_i = \begin{cases} \frac{1-x}{r} & , r \geq \max[1-x, \frac{c_R(1-\alpha)}{\alpha}(1-x)] \\ 0 & , otherwise \end{cases}$$

$$P_e(P_i) = \begin{cases} 1 & , P_i \geq \frac{1-x}{r} \text{ and } r \geq \max[1-x, \frac{c_R(1-\alpha)}{\alpha}(1-x) \\ 0 & , otherwise \end{cases}$$

and $P_s = 0$.

By Proposition 2.5, if the customer believes that (with a sufficient high probability) the regulator is effective, she behaves as though R is certainly effective and does not sue the firm. If the realization of r is low, the regulator typically does not inspect F, and in turn F does not excel effort. In this case C is worse-off in a model with asymmetric information, because she gets a low-quality product (zero payoff) with certainty, whereas if C would have known r ex-ante there would have been a positive probability to encounter a high-quality product or to be compensated if the quality is low (recall Proposition 2.3).

We further illustrate the case where consumers may be better-off with asymmetric information in the following example.

Proposition 2.6. Let $r_{min}, r_{max} < 1-x$. C assigns probability θ to R being of type r_{max} and probability $1-\theta$ to type r_{min}. If c_R and θ are sufficiently low, $(1-\theta > \frac{c}{b})$, there exists

an equilibrium where if R is of type r_{max}, $P_i = \frac{r_{min}}{r_{max}}$, and F chooses e with certainty, which is higher than if $r = r_{max}$ is common knowledge. However, if R is of type r_{min}, then $P_i = 1$, and F chooses e with probability

$$P_e^{r_{min}} = \frac{(1 - r_{min})(1 - \theta)(b - c) - (1 - \alpha)c\theta}{c(1 - \alpha)(1 - \theta) + (1 - r_{min})(1 - \theta)(b - c)},$$

In this case, the realization of r_{min} is lower than expected, and as a result the probability that firms well-behave e is lower than if $r = r_{min}$ is commonly known.

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Appendix

Proof of Proposition 2.1. 1. Let $b < c$. Then s is a dominated strategy of C. Therefore, F chooses ne with certainty and obtains a payoff 1.

2. Let $b > c$. In this case, there is no equilibrium with pure strategies.If F chooses e with certainty, then ns is the best reply of C, but then F is better off by deviating to ne. Similarly, it is easy to verify that pure ne, s and ns are not possible in the equilibrium. In the unique equilibrium of Γ_1, F is indifferent between e and ne, namely,

$$x = 1 - P_s,$$

equivalently,

$$P_s = 1 - x.$$

Let $P(ne|l)$ be the probability C assigns to the event "F chooses ne" if the quality of the product is low. Note that

$$P(ne|l) = \frac{1 - P_e}{P_e(1-\alpha) + 1 - P_e} = \frac{1 - P_e}{1 - \alpha P_e}.$$

Since in equilibrium C is indifferent between s and ns,

$$bP(ne|l) - c = 0,$$

or,

$$P_e = \frac{b - c}{b - \alpha c}. \tag{4}$$

□

Proof of Proposition 2.2. F weakly prefers e iff $x \geq 1 - rP_i$, which is equivalent to

$$P_i \geq \frac{1 - x}{r}.$$

Namely, F excels effort if the probability to detect malpractice is sufficiently high,

$$P_e(P_i) = \begin{cases} 1 & , P_i \geq \frac{1-x}{r} \\ 0 & , P_i < \frac{1-x}{r} \end{cases}. \tag{5}$$

To ensure the effort of the firm (pure e) with minimal inspection cost, the regulator R chooses $\frac{1-x}{r} = P_i < 1$ (which is feasible because the regulator is effective).

The consumer C, decides not to sue (ns). For $b < c$ (the lawsuit cost exceeds the compensation), s is a dominated strategy of C, which ends the proof. For $c < b$, ns is the

best reply for C, because F chooses e with certainty.

To prove uniqueness in case $c < b$, assume by contradiction that there is an additional equilibrium outcome where F does not choose e with certainty. First, assume that F chooses ne with certainty. Then, the best reply by C is $P_s = 1$, but then F is better off by deviating to e. This is a contradiction to ne being an equilibrium strategy of F. Second, suppose by contradiction that there is an additional equilibrium where $0 < P_e(P_i) < 1$, and $EU_R > 0$. Then, F is indifferent between e and ne, namely

$$x = (1 - rP_i^*)(1 - P_s),$$

or

$$P_i^* = \frac{1 - x - P_s}{r(1 - P_s)} \leq \frac{1 - x}{r} < 1 \text{ for } 1 - x < r.$$

For every $P_i > P_i^*$, F strictly prefers e.

In this case, for $P_i = P_i^* + \epsilon$, $(\epsilon \to 0)$, F strictly prefers e, namely, $P_e(P_i^* + \epsilon) = 1$. Accordingly, R can improve its payoff by increasing the probability of inspection by ϵ, and in turn induce the firm to excel effort e with certainty,

$$\Delta EU_R = \alpha(1 + c_R)[P_e(P_i^* + \epsilon) - P_e(P_i^*)] - \epsilon c_R \to \alpha(1 + c_R)(1 - P_e(P_i^*)) > 0$$

and $\alpha(1 + c_R)P_e(P_i^* + \epsilon) - c_R(P_i^* + \epsilon) = \alpha(1 + c_R) - c_R(P_i^* + \epsilon) > 0$ for sufficient low ϵ. This is a contradiction to P_i^* being an equilibrium strategy. □

Proof of Proposition 2.4. Let $P_i = 1$. Then, F is indifferent between e and ne iff

$$x = (1 - r)(1 - P_s),$$

or

$$P_s = \frac{1 - r - x}{1 - r},$$

and $0 < P_s$ because the regulator is ineffective. In this case, for $P_i < 1$, F strictly prefers ne.

In order to define the incentive constraint of the consumer, let $P(ne|nbl)$ be the probability C assigns to the event "F chose ne" if the quality of the product is low and ne was not detected by R (thus, C was not compensated and may have an incentive to sue).

$$P(e|nbl) = \frac{P_e(1-\alpha)}{P_e(1-\alpha) + (1-P_e)(1-r)}.$$

C is indifferent between s and ns iff

$$1 - P(e|nbl) = \frac{(1-P_e(1))(1-r)}{P_e(1)(1-\alpha) + (1-P_e(1))(1-r)} = \frac{c}{b},$$

by rearranging terms we obtain

$$P_e(1) = \frac{b-c-r(b-c)}{b-\alpha c-r(b-c)} < \frac{b-c}{b-\alpha c}. \tag{6}$$

It is easy to verify that $EU_R > 0$ because $c_R < c_R^*$. □

Proof of Proposition 2.5. The proof is similar to Proposition 2.3. The customer's best reply is ns if the payoff from ns is larger than the payoff from s:

$$0 \geq -c + bG(r \leq \max[1-x, \frac{c_R(1-\alpha)}{\alpha}(1-x)]),$$

and it holds for $G(r \leq \max[1-x, \frac{c_R(1-\alpha)}{\alpha}(1-x)]) < \frac{c}{b}$. □

Proof of Proposition 2.6. In case of a realization $r = r_{min}$, assuming that $P_i = 1$, the firm F is indifferent between e and ne if:

$$x = (1-r_{min})(1-P_s),$$

and by earranging terms we obtain that

$$P_s = \frac{1 - r_{min} - x}{1 - r_{min}} < 1.$$

P_s is feasible because the regulator R is ineffective.

In case of realization of r_{max}, the firm F prefers e if

$$x \geq (1 - r_{max} P_i)(1 - P_s).$$

It is easy to verify that for realization of r_{max}, $P_e(P_i) = 1$ if $P_i \geq \frac{r_{min}}{r_{max}}$ and $P_e(P_i) = 0$, otherwise. Then, to induce the firm F to excel effort, in case of r_{max} the regulator R chooses

$$P_i = \frac{r_{min}}{r_{max}} < \frac{1 - x}{r_{max}}.$$

$EU_R > 0$ for sufficient low c_R.

The consumer C is indifferent between s and ns if:

$$0 = -c + b \frac{(1 - \theta)(1 - r)(1 - P_e^{r_{min}})}{((1 - r)(1 - P_e^{r_{min}}) + [\theta + (1 - \theta) P_e^{r_{min}} (1 - \alpha))},$$

equivalently,

$$P_e^{r_{min}} = \frac{(1 - r_{min})(1 - \theta)(b - c) - (1 - \alpha) c \theta}{c(1 - \alpha)(1 - \theta) + (1 - r_{min})(1 - \theta)(b - c)}.$$

$P_e^{r_{min}} > 0$ for sufficiently low θ.

□