Shrink Wraps: Who Should Bear the Cost of Communicating Mass-Market Contract Terms?*

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Abstract

The paper examines the equilibrium quality of mass market contract terms, such as those in end user license agreements, when consumers can read and search for a better set of terms. Firms compete over price and quality of the terms. They can also choose to disclose (speak) the terms to consumers at cost. While all consumers must incur positive search (reading) cost to understand the terms, not everyone cares about the terms equally and they can also buy without reading. The paper examines two legal regimes: one that imposes a duty to read on the consumers and the other that imposes a duty to speak (disclose) on the firms. While neither regime strictly dominates the other in terms of social welfare, the paper shows that (1) as the reading or speaking cost converges to zero, the social welfare continuously converges to the first best; (2) consumers will have different preferences over duty-to-speak and duty-to-read regimes; and (3) the quality of the terms of non-disclosing firms may be higher. The results are consistent with the current chasm among scholars and courts over mandatory disclosure policy and also with the recent empirical findings.

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1 Introduction

A consumer orders a software on-line, and when the package arrives, she discovers that a CD-ROM is wrapped in plastic ("shrink-wrapped") with a document inside and a note on top. The note says that the terms within the package are binding if she installs the software, and if she is not happy with the terms, she can return the product for free before installation. If she later discovers that the software is defective and has damaged her computer, should she be allowed to recover more than the "replacement cost" that is stipulated in the document? What about the dispute resolution clause that mandates arbitration using the laws of Montana? Should it matter whether or not she had an ability to see the terms before purchase? For instance, what if she clicked "I agree" on the ("click-wrapped") terms on-line before purchase?

The issues over whether such mass market terms should be disclosed at the time of sale and whether the terms should be binding on the consumers if not disclosed have been deeply controversial among legal scholars and the courts. Critics argue that non-disclosure is unfair to consumers and is contrary to the contract principle of "consent."[1] Sympathetic courts have ruled in accordance that unless the terms are properly disclosed (or even explained) at the time of sale, they should not be binding on the consumers. Defenders, on the other hand, argue that forcing the sellers to disclose the terms at the time of sale will be prohibitively costly, wasteful, and/or ineffective, especially since most consumers do not, even when given a chance, read the terms before closing the transaction. Allowing them to return the product (free of shipping cost) if the consumer does not like the terms should be both sufficient and efficient.[2]

While the economic research on this issue has not been extensive,[3] the existing research

[1]See, e.g., Stewart Macaulay (2004) and Braucher (2004). Macaulay, for instance, states that "if you are a contract purist, it is very difficult to offer a convincing argument that these clauses [in rolling contracts] work to create a contract with the desired effect."

[2]See, e.g., Gillette (2004) and Ben-Shahar (2008). Ben-Shahar argues that providing conumers with a greater opportunity to read will "not produce greater readership of contracts...and could have unintended consequences."

[3]Most papers in search theory focuses on price searching by homogenous consumers. While some assume exogenous search strategies, e.g., whether or not a consumer will visit one or more firms, others construct equilibrium search strategies endogenously. See Schwartz and Wilde (1979, 1983) for the former and Diamond (1971), Stahl (1989), Katz (1990), and Robert and Stahl (1993) for the latter. Except for Robert and Stahl (1993), in all the papers, some (or no) consumers are assumed to have zero search cost.

has been similarly divided. Katz (1990), for instance, suggests that when buyers must incur reading cost to understand the terms, because it is not in the interest of the marginal buyer to read the terms, the price and the quality of the terms unravel. In equilibrium, no buyer reads and the seller proposes the worst possible terms allowed under the law. On the other side, Schwartz and Wilde (1983), for instance, argue that when there are enough buyers with zero reading cost (the "shoppers"), competition among sellers should solve or substantially mitigate the quality-of-the-terms problem. The shoppers, who costlessly compare the terms across sellers, discipline the sellers to provide more buyer-friendly terms, and when there are enough shoppers, the quality converges to the efficient level.

Our paper differs from the existing research on several fronts. First, we assume that all consumers must incur a positive reading cost to understand the terms, and a seller's voluntary, pre-sale disclosure will lower but not eliminate that cost.[4] Especially when the terms are difficult to understand, we do not think that giving the consumers a chance to read them will necessarily eliminate the cost of reading and understanding. Second, not all consumers care about the terms equally. Warranty policy for software, for instance, may be a lot more important for a computer programmer than for a casual user. Third, consumers do not have to read the terms before purchase. Unlike the search models where a buyer has to incur a search cost to visit another firm/store, a consumer in our model can always buy a product without reading the terms that accompany a product.

We examine two legal regimes: duty to read and duty to speak. In the duty to read regime, buyers have an obligation to read the terms, in that the proposed terms are binding whether or not a buyer reads them or a seller discloses them before sale. Under the duty to speak regime, sellers have an obligation to disclose the terms before sale. The obligation can be imposed in one of two ways: the law can mandate all sellers to disclose the terms as a condition for participating in the market while allowing the offered terms to bind, or can let a set of default, buyer-friendly terms to bind unless there has been a disclosure or an acceptance of different terms by a buyer.

We show that, in the duty to read regime, so long as the reading cost is not too large, there exists a set of equilibria in which consumers (who care about the terms) read the

[4] Robert and Stahl II (1993) also assume that all consumers must incur a positive search cost to visit a firm. Firms, in their model, can advertise their prices to consumers to make them informed but consumers still must incur a search cost to visit a firm, whether or not advertised. In the paper, consumers are homogeneous, i.e., they all care about low price, and they cannot purchase a product without incurring a visit cost.

terms with positive probability and purchase from sellers who offer buyer-friendly terms with positive probability. The consumers who care less about the terms purchase from sellers who offer seller-friendly terms for certain. In the duty to speak regime, there exists a similar a set of equilibria where some sellers offer buyer-friendly terms while others do not, and the consumers self-select in accordance. We show, in the duty to speak regime, that imposing a buyer-friendly set of default terms is better than mandating all sellers to speak, because when disclosure is mandated, the sellers cannot separate based on disclosure policy. Imposing a buyer-friendly set of default terms allows better separation between high quality and low quality sellers.

We show that neither regime strictly dominates the other in terms of social welfare. In the duty to read regime, consumers who care about the terms incur the cost of reading, while in the duty to speak regime with buyer-friendly default terms, low quality sellers incur the cost of disclosure to contract around the default. The social welfare under both regimes continuously converges to the first best as the reading or speaking cost converges to zero. This is in contrast to the search models that follow Diamond (1971), including Katz (1990), which show that the social welfare drops discontinuously as the reading (search) cost rises above zero. One implication of such drop is that when the speaking cost is sufficiently small, no matter how small the reading cost is, the duty to speak regime will dominate the duty to read regime. We show that this is not the case: even when the reading cost is positive, so long as it is not too large, duty to read regime can be better than the duty to speak regime.

We also show that the consumer surplus and its distribution are highly sensitive to the legal regime. For the consumers who care about the terms, because they are indifferent between reading and not reading in the duty to read regime, their surplus is equal to the surplus they can obtain through costly reading. In the duty to speak regime, on the other hand, because costly disclosure can send a perfect signal to the consumers about the quality of the terms, the consumers who care about the terms can obtain buyer-friendly terms at a favorable price even without reading. For the consumers who care less about the terms, on the other hand, the duty to speak regime is worse because the sellers who are contracting around the buyer-friendly default terms must speak and pass that cost on to them.

When the fraction of consumers who care about the terms is sufficiently large, therefore, the duty to speak regime can be better for the consumers as a whole than the duty to read regime. This, we argue, can explain the current division among academics and practitioners.

On the one hand, those who believe that the terms are important for the consumers and want to maximize their welfare will advocate the duty to speak policy, either by mandating all sellers to disclose the terms before sale or by imposing penalty default terms. Those who care more about the total surplus, on the other hand, may be more receptive to imposing the duty to read on the consumers.

Finally, we suggest that the quality difference of the terms of the sellers who disclose to those who do not may be small. Recently, Marotta-Wurgler (2008, 2009) has examined the relative quality of software license agreements of the sellers who disclose the terms before sale to of those who do not. She finds that there does not seem to be any systematic difference between the two in general, and when there is, the terms of the seller who do not disclose seem to be better. Our results are consistent with this finding. When we compare the two different regimes, the average quality of the terms by disclosing and non-disclosing sellers can be close, and if there is any difference, disclosed terms can be worse because of the sellers who attempt to contract around the buyer-friendly default terms through disclosure.

The paper is organized as follows. In the next section, we propose the basic set up of the model. To simplify the analysis, we assume that there are two types of consumers, those who care about the terms (high type) and those who do not (low type), and sellers can offer two different levels of quality, buyer-friendly (high quality) and seller-friendly (low quality) terms. In the next two sections, we examine the existence and characteristics of equilibria under two alternate legal regimes. In equilibrium, firms separate based on price, provision of quality, and the disclosure policy. In the duty to read regime, high type consumers read with positive probability and buy from high quality firms while low type consumers do not read and always purchase from low quality firms. In the duty to speak regime, on the other hand, disclosure displaces (probabilistic) reading while keeping separation. In the penultimate section, we conduct comparative statics to compare the two sets of equilibria. The last section concludes.

2 The Setup

There are $n \geq 3$ firms, each offering quality $q \in \{q_L, q_H\}$ where $q_H > q_L > 0$. Quality is determined by the contract terms that come with the product, such as the scope of warranty, limitations on usage, choice of dispute resolution, choice of law, and so on. When the terms are pro-buyer (pro-seller), quality is assumed to be high (low). For instance, if a product comes with a very generous warranty that covers consequential losses from defect, its quality is high. If, on the other hand, the warranty covers only the cost of replacement or repair, the product quality is low. Producing a low quality good costs the firm nothing, but producing high quality costs the firm $c > 0$ per unit sold.

There is a unit mass of consumers, indexed by the preference type $\tilde{\theta} \in \{0, \theta\}$, with probabilities $1-\alpha$ and α, respectively. A type $\tilde{\theta}$ consumer enjoys a surplus of $\tilde{\theta}(q-q_L)+q_L-p$ if she purchases the good with quality q and pays p.[5] Consumers costlessly observe prices posted by all firms for free before purchase, but they must visit a firm's store/site to observe the firm's disclosure ("speak") policy. The cost of visiting a firm and discovering its disclosure policy is zero, but to observe the quality being offered by the firm, they must read and understand the terms at cost. The cost of reading the terms depends on the firm's disclosure policy. If a firm does not disclose (or does not "speak"), it costs a consumer $r > 0$ to read and understand the terms. If a firm discloses ("speaks"), it costs the consumer r' to read and understand the terms, where $r > r' \geq 0$. It costs a firm s to speak per purchasing customer, where $c > s > 0$. We assume $\theta q_H - c - r > \theta q_L$, so that, if all the consumers are of type θ, it is socially desirable for a firm to produce high quality even though that requires the full reading cost on the part of the consumers.

We consider two possible legal regimes: duty to read and duty to speak. Under the duty to read regime, consumers who agree to purchase a product are bound by its terms whether they have read the terms or not. Under the duty to speak regime, firms have an obligation to communicate the terms to the consumers before sale. The duty to speak can be imposed in one of two ways: either by mandating all sellers to disclose the terms as a condition for participating in the market without any regulation on the substantive terms, or by imposing a set of buyer-friendly default terms on the sellers who do not disclose the terms before sale.

[5] The assumption that the low type consumer does not value high quality is not important. The result remains qualitatively the same as long as the low type values high quality sufficiently little.

3 Duty to Read

After observing all firms' prices for free, each consumer, based on the observed prices and her belief about their respective quality, decides whether to visit a firm and examine its product. When she visits a firm and observes its disclosure policy for free, she decides whether to read the terms and understand the quality being offered by the firm or buy without reading. If she buys without reading, her search ends and, under the duty to read regime, the offered terms are binding. If she reads and understands the quality, she can either buy that product or visit another firm, at which point he decides again whether to read and understand the quality of the product or to buy without reading.

Firms choose qualities, prices, and disclosure ("speak") policies simultaneously. Note first that under the duty to read regime, there is no separating equilibrium where high and low quality firms separate either through price or through disclosure policy. Suppose there is and the consumers believe that any firm that deviates from that equilibrium, in terms of either price or disclosure policy, must be providing low quality. Under complete separation, no consumers will read; if no one reads, there is no incentive to provide high quality since the price for the quality good must be no less than $c > 0$, so it pays to deviate and produce low quality, undermining the separating equilibrium.

Note also that there is a trivial equilibrium where no consumer reads and all firms offer low quality, do not speak, and charge zero price. Consumers in that equilibrium purchase from a firm at random. Consumers would not want to deviate, since by doing so (by reading) she only incurs the reading cost. Firms would not want to deviate, either. By charging a higher price it loses all consumers and is weakly worse off. By providing high quality or by speaking, it is strictly worse off. Finally, there cannot be an equilibrium where both high quality and low quality firms speak, since for the low quality firm, speaking is strictly dominated.

We now look for an equilibrium in which some firms offer high quality and high type consumers choose to read with positive probability. In particularly, we restrict attention on a class of equilibria in which firm(s) $i = 1, ..., k$, where $1 \leq k < n - 1$, charge price p_H and choose high quality with probability $\pi > 0$; and the other firms $i = k + 1, ..., n$ choose low quality and charge the marginal cost of zero. For labeling convenience, we call the former firm(s) "high quality" firms and the latter firms "low quality" firms (even though the former may not always choose high quality). Since the firms have the same production technology, we are envisioning a market structure, that is segmented endogenously, based on consumer search behavior.

Except for the segmentation, we shall focus on symmetric behavior. In particular, consumers of any given type behave symmetrically. Since the low type consumers do not care about high quality, they purchase from any randomly chosen low quality firm. The high type consumers follow some symmetric search/reading strategy that treat all the firms in the ex ante identical fashion, which involves reading the contracts of the terms they choose to visit with some positive probability. The set of such strategies is very large, and in fact there will be continuum of equilibria. We select the equilibrium that attains the highest total surplus and the one that attains the highest consumer surplus.

Instead of examining all possible search/reading strategies the high type consumers may follow, we try to identify several basic behavioral variables that are consistent with feasible search strategies and equilibrium conditions. To this end, suppose in any equilibrium, the high quality firm picks high quality with probability π, and the high type consumer buys from any high quality firm with probability λ and receives high quality with probability ϕ. By assumption, we must have $\lambda \geq \phi$. We call a triplet (π, λ, ϕ) an **outcome**, and we are interested in characterizing the set $\mathcal{E}$ of outcomes that can be supported in equilibrium. We will then identify an outcome that attains the highest welfare and the one attaining highest consumer surplus. To characterize $\mathcal{E}$, fix any equilibrium outcome $(\pi, \lambda, \phi) \in \mathcal{E}$. We begin by considering high type consumers' incentives.

Lemma 1 *For a high-type consumer to read with positive probability, i.e., in order for there to be a mixed strategy equilibrium, we must have*

$$\pi(\theta\Delta + q_L - p_H) + (1-\pi)\max\{q_L, \pi\theta\Delta + q_L - p_H\} - r \geq \max\{q_L, \pi\theta\Delta + q_L - p_H\}. \quad (1)$$

Proof. The expression on the right (RHS) represents the payoff that the high type consumer can earn either by buying from a low quality firm or from any high quality firm without reading its contract, whichever is more profitable. The expression on the left (LHS) represents the payoff from reading a high quality firm's terms and purchasing from that firm if the terms are good while purchasing from a different high quality or a low quality firm without reading if the terms are bad.

Suppose first that $k = 1$. In this case, the LHS is the upper bound for the payoff that a high-type consumer will ever achieve if she decides to read the terms of the high quality firm. Failure of (1) clearly means that she will never read its term.

Next, suppose $k \geq 2$. Suppose that the consumer has read the terms of all high quality firms except for one such firm, and found their qualities to be all low. The failure of (1) means that the consumer will not read the terms of the last remaining high quality firm. She will, instead, purchase from the last high quality firm or a randomly chosen low quality firm without reading, whichever is more profitable. Working inductively backward, if there are two high quality firms remaining, since she knows that she won't read the last high quality firm's terms, the failure of (1) implies that she shouldn't read the next to the last firm's terms, either. Therefore, for the high type consumer to read a high quality firm's terms with any positive probability, (1) must be satisfied. ■

It follows from (1) that

$$\pi(1-\pi)\theta\Delta \geq r \tag{2}$$

and

$$\pi(\theta\Delta - p_H) \geq r \tag{3}$$

Condition (2) can be characterized more informatively. Let $\pi^*(r) := \frac{1+\sqrt{1-\frac{4r}{\theta\Delta}}}{2}$ and $\pi_*(r) := \frac{1-\sqrt{1-\frac{4r}{\theta\Delta}}}{2}$ be the high and low roots of the equation $\pi(1-\pi)\theta\Delta = r$, respectively. For these roots to be real, we must have $r \leq \theta\Delta/4$. Given this condition, (2) is equivalently stated as: $\pi \in [\pi_*(r), \pi^*(r)]$. Note also that $\frac{d\pi^*(r)}{dr} > 0$ and $\pi^*(r) \to 1$ as $r \to 0$.

Lemma 2 *Whenever* $p_H > c$,

$$\pi\theta\Delta \geq p_H \tag{4}$$

Proof. Suppose $\pi\theta\Delta < p_H$. Then, $\pi\theta\Delta + q_L - p_H < q_L$, so high-type consumers never buy from any high quality firm without making sure by reading that its quality is high. Since $p_H > c$, all high quality firms must choose high quality with probability $\pi = 1$. But this means that $\theta\Delta < p_H$, which will clearly violate (3). ■

Suppose $\pi\theta\Delta > p_H$. Then, because buying from a high quality firm without reading its terms is better than buying from a low quality firm, no high type consumer will ever purchase from a low quality firm. In other words, $\lambda = 1$. Hence,

$$(\pi\theta\Delta - p_H)(1-\lambda) = 0. \tag{5}$$

Let's consider the firms' incentive. It is clear that a low quality firm has no incentive to unilaterally raise its price, regardless of its quality decision, given the belief by the consumers that any such deviator never chooses high quality. Next, consider the high quality firm's incentive to offer high quality. Suppose each high quality firm sells to a mass Q_H in expectation when it chooses a high quality and to a mass Q_L in expectation when it chooses a low quality. This quantities are the same across all high quality firms since the high type consumers search symmetrically ex ante toward all high quality firms. In equilibrium, a fraction ϕ of the high type consumers receive high quality, and each of k high quality firm chooses high quality and sells to Q_H consumers. Hence,

$$\alpha\phi = k\pi Q_H. \tag{6}$$

By a similar logic, we have

$$\alpha(\lambda - \phi) = k(1-\pi)Q_L. \tag{7}$$

If a high quality firm chooses high quality, it earns a profit of $(p_H - c)Q_H$. If it offers low quality, its profit is $p_H Q_L$. For the firm to have any incentive to choose high quality, the former profit cannot be less than the latter. The former cannot exceed the latter, though, since otherwise the firms will choose high quality with probability $\pi = 1$. This means that the high type consumers will never wish to read the contracts of any firms, in which case of course $Q_H = Q_L$, violating the incentive for providing high quality. In sum, the firms must be indifferent:

$$(p_H - c)Q_H = p_H Q_L$$

which implies, through (6) and (7), that

$$p_H = \frac{(1-\pi)\phi}{\phi - \lambda\pi} c \tag{8}$$

If $\phi < \lambda$, then $p_H > c$. This is intuitive. Since offering high quality is costly for the firm, if the firm can sell to consumers even with low quality (which will be the case if $\lambda - \phi > 0$), it must receive a positive rent when providing high quality. Hence, if $\phi < \lambda$, it follows from (4) that $\pi\theta\Delta \geq p_H$. Combined with (8), we conclude that

$$(\lambda - \phi)\left(\pi\theta\Delta - \frac{(1-\pi)\phi}{\phi - \lambda\pi}c\right) \geq 0. \tag{9}$$

Condition (5) can be in turn written as:

$$(1-\lambda)\left(\pi\theta\Delta - \frac{(1-\pi)\phi}{\phi - \lambda\pi}c\right) = 0. \tag{10}$$

The triple (π, λ, ϕ) must also obey a technological constraint:

$$\lambda\pi \leq \phi \leq \min\{\lambda, \overline{\phi}_k(\pi)\} \tag{11}$$

where $\overline{\phi}_k(\pi) := 1-(1-\pi)^k$. The left inequality holds from the fact that anyone purchasing from a high quality firm must receive high quality with probability no less than π. The right inequality, $\phi \leq \overline{\phi}_k(\pi)$, holds since the probability of receiving high quality cannot exceed the probability that at least one firm provides high quality.

Let

$$\mathcal{E}^* := \{(\pi, \lambda, \phi) \in [0,1]^3 | (\pi, \lambda, \phi) \text{ satisfies } (2), (9), (10) \text{ and } (11)\}$$

Since the conditions listed are only necessary, it is clear that $\mathcal{E} \subseteq \mathcal{E}^*$. In other words, an equilibrium outcome must be in $\mathcal{E}^*$, but not every element in $\mathcal{E}^*$ must be an equilibrium outcome. As will be seen, the set $\mathcal{E}^*$ is non-empty if the reading cost r is sufficiently small. In such a case, there will be multiple, in fact a continuum of, such outcomes. We will next select the outcome in $\mathcal{E}^*$ that attains the highest social welfare and the one attaining the highest consumer surplus. More importantly, we will show that these two outcomes are sustainable in equilibrium.

Let us find the expressions that represent the social welfare and consumer surplus. One important component in both is the high type consumers' equilibrium reading cost. Recall that in equilibrium each firm sells to Q_H consumers when offering high quality and to Q_L when offering a low quality. The difference $Q_H - Q_L$ must then represent the expected measure of consumers who read the terms of the firm's contract. Since there are k firms, the total expected measure of consumers reading terms of the contract must be

$$k(Q_H - Q_L) = \alpha\left(\frac{\phi - \pi\lambda}{\pi(1-\pi)}\right).$$

The social welfare is then characterized as

$$SW(\pi, \lambda, \phi) = \alpha\phi[\theta\Delta - c] - \alpha\left(\frac{\phi - \pi\lambda}{\pi(1-\pi)}\right)r + q_L,$$

and the consumer surplus is

$$\begin{aligned} CS(\pi, \lambda, \phi) &= \alpha\phi\theta\Delta - \alpha p_H\lambda - \alpha\left(\frac{\phi - \pi\lambda}{\pi(1-\pi)}\right)r + q_L \\ &= \alpha\phi\theta\Delta - \alpha\frac{\lambda(1-\pi)\phi}{\phi - \lambda\pi}c - \alpha\left(\frac{\phi - \pi\lambda}{\pi(1-\pi)}\right)r + q_L. \end{aligned}$$

3.1 Socially Optimal Equilibrium Outcome

Consider the following problem:

$$[SW] \qquad \max_{(\pi,\lambda,\phi)\in\mathcal{E}^*} SW(\pi,\lambda,\phi).$$

A solution to $[SW]$ is said to be an **socially optimal outcome**.[6] To characterize a socially optimal outcome, let

$$\hat{r} := \sup\left\{ r \leq \frac{\theta\Delta}{4} \middle| \theta\Delta \geq \psi_k(r)\frac{c}{\pi^*(r)} \right\} \tag{12}$$

where $\psi_k(r) := \frac{1-(1-\pi^*(r))^k}{1-(1-\pi^*(r))^{k-1}} = \frac{\sum_{i=0}^{k-1}(1-\pi)^i}{\sum_{i=0}^{k-2}(1-\pi)^i}$. Observe $\psi_k(r) > 1$, but, as $r \to 0$, both $\pi^*(r)$ and $\psi_k(r)$ converge to one. Since $\theta\Delta > c$, we thus have $\hat{r} > 0$. Just as the condition $r \leq \frac{\theta\Delta}{4}$ is necessary for the high type consumers to read with any probability in equilibrium, unless the condition, $\theta\Delta \geq \psi_k(r)\frac{c}{\pi^*(r)}$, is satisfied, high quality firms will have no incentive to provide high quality, in equilibrium, regardless of the high type consumers' behavior. The optimal outcome is now characterized.

Lemma 3 *If $r \leq \hat{r}$, then a socially optimal outcome is $(\pi,\lambda,\phi) = (\pi^*(r),\lambda^*(r),\phi^*(r))$, where*

$$\lambda^*(r) = \begin{cases} \frac{\pi^*(r)\theta\Delta-(1-\pi^*(r))c}{\pi^*(r)\theta\Delta} & \text{if } k=1 \\ 1 & \text{if } k\geq 2 \end{cases}$$

and

$$\phi^*(r) = \begin{cases} \pi^*(r) & \text{if } k=1 \\ \frac{\pi^*(r)^2\theta\Delta}{\pi^*(r)\theta\Delta-(1-\pi^*(r))c} & \text{if } k\geq 2 \end{cases}$$

Proof. See the Appendix. ■

It remains to see whether and how the optimal outcome can be implemented in equilibrium. Suppose each high quality firm chooses high quality with probability $\pi = \pi^*(r)$. Since $\pi^*(r)(1-\pi^*(r))\theta\Delta = r$, the high type consumer is indifferent between reading a

[6] Socially optimal outcome does not necessarily maximize the consumer surplus, however. We can, instead, maximize $CS(\pi,\lambda,\phi)$ subject to $(\pi,\lambda,\phi)\in\mathcal{E}^*$ to derive a set of consumer optimal outcome. We skip the analysis but to briefly summarize: in equilibrium, the high-type consumers read the terms with probability one until they either find a high-quality good or reach the last store, in which case they buy without reading. Although the high-type's probability of receiving a high-quality good is higher the social welfare is lower due to the higher incurrence of reading cost.

high quality firm's terms or buying the product without reading. Consider the following search and reading strategy for the high type consumers. Each high type consumer visits a randomly chosen high quality firm and randomize over whether to read its terms. With probability $\rho \in [0,1]$, she reads its term and buys the good if and only if it is high quality; with the remaining probability $1-\rho$ she buys the product without reading its terms. In the former case, if the quality is low (which occurs with probability $1-\pi^*(r)$), she buys from a low-quality firm if $k=1$, and, if $k \geq 2$, then she visits another, randomly chosen, high quality firm, and proceeds with the same strategy until it is the last high quality firm, in which case she simply buys its good without reading its terms. With this stationary search and reading strategy, a high type consumer will purchase a high-quality good with probability:

$$\Upsilon(\rho;\pi) = \pi + \rho(1-\pi)\left[\pi + \rho(1-\pi)\left[....[\pi]\right]\right] = \pi\left(\sum_{i=0}^{k-1}\rho^i(1-\pi)^i\right)$$

First consider the case of $k=1$. Then, $\Upsilon(\rho;\pi)=\pi$, so if the sole high quality firm randomizes with $\pi=\pi^*(r)$, the consumer receives high quality with probability $\pi^*(r)$, just as required in the socially optimal outcome. If consumer reads its terms with probability $\tilde{\rho}(r) = \frac{c}{\pi^*(r)\theta\Delta}$, then the consumer will purchase from the sole high-quality firm with probability

$$1-\tilde{\rho}(r)+\tilde{\rho}(r)\pi^*(r) = \frac{\pi^*(r)\theta\Delta - (1-\pi^*(r))c}{\pi^*(r)\theta\Delta} = \lambda^*(r)$$

as desired in the socially optimal outcome.

Now consider $k \geq 2$. Note here that $\Upsilon(\rho;\pi)$ increases continuously with ρ, and equals π when $\rho=0$ and equals $\overline{\phi}_k(\pi)$ when $\rho=1$. This means that for any $\phi \in [\pi, \overline{\phi}_k(\pi)]$, there exists ρ such that $\Upsilon(\rho;\pi)=\phi$. In particular, there exists $\hat{\rho}(r)$ such that $\Upsilon(\hat{\rho}(r);\pi^*(r)) = \phi^*(r)$. If the consumer follows the stationary search and reading strategy with $\rho=\hat{\rho}(r)$, then she will obtain high quality with probability $\phi^*(r)$. Since she ultimately purchases from a high quality firm, $\lambda=1$, just as in the socially optimal outcome.

PROPOSITION 1 *If $r \leq \hat{r}$, there exists an equilibrium implementing the outcome $(\pi^*(r), \lambda^*, \phi^*(r))$. In this equilibrium, each firm $i, ..., k$ chooses high quality with probability $\pi^*(r)$ and charges price $p_H = \pi^*(r)\theta\Delta$, and the remaining firms $k+1, ..., n$, choose low quality and charges zero price; each low type consumer purchases from a randomly chosen low quality firm, and each high type consumer employs the search/reading/purchasing strategy described above* *with $\rho = \tilde{\rho}(r)$ if $k = 1$ and with $\hat{\rho}(r)$ if $k \geq 2$. The equilibrium outcome yields the social welfare of*

$$SW^*(k) := \begin{cases} \alpha\left(\pi^*(r)\theta\Delta - c\right) + q_L & \text{if } k = 1 \\ \alpha\left(\pi^*(r)\theta\Delta - \phi^*(r)c\right) + q_L & \text{if } k \geq 2 \end{cases}$$

Consumers enjoys any zero rents, attaining the payoff of

$$CS^*(k) = q_L.$$

Proof. Observe first the socially optimal outcome $(\pi, \lambda, \phi) = (\pi^*(r), \lambda^*(r), \phi^*(r))$ satisfies (3) with equality. This means from (2) that high type consumers are indifferent to reading the terms of the firms she visits. The outcome also satisfies (9) with $\phi < \lambda$ and $\pi\theta\Delta = \frac{(1-\pi)\phi}{\phi-\lambda\pi}c$. This latter equality means, via (8), that $\pi\theta\Delta = p_H$, which is precisely the stated pricing strategy by high-quality firms. The price level in turn implies that

$$\pi\theta\Delta + q_L - p_H = q_L$$

which means that the high type consumers are indifferent between purchasing from a high-quality firm (without reading its terms) and purchasing from a low-quality firm. The two types of indifference means that employing the strategy with $\hat{\rho}(r)$ is a best response for each high type consumer (when all other players adopt their own part of the equilibrium strategies).

Low quality firms have no profitable unilateral deviation as long as such a deviation is met with a belief that the deviator is offering low quality. Meanwhile, the price level $p_H = \pi^*(r)\theta\Delta$ means that the high quality firms are indifferent between offering low quality and offering high quality, given that the high type consumers follow the strategy with $\hat{\rho}(r)$ which yields the desired level of ϕ implementing (8). Hence, it is the best response of each high-quality firm to randomize with $\pi = \pi^*(r)$. ■

Several observations are worth making. First, the socially optimal outcome requires the high type consumers to appropriate none of the additional surplus associated with high quality. In other words, all the surplus associated with matching high quality to high type consumers are appropriated by the high quality firms. These rents serve to motivate them to provide high quality. More precisely, the threat of losing the rents in case high type consumers read their contracts motivate them to choose high quality with positive probability. As will be seen, it is indeed possible to motivate firms to provide high quality with some surplus allocated to high type consumers. But that requires them to read the contracts more vigorously, thus creating more deadweight loss. The social welfare thus will be lower with such an outcome.

Relatedly, the socially optimal outcome never induces the high type consumers to read contracts with probability one. More precisely, with positive probability, the high type consumers choose not to read some contracts. Again, this can be understood from the perspective of optimally balancing the trade-off of reading cost and the incentive for quality provision.

The number of high quality firms competing matters only when it rises from one to two, but competition has no further effect on social welfare or consumer surplus if the number rises beyond $k = 2$. If there is only one high quality firm, the high-type consumers can only punish the firm by switching to a low-quality firm. Further, the consumers can consumer high quality with probability no high than $\pi^*(r)$. If there are more than one high quality firm, consumers can punish a firm (for choosing a low quality) by switching to another high quality firm and can thus increase its chance of consuming high quality above $\pi^*(r)$. Indeed, such a strategy turns out to be optimal. At the same time, the strategy implementing the optimal outcome does not require the consumers to read the terms of every (high-quality) firm she visits with probability one. In fact, there is a search/reading strategy that will enable the consumers to implement the optimal outcome no matter how many high quality firms there are (so long as there is more than one such firm). This does not mean, however, that the consumers will adopt the same search strategy regardless of the number of high quality firms. The optimal search/reading probability $\hat{\rho}$ declines with k.

Last, notice that both $\phi^*(r)$ and $\pi^*(r)$ approach 1 as $r \to 0$. Hence, as $r \to 0$,

$$SW^*(r) \to \alpha(\theta\Delta - c) + q_L$$

which is the first best. Despite the free riding and shirking on reading, the consumers can non-cooperatively enforce the first best outcome in the limit as the reading becomes costless. This results stands in sharp contrast to the analysis by Katz of the monopoly case. In his model, the free riding problem causes the consumers to shirk on reading to such an extent that no consumer will ever read the terms of a monopolist, and the latter in turn shirks on quality, so that the lowest possible quality is always chosen regardless of the size of the reading cost. In this sense, there is a discontinuity of equilibrium behavior and quality choice at zero reading cost. In our model, competition restores the continuity at zero reading costs. The free-riding/shirking problem is overcome due to the firms randomizing on quality, which in turn motivates the consumers to read and inspect the quality. The latter behavior in turn motivates the firms to provide high quality with positive probability.

4 Duty to Speak

Suppose we impose on the firms a duty to communicate ("speak") the terms to the consumer before purchase. There are two different ways to impose such a duty. The first is through a set of penalty default terms. Under this regime (the "default speak (DS) regime"), if either a firm speaks the terms to a consumer and/or the consumer reads the terms, the offered terms are binding. If a firm does not speak the terms and a consumer does not read, regardless of the actual terms, default terms are binding. We assume that default terms are pro-consumer (q_H).[7]

Under the second regime (the "mandatory speak (MS) regime"), the law can require all firms to speak the terms to consumers as a pre-condition to be able to sell in the market but without imposing any default substantive terms. Firms must speak but the offered terms are binding on the consumers whether or not they read the terms. This regime induces behaviors that are similar to the duty to read regime but for the firms' speaking. Since we can adopt the analysis from the previous section without much change, we focus first on the default speak regime.

In the default speak regime, if a firm wants to offer high quality, conditional on price, it is better for the firm not to incur s and communicate the terms to a consumer. Therefore, a firm will speak the terms only when it attempts to contract around the default terms and provide low quality (q_L). Similarly, if a consumer observes that a firm is silent, she knows that the quality is high, whereas if she observes that a firm attempts to speak the terms, she must know that the quality is low. In either case, the consumer has no incentive to read the terms.

Suppose high quality firms do not speak and charge p_H, and low quality firms speak and charge p_L. For the high type consumers, they will purchase from the high quality, non-speaking firm if $\theta\Delta + q_L - p_H \geq q_L - p_L$ or $\theta\Delta \geq p_H - p_L$. The low type consumers, on the other hand, will always purchase from the firm(s) with the lowest price. Since,

[7] Another variation is to impose the default terms whenever a seller does not speak, regardless of whether or not a buyer reads and accepts the terms. Substantive results will not be different.

by assumption $\theta\Delta \geq c$, we must have $\theta\Delta \geq c - s$. This implies that when firms engage in marginal cost pricing ($p_H = c$ and $p_L = s$), the high type consumers purchase from non-speaking firms.

Similar to the case where the consumers have the duty to read, there is a trivial equilibrium where all firms set $(p_L = s, q_L, \mathit{speak})$ and all consumers buy at a randomly chosen firm without reading. Consumers believe any firm that offers $p \neq p_L$ to be producing low quality. If a firm deviates by setting $p > p_L$, whether the firm offers high or low quality, consumers will not visit the firm based on their belief. Reducing the price below s will only produce a negative profit. Hence, there is no deviation. Unlike the case where the consumers have the duty to read, in this equilibrium, the firms have to incur the speaking cost. The social welfare is $SW = q_L - s$. Unlike the trivial pooling equilibrium in the duty to read case, the social welfare is lower because all firms must speak to contract around the default terms. In addition to the trivial equilibrium, there also is a separating equilibrium similar to the one in the duty to read regime.

Proposition 2 *In the default speak regime, there is a separating equilibrium where firms* $1, ..., k$, $1 \leq k \leq n-2$ *("high quality firms") use* $(p_H, q_H, \text{not speak})$*; and firms* $k+1, ..., n$ *("low quality firms") use* $(p_L = s, q_L, \mathit{speak})$*. When* $n = 3$, $p_H \in [c, \theta\Delta + s]$ *and when* $n \geq 4$, $p_H = c$*. All high type consumers purchase from the high quality firms and all low type consumers purchase from low quality firms. Neither type of consumers reads. The equilibrium social welfare is*

$$SW^{DS}(s) = \alpha(\theta\Delta - c) - (1 - \alpha)s + q_L$$

When $n \geq 4$*, consumers enjoy the maximal welfare, attaining the payoff of*

$$CS^{DS}(s) = SW^{DS}(s).$$

Proof. Suppose $n = 3$. Two firms use $(p_L = s, q_L, \mathit{speak})$ and one firm uses $(p_H, q_H, \text{not speak})$ where $p_H \in [c, \theta\Delta + s]$. High type consumers purchase from the high quality firm and the low type consumers purchase from the low quality firms at random. Consumers believe that (1) if they observe any price $p \notin \{p_H, p_L\}$ by either type of firms, the firm must be offering q_L and (2) all speaking, low quality firms offer q_L.

The high quality firm would not want to deviate by either setting $p'_H \neq p_H$ or by speaking, since by doing so, all the high type consumers will either not visit the firm or go to a low quality firm upon discovering the firm's speaking policy. The low type firms would not want to deviate either since charging any price $p'_L \neq p_L$ results in either zero or negative profit and not speaking results in a negative profit. The condition $p_H \in [c, \theta\Delta + s]$ guarantees that the high type consumers are better off purchasing from the high quality firm than from a low quality firm.

Suppose $n \geq 4$. Now, high quality firms use ($p_H = c, q_H, \textit{not speak}$) and the low quality firms use ($p_L = s, q_L, \textit{speak}$). Consumers separate based on their types as before with the similar set of beliefs.

To show that there is no profitable deviation, suppose a firm offers ($p_L = s, q_L, \textit{speak}$). If it were to deviate and charge $p_L < p < p_H$, no consumers will come since they can purchase q_L from cheaper firms. If it were to charge $p = p_H$ and to speak, consumers will not purchase from the firm, believing that the firm offers low quality. Finally, offering q_H (by not speaking) while charging p_L or setting $p < p_L$ would result in a negative profit. For similar reasons, a firm would not want to deviate from ($p_H = c, q_H, \textit{not speak}$), either. ■

Although the market is segmented between high and low quality firms and the consumers choose in accordance, the social welfare is lower by the cost of communication born by the low quality firms. As $s \to 0$, the social welfare approaches the first best level: $SW^{DS}(s) \to \alpha(\theta\Delta - c) + q_L$. When $n \geq 4$, both types of firms charge their respective marginal costs and earn zero profit in equilibrium and the socially optimal outcome is also the consumer optimal outcome. Finally, all high type consumers purchase high quality goods from high quality firms, $\phi^* = \lambda^* = 1$.

Under the mandatory speak regime, because all firms must communicate their terms to the consumers, the consumers' reading cost is lowered from r to r'. On the other hand, because speaking is mandatory, the consumers cannot tell whether the offered terms are of high or low quality. They must incur the cost of reading to find its true quality and this introduces the same dynamic as in the duty to read case.

Proposition 3 *In the mandatory speak regime, if $r' \leq \hat{r}$, there exists an equilibrium implementing the socially optimal outcome $(\pi, \lambda, \phi) = (\pi^*(r'), \lambda^{MS}(r', s), \phi^{MS}(r', s))$, where*

$$\lambda^{MS}(r', s) = \begin{cases} \frac{(\pi^*(r')\theta\Delta - s)\theta\Delta - (1-\pi^*(r'))c}{(\pi^*(r')\theta\Delta - s)} & \textit{if } k = 1 \\ 1 & \textit{if } k \geq 2 \end{cases}$$

and

$$\phi^{MS}(r', s) = \begin{cases} \pi^*(r') & \text{if } k = 1 \\ \frac{\pi^*(r')(\pi^*(r')\theta\Delta - s)}{(\pi^*(r')\theta\Delta - s) - (1-\pi^*(r'))c} & \text{if } k \geq 2 \end{cases}$$

In the equilibrium, each firm $i, ..., k$ chooses high quality with probability $\pi^*(r')$ and charges price $p_H = \pi^*(r')\theta\Delta$, and the remaining firms $k+1, ..., n$, choose low quality and charges zero price; each low type consumer purchases from a randomly chosen low quality firm, and each high type consumer employs the search/reading/purchasing strategy identical to that under the duty to read regime. The equilibrium outcome yields the social welfare of

$$SW^{MS}(k) := \begin{cases} \alpha\left(\pi^*(r')\theta\Delta - c\right) + q_L - s & \text{if } k = 1 \\ \alpha\left(\pi^*(r')\theta\Delta - \phi^{MS}(r', s)c\right) + q_L - s & \text{if } k \geq 2 \end{cases}$$

Consumers enjoys zero rents, attaining the payoff of

$$CS^{MS}(k) = q_L.$$

Proof. Analogous to the duty to read regime case. ■

Compared to the duty to read case, the cost borne by the firms to speak their terms to the consumers lower the social welfare by s. On the other hand, because the reading cost is also lower, the high type consumers are more likely to purchase the high quality products: $\pi^*(r') > \pi^*(r)$ and $\phi^{MS}(r', s) > \phi^*(r)$. When compared to the duty to read regime, therefore, the relative social welfare is ambiguous. However, when compared to the default speak regime, it is not.

Corollary 1 *The default speak regime produces a strictly higher social welfare than the mandatory speak regime.*

Proof. When $k = 1$, $\alpha\left(\pi^*(r')\theta\Delta - c\right) + q_L - s < \alpha(\theta\Delta - c) - (1-\alpha)s + q_L$. When $k \geq 2$, since $\phi^{MS}(r, s) > \pi^*(r)\ \forall r$, $\pi^*(r')\theta\Delta - \phi^{MS}(r', s)c < \pi^*(r')[\theta\Delta - c] < \theta\Delta - c$. This implies that

$$\begin{aligned} &\alpha\left(\pi^*(r')\theta\Delta - \phi^{MS}(r', s)c\right) + q_L - s \\ &\qquad < \alpha\pi^*(r')[\theta\Delta - c] + q_L - s \\ &\qquad\qquad < \alpha(\theta\Delta - c) - (1-\alpha)s + q_L \end{aligned}$$

Therefore, $SW^{MS}(k) < SW^{DS}(k)\ \forall k$. ■

Requiring all firms to speak leads to lower social welfare not only because all, as opposed to a subset of, firms must incur the cost of communication, but also because the high type consumers still need to monitor high quality firms by reading the terms with a positive probability. The latter inefficiency occurs because disclosure policy per se does not distinguish between firm types.

5 Comparing Legal Regimes

We now compare the two legal regimes. Given the multiplicity of equilibria in each regime, we must select an equilibrium. Under the duty-to-speak regime, we focus on the separating equilibrium using the default set of terms.

PROPOSITION 4 *The duty to read regime welfare dominates the duty to (default) speak regime if and only if $r < \bar{r}(s)$, where $\bar{r}(s) > 0$ for any $s > 0$ and $\bar{r}(\cdot)$ is increasing. The ratio, $\frac{\bar{r}(s)}{s}$ converges to $\frac{1-\alpha}{\alpha}$ as $s \to 0$, if $k = 1$; and $\frac{\bar{r}(s)}{s}$ converges to a level strictly higher than $\frac{1-\alpha}{\alpha}$ as $s \to 0$, if $k > 1$.*

Proof. The first statement follows from the fact that the social welfare under duty to read, $SW^*(k)$, decreases in r, that $SW^*(k) \to \alpha(\theta\Delta - c) + q_L$ as $r \to 0$, and that social welfare under duty to speak decreases in s. To prove the second statement, observe

$$\frac{SW^*(1) - SW^{DS}(1)}{s} = (1-\alpha) - \alpha\frac{(1-\pi^*(r))\theta\Delta}{s} = (1-\alpha) - \alpha\frac{r}{s\pi^*(r)}.$$

Since the RHS must vanish if $r = \bar{r}(s)$. It thus follows that $\frac{\bar{r}(s)}{s} \to \frac{1-\alpha}{\alpha}$ as $s \to 0$. The case of $k > 1$ is completely analogous except for the fact that the first equality holds with strict inequality, which then leads to the desired result. ■

This result suggests that the comparison of the two regimes depends on the relative magnitudes of the consumers' cost of reading and the firms' cost of speaking. Although the fact that these two costs would figure in the comparison of the two regimes seems sensible and natural, this has not been the implication of the existing literature. For instance, Katz (1990) demonstrates that, in the case of a monopolist, no consumer reads and no firm provides high quality in the duty to read regime, no matter how small the reading cost is. This led him to conclude that if the firm's speaking cost is sufficiently low, the duty to speak regime will dominate the duty to read regime, whenever the reading cost is positive.

The above proposition suggests a different conclusion in the case of competition. If there are three or more firms, the competition among firms can motivate consumers to read the terms of the firms' contracts under the duty-to-read regime, which in turn can motivate the firms to provide high quality. The equilibrium incentives for both consumers and the firms become more effective as the consumers' reading cost declines, and in the limit as the reading cost vanishes, the outcome under the duty-to-read regime approaches the first best. Consequently, for any level of speaking cost, there exists a level of reading costs that will cause the duty-to-read regime to dominate the duty-to-speak regime.

In practice, the per-consumer reading cost and per-consumer speaking cost for the firms may be very small. The second statement in the proposition makes the comparison of the two legal regimes precise in such a case. In particular, it suggests that if $\alpha \approx \frac{1}{2}$, the duty-to-read regime could dominate the duty-to-speak even when the reading cost is higher than the firms' speaking cost, if both are sufficiently small and $k > 1$. This result lends support to the duty-to-read regime since in practice the speaking cost on the part of the firm is likely to be higher than the reading cost on the part of the consumers. This result follows from the subtle difference in the way the two regimes work: while any firm providing low quality *must* incur the speaking cost under the duty-to-speak regime, under the duty-to-read regime, the consumers *may not always* read a firm's terms to motivate it to choose high quality. Only the credible threat to do so is sufficient for the motivation. In fact, in the socially efficient equilibrium, the cost of reading is expended efficiently vis-a-vis firms' quality choice. More precisely, each high type consumer receives high quality with probability $\phi^*(r)$ but ends up appropriating the surplus of $\pi^*(r)$ from high quality, with the difference $\phi^*(r) - \pi^*(r)$ being lost to the reading cost expended by consumers. That is, motivating a unit probability of high quality from a firm requires only probability $\frac{\phi^*(r)-\pi^*(r)}{\phi^*(r)} < 1$ of reading by a consumer. This feature favors the duty to read regime.

Before we proceed, we note that while the proposition relies on the socially optimal equilibrium in the duty to read regime, both statements of the proposition are qualitatively valid had we relied, instead, on the consumer optimal equilibrium. With the consumer optimal equilibrium, the first statement holds relative to some threshold $\tilde{\rho}(s)$ that satisfies the second statement. Next, we compare the two regimes with respect to their respective impact on consumer surplus.

PROPOSITION 5 *The high-type consumers are better off under the duty-to-speak regime; but low-type consumers are worse off under that regime.*

Proof. In the separating equilibrium of the duty to speak regime, the high type consumers enjoy the surplus of $\theta\Delta - c + q_L$, whereas the low-type consumers realize the surplus of $q_L - s$. In the duty-to-read regime, the high-type consumers receive at most the surplus of $\pi^*(r)\theta\Delta - \psi_k(r)c + q_L < \theta\Delta - c + q_L$, and the low-type consumers receive q_L. ■

The two regimes produce welfare trade-offs between the two groups of consumers. The duty to read regime imposes the burden of communicating the contract terms on the consumers, and those who would be adversely affected by the sellers' moral hazard—the high-type consumers—pay the cost by reading. In contrast, the duty to speak regime imposes the burden of communication on the sellers, and naturally those departing from the default, consumer-friendly terms must pay the cost of communication. This cost is passed along to the low-type consumers through a higher price, leading them to prefer the duty to read regime.

6 Conclusion

The paper has examined the issues of mass market contract terms, such as end user license agreements (EULA's), that accompany goods and services. The analysis has relied on a search model in which consumers search for quality, such as better warranty terms and minimal use restrictions, rather than price, while firms compete on price, quality and disclosure policy. Unlike the existing search models, while all consumers must incur a positive reading (search) cost to understand the terms, (1) not everyone cares about the terms equally and (2) they can buy a product without fully understanding its quality, i.e., without reading. At the same time, some consumers (high type) care more about quality than others (low type).

The paper has examined two legal regimes: one that makes all contract terms binding on the consumers regardless of their reading behavior (duty-to-read regime) and one that mandates some form of pre-sale disclosure on the sellers (duty-to-speak regime). The paper demonstrates that while neither regime strictly dominates the other, as either the reading or speak cost converges to zero, the equilibrium social welfare continuously converges to the first best. The distribution of welfare is sensitive to the regime: the consumers who care about the terms will prefer the duty-to-speak regime, but those who do not will prefer the other. Finally, the paper shows that when we compare the seller who disclose the terms to those who do not, not only might their qualify difference small, but the disclosing seller's terms might actually be worse. This finding is consistent with the recent empirical research on end user license agreements.

Appendix A: Proofs

Proof. [Proof of Lemma 3] Observe first the candidate optimal outcome $(\pi, \lambda, \phi) = (\pi^*(r), \lambda^*(r), \phi^*(r))$ satisfies $\phi < \lambda$ and $\pi\theta\Delta = \frac{(1-\pi)\phi}{\phi-\lambda\pi}c$, namely condition (9) with equality. Hence, condition (10) holds. Condition (3) also holds with equality, with $\pi = \pi^*(r)$. Finally, (11) also holds given that $r \leq \hat{r}$. Hence, $(\pi, \lambda, \phi) \in \mathcal{E}^*$. This means that, for $r \leq \hat{r}$, $\mathcal{E}^*$ is non-empty. It is also compact. Hence, the problem [SW] has a solution. We first establish the following claim:

Claim 1 *If (π, λ, ϕ) solves [SW], then $\pi\theta\Delta = \frac{(1-\pi)\phi}{\phi-\lambda\pi}c$.*

Proof. *If this is not true, then either we have $\lambda = \phi$ or $\pi\theta\Delta > \frac{(1-\pi)\phi}{\phi-\lambda\pi}c$. The first possibility can be easily ruled out, since $\lambda = \phi < 1$, then (11) means that $\pi\theta\Delta = \frac{(1-\pi)\phi}{\phi-\lambda\pi}c$, a contradiction.*

Hence, suppose $\lambda > \phi$ and $\pi\theta\Delta > \frac{(1-\pi)\phi}{\phi-\lambda\pi}c$. By (11), we have $\lambda = 1$. Since the constraint for ϕ never binds from below, we must have

$$\frac{\partial SW}{\partial \phi} = \alpha\left(\theta\Delta - \frac{r}{\pi(1-\pi)} - c\right) \geq 0. \tag{13}$$

Suppose first this condition holds with equality. Then,

$$SW(\pi, 1, \phi) = \alpha\frac{r}{1-\pi} + q_L = \pi(\theta\Delta - c) + q_L.$$

If $\pi < \pi^*(r)$, then raising π can increase social welfare without violating any constraints. Hence, we must have $\pi = \pi^*(r)$. But then $\theta\Delta = \frac{r}{\pi(1-\pi)}$, so $\frac{\partial SW}{\partial \phi} < 0$, a contradiction.

Suppose now $\frac{\partial SW}{\partial \phi} > 0$. Then, we must have $\phi = \overline{\phi}_k(\pi)$. Then,

$$\begin{aligned}
\frac{dSW(\pi, 1, \overline{\phi}_k(\pi))}{d\pi} &= \frac{d\overline{\phi}_k}{d\pi}\frac{\partial SW}{\partial \phi} + \alpha r\frac{\pi^2 + \overline{\phi}_k(\pi)(1-2\pi)}{\pi^2(1-\pi)^2} \\
&> \alpha r\frac{\pi^2 + \overline{\phi}_k(\pi)(1-2\pi)}{\pi^2(1-\pi)^2} \\
&= \alpha r\frac{\pi^2 + (1-(1-\pi)^k)(1-2\pi)}{\pi^2(1-\pi)^2} \\
&= \alpha r\frac{(1-\pi)^2 - (1-\pi)^k(1-2\pi)}{\pi^2(1-\pi)^2} \\
&= \alpha r\frac{(1-\pi)^2(1-(1-\pi)^{k-2}(1-2\pi))}{\pi^2(1-\pi)^2} \\
&> 0,
\end{aligned}$$

for all $k \geq 1$. Hence, again $\pi = \pi^*(r)$, which leads to the same contradiction of $\frac{\partial SW}{\partial \phi} < 0$. ■

Using Claim 1, we can rewrite the social welfare objective as

$$\begin{aligned} SW(\pi, \lambda, \phi) &= \alpha\phi[\theta\Delta - c] - \alpha\left(\frac{\phi - \pi\lambda}{\pi(1-\pi)}\right) r + q_L \\ &= \alpha\phi\left(\theta\Delta - \frac{cr}{\pi^2\theta\Delta} - c\right). \end{aligned}$$

Observe

$$\begin{aligned} \frac{\partial SW}{\partial \phi} &= \alpha\left(\theta\Delta - \frac{cr}{\pi^2\theta\Delta} - c\right) \\ &\geq \theta\Delta - \frac{1-\pi}{\pi}c - c \\ &= \theta\Delta - \frac{1}{\pi}c > 0, \end{aligned}$$

where the first inequality follows from (3) and the last from Claim 1. One can easily see that $\frac{\partial SW}{\partial \pi} > 0$.

Let $G(\pi, \lambda, \phi) := (\phi - \lambda\pi)\pi\theta\Delta - (1-\pi)\phi c$. One can easily find that $G_\lambda < 0$ and $G_\phi > 0$ when $G = 0$. Suppose first that $G_\pi \leq 0$ at the optimal (π, λ, ϕ). Then, $\frac{d\phi}{d\pi}|_{G=0} = -\frac{G_\pi}{G_\phi} \geq 0$. Hence,

$$\frac{dSW}{d\pi}|_{G=0} = \frac{\partial SW}{\partial \phi}\frac{d\phi}{d\pi}|_{G=0} + \frac{\partial SW}{\partial \pi} > 0.$$

Hence, we conclude that $\pi = \pi^*(r)$.

Suppose now $G_\pi > 0$ at the optimal (π, λ, ϕ). Then, $\frac{d\lambda}{d\pi}|_{G=0} = -\frac{G_\pi}{G_\lambda} > 0$. Hence,

$$\begin{aligned} \frac{dSW}{d\pi}|_{G=0} &= \frac{\partial SW}{\partial \lambda}\frac{d\lambda}{d\pi}|_{G=0} + \frac{\partial SW}{\partial \pi} \\ &= \frac{\partial SW}{\partial \pi} > 0. \end{aligned}$$

We again conclude that $\pi = \pi^*(r)$.

Next, using $\frac{d\phi}{d\lambda}|_{G=0} = -\frac{G_\lambda}{G_\phi} > 0$, we observe

$$\frac{dSW}{d\lambda}|_{G=0} = \frac{\partial SW}{\partial \phi}\frac{d\phi}{d\lambda}|_{G=0} + \frac{\partial SW}{\partial \lambda} > 0,$$

which leads us to conclude that either the upper bound for either λ or ϕ must be binding. In the case of $k=1$, the upper bound for ϕ, $\overline{\phi}_1(\pi)=\pi$ is reached first, so $\phi=\pi=\pi^*(r)$. In the case of $k\geq 2$, the upper bound for λ is reached first, so $\lambda=1$.

Finally, Claim 1 implies that ϕ must be chosen to satisfy $G(\pi,\lambda,\phi)=0$. Hence, in the case of $k=1$, since $\pi=\pi^*(r)$ and $\phi=\pi^*(r)$, we must have $\lambda=\frac{\pi^*(r)\theta\Delta-(1-\pi^*(r))c}{\pi^*(r)\theta\Delta}$. In the case of $k\geq 2$, since $\pi=\pi^*(r)$ and $\lambda=1$, we must have $\phi=\frac{\pi^*(r)^2\theta\Delta}{\pi^*(r)\theta\Delta-(1-\pi^*(r))c}$.

Since the necessary condition of optimality pins down a unique outcome $(\pi^*(r),\lambda^*(r),\phi^*(r))$, and the problem $[SW]$ has a solution, we conclude that the outcome indeed solves $[SW]$.
■

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