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Incentivizing Investments in Environmental Quality

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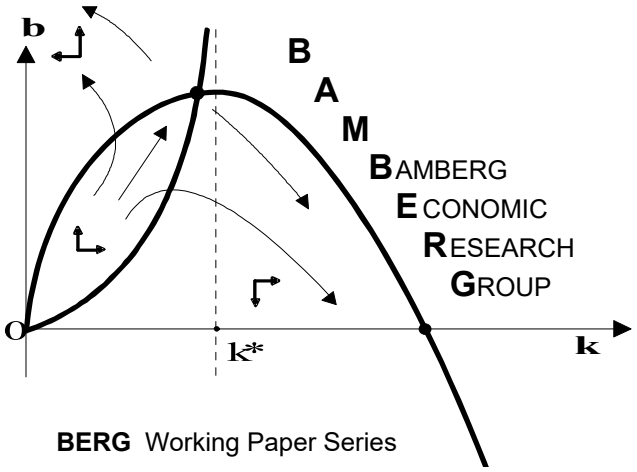
Working Paper No. 206

May 2025



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https://doi.org/10.20378/irb-

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Awards vs. Labels: Incentivizing Investments in Environmental Quality*

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May 6, 2025

Abstract

Although consumers often care about environmental quality, limited attention impairs consumers' perception of environmental quality. Environmental awards and labels make environmental quality salient and attract consumers' attention. We analyze how awards and labels affect firms' investments in environmental quality and social welfare. We show that, with an award, both firms invest in environmental quality; with a label, only one firm invests. Under awards, investments depend positively on salience. Under labels, investments depend non-monotonically on salience. A welfare-maximizing social planner prefers awards over labels if and only if marginal damage and salience are sufficiently high such that consumers overestimate the environmental quality of the goods.

KEYWORDS: awards, environmental quality, labels, limited attention, salience.

JEL CODE: D91, L13, L15, Q52, Q58

*We are grateful to Joshua Bißbort, Fabian Dietz, Stephan Eitel, Florian Herold, Marco Sahm, Armin Schmutzler, and participants at the 38th BGPE Research Workshop in Bayreuth, the 2025 AURÖ Workshop for Young Researchers in Environmental and Resource Economics, the CESifo / ifo Junior Workshop on Energy & Climate Economics 2025, and seminars at the University of Bamberg for valuable comments and suggestions. Stefanie Y. Schmitt gratefully acknowledges financial support from the Joachim Herz Foundation. Lisa Heidelmeier gratefully acknowledges financial support by the Hans-Böckler-Stiftung.

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1 Introduction

Although consumers often care about the environmental quality of the goods they consume,[1] limited attention impairs consumers' perception of environmental quality.[2] To increase the salience and thereby draw consumers' attention to environmental quality, firms often employ environmental labels. Prominent labels include, for example, *Blue Angel*, *EU Ecolabel*, *Energy Star*, *FSC*, *Green Button*, or *WaterSense*.[3] Increasingly, firms that won an environmental award also advertise this award on their goods to make their environmental quality salient and attract consumers' attention. Environmental awards include, for example, the *UN Global Climate Action Award*, the *Champions of the Earth*, or the *German Sustainability Award*.[4]

In this article, we analyze the effects of environmental awards and labels on firms' investments in environmental quality. We discuss how environmental awards and labels differ in incentivizing investments and investigate the implications of environmental awards and labels on social welfare. In particular, we analyze under which circumstances a social planner should implement an environmental award and under which circumstances a social planner should implement an environmental label.

We consider a model with two firms, a social planner with the objective to maximize social welfare, and a unit mass of consumers. The social planner chooses between implementing an environmental award and implementing an environmental label. If the social planner implements an environmental award, the firms compete in a lottery contest for the award. That means, a firm's probability of winning the award is given by the firm's relative investment in environmental quality and is thus increasing in the firm's absolute investment in environmental quality. If the social planner implements an environmental label, a firm receives the label if its investments in environmental quality exceed the labeling threshold.

[1] See, e.g., Ward et al. (2011), Löschel et al. (2013), Kuhn & Uler (2019), Hulshof & Mulder (2020), Morone et al. (2021), Bartling et al. (2024), European Commission—Directorate-General for Communication (2024), Ruggeri et al. (2024).

[2] See, e.g., Allcott & Taubinsky (2015), Sexton (2015), Tiefenbeck et al. (2018), Wang et al. (2018), Andor et al. (2020), Boogen et al. (2022), Sejas-Portillo et al. (2025).

[3] The *Blue Angel* is a label for environmental friendly products in Germany (RAL gGmbH 2024*b*). The *EU Ecolabel* is a label for environmental friendly products in the EU (RAL gGmbH 2024*a*). The *Energy Star* is a label for energy efficiency in the US (Energy Star 2024). The *FSC* is a label for a sustainable management of forests (Forest Stewardship Council 2024). The *Green Button* is a label for sustainable textiles in Germany (Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH 2024). *WaterSense* is a label for water efficiency in the US (Environmental Protection Agency - United States 2024).

[4] The *UN Global Climate Action Award* highlights projects and any initiatives by people, businesses, governments, and industries that focus both on climate change and broader economic, social, and environmental challenges (UNFCCC 2024). The *Champions of the Earth award* of the UN Environment Program recognizes individuals and organizations for innovative and transformative actions fighting against climate change, biodiversity loss, and pollution and waste (United Nations Environment Programme 2024). The *German Sustainability Award* rewards companies, municipalities, and research institutions for their ecological and social engagement (Stiftung Deutscher Nachhaltigkeitspreis 2024).

We assume that consumers do not pay attention to the environmental quality of a good unless an environmental award or an environmental label makes the environmental quality of the good salient. That means, we focus on the attention-generating effect of awards and labels. Nevertheless, awards and labels do not always ensure that consumers perceive the true environmental quality of the good. Depending on the designs of the award and the label, consumers may perceive the environmental qualities perfectly or imperfectly, i.e., the perception of consumers may be biased. We capture both cases by including a salience parameter that may distort the perception of environmental quality and allows for under- as well as for overestimation of environmental quality.[5]

Our article highlights that environmental awards and labels affect firms' investments in environmental quality differently. With an award, both firms invest in environmental quality. With a label, at most one firm invests in environmental quality. The underlying reason is that firms have an incentive to differentiate in environmental quality to generate market power. With the award, consumers only perceive the environmental quality of the award winner. Therefore, even if both firms invest equally in environmental quality, consumers perceive a difference in environmental quality between the winner and the loser of the contest. We show that, with the award, firms' investments are increasing in the salience that the award generates. In contrast, with the label, if both firms invest equally into environmental quality, consumers would perceive the goods as identical. This would yield intense price competition and prices equal to marginal costs. Therefore, firms differentiate with one firm investing to receive the label and one firm not investing enough to receive the label. The investments in environmental quality depend on the labeling threshold. We show that investments are weakly increasing in the labeling threshold as long as the labeling threshold is sufficiently low. If the labeling threshold is too high, neither firm invests in environmental quality. The social planner sets the labeling threshold to maximize social welfare. The optimal labeling threshold depends non-monotonically on the salience that the label generates as well as on the marginal damage of emissions from production.

Whether an environmental award or an environmental label results in higher social welfare depends on the salience that the award and the label generate as well as on the marginal damage caused by emissions. We show that if consumers perceive the environmental quality of awarded and of labeled goods perfectly or if consumers underestimate the environmental quality of labeled or awarded goods, the environmental label results in higher social welfare than the award. In contrast, the environmental award results in higher social welfare than the environmental label if and only if the marginal damage and the salience of environmental quality are sufficiently high such that consumers overesti-

[5]Empirical evidence shows that environmental advertisement and labels may induce consumers to perceive environmental performance higher (e.g., Houde 2018, Sejas-Portillo et al. 2025) or lower (e.g., Andor et al. 2019) than it actually is.

mate the environmental quality of awarded and of labeled goods. The social planner has a higher level of control with the label. With the label, the social planner can choose the labeling threshold optimally. Such an optimization is not possible with the award. In particular, the social planner can induce the same level of emissions under the label regime as under the award regime. Under this particular labeling threshold, consumers' benefits with the label are higher than with the award. Yet, the costs to firms are higher with the label. For sufficiently low salience, the benefits of the label outweigh the costs.

In addition, we explore three extensions of our model. First, as environmental awards and labels are often introduced by NGOs, we discuss whether an NGO with the objective to minimize total damages introduces an environmental award or an environmental label. We show that an NGO always implements an environmental label. With the label, the NGO can ensure higher total investments in environmental quality and thus lower damages.

Second, we assume that the existence of an environmental award draws consumers' attention to environmental quality in general. Therefore, the environmental quality of both goods, awarded and non-awarded, becomes salient. However, the salience of the awarded good is higher than the salience of the non-awarded good. This translates into a contest with two prizes. This extension increases the range of values for which the social planner chooses the award instead of the label: The award is preferable to the label also for lower values of the marginal damage. Nevertheless, the award only yields higher welfare than the label in cases where awards and labels lead to sufficient overestimating of environmental quality and the salience of the non-awarded good is sufficiently high. Otherwise, the label yields higher social welfare.

Third, environmental awards and labels might not draw consumers' attention to the environmental quality of goods in the same way. Therefore, we extend the baseline model by allowing the salience generated by the environmental award and the salience generated by the environmental label to differ. We show that, the environmental award results in higher social welfare than the environmental label if and only if consumers' estimation of the environmental quality of the awarded good is not too high (such that costs to firms remain sufficiently low) while either sufficiently underestimating or sufficiently overestimating the environmental quality of the label. In these cases, firms invest less in environmental quality with the label than with the award. Otherwise, the label yields higher social welfare.

The remainder of the article is structured as follows: In Section 2, we discuss our contributions to the related literature. Section 3 introduces our model. In Section 4, we analyze the social planner's decision between implementing an environmental award and implementing an environmental label, the firms' equilibrium investments in environmental quality, and the equilibrium prices. In Section 5, we discuss extensions to the main model. Section 6 concludes.

2 Related literature

Environmental awards and environmental labels make firms' environmental performance visible to consumers. In this article, we analyze the effects of environmental awards and environmental labels on firms' investments in environmental quality and on social welfare. Therefore, we contribute primarily to two strands of the environmental economics literature.

First, we contribute to the literature on eco-labels. A large part of this literature analyzes under which conditions introducing an eco-label increases welfare or reduces environmental externalities. Previous literature finds that the labeling design, firms' relative investment costs, and costs for eco-labeling influence the effectiveness of eco-labels (e.g., Amacher et al. 2004, Ibanez & Grolleau 2008, Li & van't Veld 2015, Fischer & Lyon 2019). Nevertheless, several articles also highlight that labels can reduce welfare: For example, labels can have negative welfare effects if there is potential for fraud in green markets (Hamilton & Zilberman 2006), if the certification process is noisy (Mason 2011), if consumers are confused about the label standards (Harbaugh et al. 2011), or if consumers need to acquire information about the label standards to understand the meaning of a particular label (Heyes et al. 2020). In addition, firms can have incentives to increase investment in brown technologies before labels are adopted which increases overall externalities (Dosi & Moretto 2001). If labeling criteria are endogenously determined to maximize total surplus, labels may, for example, have a negative effect on consumer surplus through higher prices such that it is optimal not to implement any label (Ben Youssef & Lahmandi-Ayed 2008).[6]

The existing literature mostly assumes that consumers can directly infer the environmental quality of a good from its label. However, labels do not always ensure that consumers perceive the true environmental quality of the goods. Consumers' perception of environmental quality depends on the salience of the label. We contribute to this literature by accounting for salience effects. This extension to the existing literature also allows us to capture biases in consumer perception. We highlight the importance of accounting for salience by showing that salience affects firms' investments in environmental quality, prices, and welfare as well as the optimal labeling threshold that the social planner implements.

Second, we contribute to the literature on environmental awards. In contrast to the labeling literature, only little research analyzes the effects of environmental awards on investments in environmental quality and on welfare. We model the environmental award as a contest.[7] The previous literature on contests in environmental economics concentrates on the effects of monetary prizes on the provision of a public good, on countries' efforts

[6]For an overview of the eco-labeling literature see van't Veld (2020).

[7]For an overview on contest theory see Konrad (2009).

to reduce emissions, or on firms' environmental investments when subsidies are allocated via a contest (e.g., Morgan 2000, Bos et al. 2016, Osorio & Zhang 2022). In contrast, we focus on the effects of winning an award on consumers' willingness to pay and on the resulting changes in demand. Thereby we provide insights into how environmental contests affect consumer behavior. Heidelmeier & Sahm (2025) also account for effects of environmental awards on consumers' perceptions of the awarded good. However, they focus on the analysis of the optimal environmental award and highlight that implementing an environmental award may harm consumers. In contrast, we focus on how investments in environmental quality depend on different levels of salience.

Our main contribution is to show that environmental awards and environmental labels have different effects on firms' incentives to invest in environmental quality. Thereby, we combine the two strands of the literature on eco-labels and on environmental awards. Our analysis provides a better understanding of the circumstances under which a welfare-maximizing social planner should implement an environmental award and under which circumstances a welfare-maximizing social planner should implement an environmental label. In addition, we contribute to each of the two strands separately by analyzing how consumers' limited attention affects firms' investments in environmental quality.

We draw on the limited attention literature and assume that awards and labels draw consumers' attention to the environmental quality by making environmental quality salient. In modeling salience, we draw on DellaVigna (2009) and Gabaix (2019).[8] Other articles that incorporate limited attention into models with environmental externalities, for example, show that optimal taxes should depend on consumers' attention (Allcott et al. 2014, Houde & Myers 2019, Farhi & Gabaix 2020, Gilbert & Graff Zivin 2020, van der Ploeg 2025). Heyes et al. (2018) analyze firms' competition with an NGO about making externalities salient. In contrast to these articles, we focus on how policy interventions affect firms' investments in environmental quality. Our article is thus more closely related to Schmitt (2025).[9] In contrast to Schmitt (2025), who analyzes the effects of taxes, subsidies, information campaigns, and mandatory disclosure on firms' investments and on welfare, we focus on awards vs. labels and compare the effectiveness of these policy instruments.

[8] Articles modeling markets for a good with salient attributes and limited consumer attention include, for example, Eliaz & Spiegler (2011), Bordalo et al. (2016), Hefti (2018), Hefti & Liu (2020), Carroni et al. (2023). For an overview of the literature on limited attention see Gabaix (2019).

[9] In particular, given the underlying vertical product differentiation model, the mechanism behind our label and the perception threshold in Schmitt (2025) are similar. However, our results on investments under an environmental award differ significantly.

3 Model

We consider a market where two firms, firm 1 and firm 2, compete for a unit mass of consumers. The firms produce goods with identical base value $v \in \mathbb{R}_0^+$ to consumers. The production of the goods causes emissions. To reduce the per-unit emissions, firms can invest in environmental quality $q_i \in \mathbb{R}_0^+$ with $i \in \{1, 2\}$. The per-unit net emissions of firm i are then $e - q_i$.[10] Investing in environmental quality is costly. We assume that firms have identical cost functions $C(q_i) = cq_i^2$ with $c \in \mathbb{R}_0^+$. In addition, we assume that all other production costs are identical and set them to zero.

Each consumer wants to buy exactly one unit of the good. A consumer who buys one unit of the good from firm $i \in \{1, 2\}$ receives utility

$$u_\theta(i) = v + \theta q_i - p_i, \tag{1}$$

where p_i is the price of the good of firm i and θ is the marginal willingness to pay for environmental quality. We assume that θ is uniformly distributed on $[0, 1]$ and that v is large enough such that, in equilibrium, the market is covered.

Although consumers value the environmental quality of goods, consumers do not automatically pay attention to the environmental quality of goods. In particular, we assume that consumers do not consider the environmental quality of goods that carry neither an award nor a label. In contrast, awards and labels make the environmental quality salient and draw consumers' attention to the environmental quality of the awarded/labeled good. Thus consumers consider the environmental quality of goods that carry an award or a label. We assume that consumers' perception of the environmental quality of an awarded or a labeled good depends on the salience $\sigma > 0$ that awards and labels generate: σq_i. Consequently, the perceived environmental quality of good i is

$$\hat{q}_i = \begin{cases} \sigma q_i & \text{if good } i \text{ has received an award / a label,} \\ 0 & \text{otherwise.} \end{cases} \tag{2}$$

With the award, only one firm wins the award. If firm i wins the award, the perceived environmental quality is $\hat{q}_i = \sigma q_i$. If firm i does not win the award, the perceived environmental quality is $\hat{q}_i = 0$. With the label, both firms may receive the label. If firm i receives the label, the perceived environmental quality is $\hat{q}_i = \sigma q_i$. If firm i does not receive the label, the perceived environmental quality is $\hat{q}_i = 0$.[11] As the perceived environmental

[10] We assume that e is large enough such that, in equilibrium, firms' emissions are always positive.

[11] Without further information, consumers do not pay attention to the environmental quality of goods which results in a perceived environmental quality of $\hat{q}_i = 0$. If a firm makes its environmental quality salient, consumers update towards the true environmental quality, i.e., $\hat{q}_i = (1 - \sigma) \cdot 0 + \sigma \cdot q_i = \sigma q_i$. To capture evidence that labels (and awards) can lead to overestimation of environmental quality, we allow for $\sigma > 1$. See DellaVigna (2009) and Gabaix (2019) for similar approaches.

quality depends on the true environmental quality, if both firms receive the label but differ in their environmental qualities, then consumers do perceive a difference in environmental quality.[12] If $\sigma = 1$, consumers perceive the environmental quality of awarded/labeled goods perfectly. If $\sigma < 1$, the perceived environmental quality of awarded/labeled goods is lower than the true environmental quality (underestimation). If $\sigma > 1$, the perceived environmental quality of awarded/labeled goods is higher than the true environmental quality (overestimation).

In their consumption decision, consumers take the perceived environmental quality $\hat{q}_i$ into account. Therefore, we distinguish between the experienced utility in (1) and the decision utility

$$\hat{u}_\theta(i) = v + \theta\hat{q}_i - p_i.$$

In equilibrium, one firm produces goods with higher environmental quality than the other firm. We denote by h the firm with the higher perceived environmental quality and by l the firm with the lower perceived environmental quality, i.e., $\hat{q}_h \geq \hat{q}_l$. Consumers buy the good of the firm with the higher perceived environmental quality if their decision utility from buying the good with the higher perceived environmental quality exceeds the decision utility from buying the good with the lower perceived environmental quality:

$$\hat{u}_\theta(h) \geq \hat{u}_\theta(l) \;\Leftrightarrow\; \theta \geq \bar{\theta} \equiv \frac{p_h - p_l}{\hat{q}_h - \hat{q}_l}.$$

$\bar{\theta}$ describes the indifferent consumer. Therefore, the demand for the good of the firm with the higher and the demand for the good with the lower perceived environmental quality are $x_h^D(p_h, p_l, \hat{q}_h, \hat{q}_l) = 1 - \bar{\theta}$ and $x_l^D(p_h, p_l, \hat{q}_h, \hat{q}_l) = \bar{\theta}$.

The social planner can implement either an award or a label. If the social planner implements an award, firms compete for the award in a lottery contest. Then, firm i's probability of winning the environmental award $\alpha_i(q_i, q_j)$ is given by the following contest success function:

$$\alpha_i(q_i, q_j) = \begin{cases} \frac{1}{2} & \text{if } q_i = q_j \\ \frac{q_i}{q_i + q_j} & \text{otherwise,} \end{cases}$$

for $i, j \in \{1, 2\}$ and $i \neq j$ (Tullock 1980). This contest success function reflects that a social planner cannot always perfectly observe firms' investments and fully discriminate when assigning the environmental award. The lottery contest incorporates some noise: A firm can (ceteris paribus) increase its probability of winning the award by increasing its investment, but the firm with the highest investment does not win with certainty.

[12] For example, energy labels may give consumers information about the true environmental quality if they include information such as the actual kWh usage.

If the social planner implements a label, the social planner has to determine a labeling threshold $\bar{q}$. Goods with environmental quality $q_i \geq \bar{q}$ receive the label and goods with environmental quality $q_i < \bar{q}$ do not receive the label. If the social planner implements the award, only one firm can receive the award, but if the social planner implements the label, both firms can receive the label.

The social planner decides between either implementing an award or implementing a label to maximize social welfare: $W = CS + PS - D(E)$, i.e., the sum of consumer surplus (CS) and producer surplus (PS, the sum of firms' profits), minus the damages caused by emissions $D(E)$ where $E = (e - q_1)x_1^D(p_1, p_2, \hat{q}_1, \hat{q}_2) + (e - q_2)x_2^D(p_1, p_2, \hat{q}_1, \hat{q}_2)$ are the total net emissions in the market. We assume the following damage function: $D(E) = \delta E$ with $\delta > 0$ representing marginal damage.

We consider the following three-stage game (see Figure 1): In the first stage, the social planner decides whether to implement either an award or a label with threshold $\bar{q}$.[13] In the second stage, firms observe the decision of the social planner and simultaneously invest in environmental quality. In the third stage, if the social planner has implemented an award, the social planner awards the contest winner and firms observe the environmental quality of their competitor and which firm received the award. Then, firms simultaneously choose their prices. In contrast, if the social planner has implemented a label, the social planner labels the goods that exceed the labeling threshold and firms observe the environmental quality of their competitor and which goods are labeled. Then, firms simultaneously choose their prices. Afterwards, consumers make their consumption decision. We solve the game by backward-induction for the subgame-perfect equilibria in pure strategies.

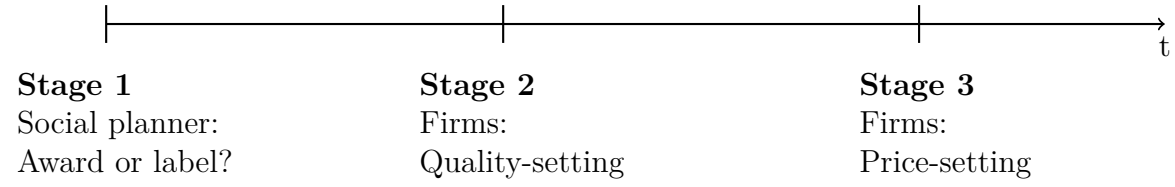

Figure 1: Timeline.

In general, we denote the environmental quality and the price of firm i by q_i and p_i. However, to facilitate comparison between awards and labels, we add subscripts A for award and L for label for the equilibrium environmental qualities and prices, i.e., $q_{i,A}^*$, $p_{i,A}^*$, $q_{i,L}^*$, and $p_{i,L}^*$.

4 Awards vs. labels

In this section, we derive and compare the equilibrium outcomes under awards and labels.

[13] In Section 5.1, we discuss how our results change if, instead of a social planner, an NGO with the objective to minimize total damage decides between introducing an award or introducing a label.

4.1 Price-setting stage

In the third stage of the game, firms choose their prices to maximize their profits given the investments in environmental quality from the previous stage. The profits of the firms depend on the perceived environmental qualities. Consequently, the price-setting stage is identical for the subgames where the social planner has implemented an award and for the subgames where the social planner has implemented a label. Firms simultaneously choose their prices to maximize their profits

$$\pi_h(p_h, p_l, \hat{q}_h, \hat{q}_l) = p_h \cdot x_h^D(p_h, p_l, \hat{q}_h, \hat{q}_l) - cq_h^2 = p_h(1 - \bar{\theta}) - cq_h^2$$
$$\pi_l(p_h, p_l, \hat{q}_h, \hat{q}_l) = p_l \cdot x_l^D(p_h, p_l, \hat{q}_h, \hat{q}_l) - cq_l^2 = p_l\bar{\theta} - cq_l^2.$$

Consequently, equilibrium prices are

$$p_h = \frac{2}{3}(\hat{q}_h - \hat{q}_l) \quad \text{and} \quad p_l = \frac{1}{3}(\hat{q}_h - \hat{q}_l). \tag{3}$$

Prices are increasing in the perceived difference in environmental qualities. The firm with the higher perceived environmental quality chooses a higher price in equilibrium. The indifferent consumer is located at $\bar{\theta} = 1/3$ such that the demand for the good with the higher perceived environmental quality is $x_h^D = 2/3$ and the demand for the good with the lower perceived environmental quality is $x_l^D = 1/3$.

4.2 Quality-setting stage

In the second stage of the game, firms invest in environmental quality q_i anticipating the market prices. We need to distinguish two cases. First, we analyze firms' investments in environmental quality if the social planner has implemented an environmental award. Second, we analyze firms' investments in environmental quality if the social planner has implemented an environmental label.

4.2.1 Environmental award

If the social planner has implemented an award, consumers' perceived environmental quality of a good depends on whether the good is awarded or not. Firms' investments in environmental quality determine (i) the probability with which each firm wins the award and (ii) the profits that the firms receive if they win and if they lose the contest.

The firm that wins the contest is always the firm with the higher perceived environmental quality, i.e., firm h, whereas the firm that loses the contest is always the firm with the lower perceived environmental quality, i.e., firm l. If firm i wins the award, the perceived environmental qualities of firms $i, j \in \{1, 2\}$ with $i \neq j$ are $\hat{q}_i = \hat{q}_h = \sigma q_i$ and $\hat{q}_j = \hat{q}_l = 0$. The corresponding profit of firm i is $\pi_h(\hat{q}_h = \sigma q_i, \hat{q}_l = 0)$. If firm i loses and

firm j wins the award, the perceived environmental qualities of the firms are $\hat{q}_i = \hat{q}_l = 0$ and $\hat{q}_j = \hat{q}_h = \sigma q_j$. The corresponding profit of firm i is $\pi_l(\hat{q}_h = \sigma q_j, \hat{q}_l = 0)$.

Consequently, the expected profit of firm i is

$$\begin{aligned}\mathbb{E}[\pi_i] &= \alpha_i(q_i, q_j) \cdot \pi_h(\hat{q}_h = \sigma q_i, \hat{q}_l = 0) + \Big(1 - \alpha_i(q_i, q_j)\Big) \cdot \pi_l(\hat{q}_h = \sigma q_j, \hat{q}_l = 0) \\ &= \frac{q_i}{q_i + q_j}\frac{4}{9}\sigma q_i + \left(1 - \frac{q_i}{q_i + q_j}\right)\frac{1}{9}\sigma q_j - c q_i^2.\end{aligned}$$

Firms choose their environmental qualities simultaneously to maximize their expected profits. Firms face the following trade-off: On the one hand, as a higher investment translates into a higher probability of winning the contest, the firms have an incentive to invest in environmental quality. On the other hand, as a higher investment results in higher costs, the firms have an incentive to invest less in environmental quality. In equilibrium, firms choose investments in environmental quality to balance these two effects. Proposition 1 summarizes the equilibrium.

Proposition 1 (Award equilibrium) *Let $i \in \{1, 2\}$ and denote by h (l) the firm that wins (loses) the contest and thus has a higher (lower) perceived environmental quality. If the social planner has implemented an award, in the subgame-perfect equilibrium, environmental qualities and prices are $q^*_{i,A} = (11\sigma)/(72c)$, $p^*_{h,A} = 2\sigma q^*_{i,A}/3$, and $p^*_{l,A} = \sigma q^*_{i,A}/3$.*

The proof is in Appendix A.

Proposition 1 shows that, in equilibrium, both firms invest the same amount into environmental quality. Firms' investments in environmental quality are increasing in the salience σ that the award generates and are decreasing in the investment costs c. As firms choose the same environmental qualities in equilibrium, both firms are equally likely to win the award. Yet, consumers perceive the environmental quality of the firm that wins the award to be higher than the environmental quality of the firm that loses. Therefore, the firm that wins the award is able to charge a higher price, i.e., $p^*_{h,A} > p^*_{l,A}$. Nevertheless, both firms charge positive prices.

4.2.2 Environmental label

If the social planner has implemented an environmental label with threshold $\bar{q}$, consumers' perceived environmental quality of a good depends on whether the good receives the label. If the good of firm $i \in \{1, 2\}$ does not receive the label, i.e., if $q_i < \bar{q}$, consumers perceive the environmental quality of the good as $\hat{q}_i = 0$. If the good of firm i receives the label, i.e., if $q_i \geq \bar{q}$, consumers perceive the environmental quality of the good as $\hat{q}_i = \sigma q_i$. The profit of firm i depends on (i) whether firm i receives the label, (ii) whether firm $j \in \{1, 2\}$ with $i \neq j$ receives the label, and (iii) whether firm i is the firm with the higher perceived environmental quality.

If $q_j \geq \bar{q}$, firm j receives the label and the profit of firm i is

$$\pi_i(q_i, q_j) = \begin{cases} \frac{4}{9}(\sigma q_i - \sigma q_j) - cq_i^2 & \text{if } q_i \geq q_j \\ \frac{1}{9}(\sigma q_j - \sigma q_i) - cq_i^2 & \text{if } \bar{q} \leq q_i < q_j \\ \frac{1}{9}\sigma q_j - cq_i^2 & \text{if } q_i < \bar{q}. \end{cases} \tag{4}$$

If firm j receives the label, the profit of firm i depends on whether firm i also receives the label or whether firm i does not receive the label. If firm i also receives the label, i.e., $q_i \geq \bar{q}$, the perceived environmental qualities of the firms are $\hat{q}_i = \sigma q_i$ and $\hat{q}_j = \sigma q_j$. Then, the prices and the resulting revenues depend on which firm has the higher environmental quality. If firm i chooses a higher environmental quality than firm j, i.e., $q_i \geq q_j$ (first case of (4)), firm i is the firm with the higher perceived environmental quality, sets a higher price in the price-setting stage, and thus receives a higher revenue than firm j. In contrast, if firm i chooses a lower environmental quality than firm j, i.e., $q_i < q_j$ (second case of (4)), firm i is the firm with the lower perceived environmental quality, sets a lower price in the price-setting stage, and thus receives a lower revenue than firm j. The third case of (4) illustrates the situation where firm i chooses a quality below the labeling threshold and thus does not receive the label. As the prices depend on the difference in perceived environmental qualities, in this case, the prices depend only on firm j's environmental quality: $\hat{q}_j - \hat{q}_i = \sigma q_j - 0$.

If $q_j < \bar{q}$, firm j does not receive the label and the profit of firm i is

$$\pi_i(q_i, q_j) = \begin{cases} \frac{4}{9}\sigma q_i - cq_i^2 & \text{if } q_i \geq \bar{q} \\ -cq_i^2 & \text{if } q_i < \bar{q}. \end{cases} \tag{5}$$

If firm j does not receive the label, the profit of firm i only depends on whether firm i receives the label. If firm i chooses an environmental quality above the labeling threshold, i.e., $q_i \geq \bar{q}$ (first case of (5)), firm i is always the firm with the higher perceived environmental quality and thus chooses a higher price than firm j in the price-setting stage. If firm i chooses an environmental quality below the labeling threshold, i.e., $q_i < \bar{q}$ (second case of (5)), consumers do not perceive any difference in environmental quality between the goods. The intense price competition drives prices down to marginal costs of zero and both firms make zero revenue.

Firms simultaneously choose their environmental qualities to maximize their profits.[14] The optimal environmental qualities depend on the labeling threshold $\bar{q}$. In general, firms have an incentive to differentiate in their environmental qualities and to ensure that consumers perceive this difference. If firms choose goods with identical environmental

[14]We make the following tie-breaking assumption: If firm i is indifferent between an environmental quality $q_i < \bar{q}$ and an environmental quality $q_i \geq \bar{q}$, firm i chooses quality $q_i \geq \bar{q}$ and implements the label.

quality, the goods only differ in prices. This leads to intense price competition and thus to prices equal to marginal costs of zero. In contrast, a perceived difference in environmental quality gives firms market power to charge prices above marginal costs and the optimal prices depend on the difference in perceived environmental qualities (see Section 4.1). Consequently, in the benchmark where the social planner labels all goods, i.e., $\bar{q} = 0$, two asymmetric equilibria result where firms differentiate with one firm choosing a positive environmental quality and the other firm choosing zero environmental quality: $q^*_{i,L} = (2\sigma)/(9c)$, $q^*_{j,L} = 0$ for all $i, j \in \{1, 2\}$ and $i \neq j$. This benchmark equilibrium is maintained as long as the labeling threshold is sufficiently low, i.e., for $\bar{q} \leq (2\sigma)/(9c)$.

If the social planner chooses a labeling threshold $\bar{q} > (2\sigma)/(9c)$, the firm with the higher environmental quality needs to increase its investment in environmental quality. With an environmental quality of $q_{i,L} = (2\sigma)/(9c)$, firm i would no longer receive the label. Then, consumers would perceive both goods as having identical environmental quality $\hat{q}_i = \hat{q}_j = 0$ and intense price competition ensures zero revenues. To avoid this case, firm i increases its investment to produce goods where the environmental quality is high enough to receive the label: $q^*_{i,L} = \bar{q}$. Then, consumers perceive a product differentiation and both firms are able to choose prices above marginal costs and make positive revenues. With increasing labeling threshold, firm i needs to increase its investments which increases the costs. For $\bar{q} > (4\sigma)/(9c)$, the costs exceed the revenues such that the firm prefers to produce goods that do not satisfy the labeling criteria. Then, as consumers do not perceive the environmental quality of the goods and are not willing to pay for positive environmental quality, but positive investments are costly, the firms do not invest in environmental quality.

Lemma 1 summarizes the equilibria.

Lemma 1 *Let $i, j \in \{1, 2\}$ with $i \neq j$. If the social planner implements a label with labeling threshold $\bar{q}$, the subgame-perfect equilibria depend on the labeling threshold:*

(i) If $\bar{q} \leq (4\sigma)/(9c)$, two asymmetric subgame-perfect equilibria exist where environmental qualities and prices are $q^*_{i,L} = max\{(2\sigma)/(9c), \bar{q}\}$, $q^*_{j,L} = 0$, $p^*_{i,L} = 2\sigma q^*_{i,L}/3$, and $p^*_{j,L} = \sigma q^*_{i,L}/3$.

(ii) If $\bar{q} > (4\sigma)/(9c)$, one symmetric subgame-perfect equilibrium exists where environmental qualities and prices are $q^*_{i,L} = q^*_{j,L} = 0$, $p^*_{i,L} = p^*_{j,L} = 0$.

The proof is in Appendix B.1.

Lemma 1 shows that firms' investments in environmental quality depend on the labeling threshold that the social planner chooses. As long as the labeling threshold is sufficiently low, i.e., $\bar{q} \leq (4\sigma)/(9c)$, investments in environmental quality are weakly increasing in the labeling threshold. In addition, an increase in the salience σ increases the

range for which one firm chooses a positive level of investment and (weakly) increases that investment.

The social planner chooses the labeling threshold optimally to maximize social welfare. As increasing prices imply a pure reallocation of welfare from consumers to firms, the social planner only takes into account the effects of the labeling threshold on the equilibrium environmental qualities and on firms' costs. A labeling threshold that increases investments in environmental quality is beneficial to consumers as consumers receive a higher utility from consuming the goods and higher investments additionally reduce damages. Yet, a labeling threshold that increases investments in environmental quality is harmful to firms because it increases firms' costs. The optimal labeling threshold takes this trade-off into account.

According to Lemma 1, equilibrium environmental qualities depend on the salience σ. If σ increases, the investments weakly increase and the range of labeling thresholds for which one firm invests a positive amount into environmental quality increases. Consequently, the optimal labeling threshold depends on the salience σ: First, as long as the salience is sufficiently low (relative to the marginal damage), i.e., if $\sigma \leq (2+3\delta)/4$, the positive effects outweigh the negative effects and the social planner chooses the labeling threshold that maximizes (average) investments in environmental quality: $\bar{q}^* = (4\sigma)/(9c)$. Second, for greater salience, i.e., if $(2+3\delta)/4 < \sigma < (2+3\delta)/2$, such a labeling threshold would imply high costs for the firms. To reduce this negative effect, the social planner chooses a lower labeling threshold such that one firm still invests more into environmental quality than in the benchmark, but without being excessively costly. Third, if σ increases further, i.e., if $(2+3\delta)/2 \leq \sigma \leq 2+3\delta$, it becomes optimal to choose a labeling threshold such that the benchmark equilibrium results. Fourth, if $\sigma > 2+3\delta$, setting the labeling threshold such that one firm invests any positive amount into environmental quality implies high costs for the firm. This negative effect outweighs any positive effects.

Proposition 2 summarizes the results.

Proposition 2 (Label equilibria) *Let $i, j \in \{1,2\}$ with $i \neq j$. If the social planner implements a label, the optimal labeling threshold depends on the salience σ:*

(i) If $\sigma \leq (2+3\delta)/4$, the optimal labeling threshold is $\bar{q}^* = (4\sigma)/(9c)$ and firms' equilibrium environmental qualities and prices are $q^*_{i,L} = \bar{q}$, $q^*_{j,L} = 0$, $p^*_{i,L} = 2\sigma q^*_{i,L}/3$, and $p^*_{j,L} = \sigma q^*_{i,L}/3$.

(ii) If $(2+3\delta)/4 < \sigma < (2+3\delta)/2$, the optimal labeling threshold is $\bar{q}^* = (2+3\delta)/(9c)$ and firms' equilibrium environmental qualities and prices are $q^*_{i,L} = \bar{q}$, $q^*_{j,L} = 0$, $p^*_{i,L} = 2\sigma q^*_{i,L}/3$, and $p^*_{j,L} = \sigma q^*_{i,L}/3$.

(iii) If $(2+3\delta)/2 \leq \sigma \leq 2+3\delta$, the optimal labeling threshold is any $\bar{q}^* \in [0, 2\sigma/(9c)]$ and firms' equilibrium environmental qualities and prices are $q^*_{i,L} = (2\sigma)/(9c)$, $q^*_{j,L} = 0$, $p^*_{i,L} = 2\sigma q^*_{i,L}/3$, and $p^*_{j,L} = \sigma q^*_{i,L}/3$.

(iv) If $\sigma > 2 + 3\delta$, the optimal labeling threshold is any $\bar{q}^* \in ((4\sigma)/(9c), \infty)$ and firms' equilibrium environmental qualities and prices are $q^*_{i,L} = q^*_{j,L} = 0$ and $p^*_{i,L} = p^*_{j,L} = 0$.

The proof is in Appendix B.2.

4.3 Social planner: awards vs. labels

In the first stage of the game, the social planner chooses between implementing an award and implementing a label. The social planner can also choose not to implement any policy (no policy case, denoted by N). However, without any policy intervention, consumers cannot distinguish between the goods' environmental qualities. Then, perceived environmental qualities are $\hat{q}_{i,N} = 0$ for $i \in \{1, 2\}$. The game reduces to Bertrand competition where prices are set equal to marginal costs. That means, independent of their actual investments in environmental quality, firms receive zero revenue. In addition, any positive investment in environmental quality is costly. Consequently, without any policy intervention, both firms do not invest in environmental quality: $q^*_{i,N} = 0$ for $i \in \{1, 2\}$. The social welfare is $W_N = v - \delta e$. As shown in Appendix B.2, welfare under labeling is weakly higher than welfare without any policy. Therefore, we only focus on awards vs. labels.

The social planner implements the policy which generates the higher social welfare. Consumers benefit from goods with higher environmental quality which increases social welfare. In addition, higher environmental quality reduces damages which also increases social welfare. However, producing goods with environmental quality is costly. Therefore, higher environmental quality also has negative effects on social welfare.

One major difference between awards and labels is that, in equilibrium, with the award both firms invest in environmental quality, whereas, with the label only one firm invests in environmental quality. If $\sigma \leq (2 + 3\delta)/4$, the total investments in environmental quality with the label are higher than the total investments with the award ($q^*_{1,A} + q^*_{2,A} = (22\sigma)/(72c)$, $q^*_{1,L} + q^*_{2,L} = (4\sigma)/(9c)$). Consumers receive more utility and damages are lower with the label, but costs are lower with the award. In sum, if $\sigma \leq (2 + 3\delta)/4$, the positive effects of the label dominate. Consequently, for any $\sigma \leq (2 + 3\delta)/4$, the social planner implements the label.

If $(2 + 3\delta)/4 < \sigma < (2 + 3\delta)/2$, with the label, 2/3 of the consumers buy from the high-quality firm and receive an environmental quality of $(2 + 3\delta)/(9c)$, whereas, 1/3 of consumers buy from the low-quality firm and receive an environmental quality of 0. In contrast, with the award all consumers receive an environmental quality of $(11\sigma)/(72c) < (2+3\delta)/(9c)$. However, the salience parameter σ determines whether total investments are higher with the award or with the label. The salience parameter σ also determines whether damages are higher with the award or with the label. In addition, costs are lower with the award. Consequently, if the marginal damage δ (i.e., the weight

of the damage in the social welfare is high) and the salience σ (which affects the firms' costs more than consumers' utility) are sufficiently large, the social planner implements the award. Otherwise, the social planner implements the label.

If $(2+3\delta)/2 \leq \sigma \leq 2+3\delta$, the total investments in environmental quality with the award are higher than with the label ($q^*_{1,A} + q^*_{2,A} = (22\sigma)/(72c)$, $q^*_{1,L} + q^*_{2,L} = (2\sigma)/(9c)$). With the label, 2/3 of the consumers buy from the high-quality firm and receive an environmental quality of $(2\sigma)/(9c)$, whereas, 1/3 of consumers buy from the low-quality firm and receive an environmental quality of 0. In contrast, with the award all consumers receive an environmental quality of $(11\sigma)/(72c) < (2\sigma)/(9c)$. Damages are lower with the award than with the label. In addition, costs are lower with the award. Consequently, if the marginal damage δ is sufficiently large (i.e., the weight of the damages in the social welfare is high) or the marginal damage is intermediate and the salience σ is sufficiently large (which affects the firms' costs more than consumers' utility and thus benefits the award), the social planner implements the award. Otherwise, the social planner implements the label.

If $\sigma > 2+3\delta$, the total investments in environmental quality with the award are higher than with the label ($q^*_{i,A} = (11\sigma)/(72c)$, $q^*_{i,L} = 0$ for all $i \in 1, 2$). Consequently, consumers receive more utility and damages are lower with the award, but costs are lower with the label. Whether the positive effects of the award dominate depends on the marginal damage δ and the salience σ. If the marginal damage is sufficiently large (i.e., the weight of the damage in the social welfare is large) and the salience is sufficiently small (which affects the firms' costs more than consumers' utility), the social planner implements the award. Otherwise, the social planner implements the label.

Proposition 3 summarizes the results.

Proposition 3 (Award vs. Label) *Whether the social planner implements an environmental award or an environmental label depends on the marginal damage δ and the salience σ that awards and labels generate: The social planner implements the award if and only if the marginal damage and the salience are sufficiently high, i.e., if and only if* $48/11 < \sigma \leq 22/5$ *with* $(33\sigma-32)/48-\sqrt{121\sigma^2-528\sigma}/48 < \delta < (33\sigma-32)/48+\sqrt{121\sigma^2-528\sigma}/48$ *or* $\sigma > 22/5$ *with* $max\{(58-7\sigma)/12, (11\sigma-18)/36\} < \delta < (33\sigma-32)/48+\sqrt{121\sigma^2-528\sigma}/48$. *Otherwise, the social planner implements the label.*

The proof is in Appendix C.

Figure 2 illustrates Proposition 3 graphically. The social planner only implements an award if salience is sufficiently high. In particular, the award never gives a higher social welfare than the label if salience σ is so low that consumers perceive the environmental quality of a labeled/award-winning good as lower than it actually is. In addition, even if labels or awards ensure that consumers perceive the environmental quality of labeled/awarded goods perfectly, the award never yields a higher social welfare than the

label. That means, the label is always better for salience $\sigma \leq 1$.

The award and the label provide mechanisms for firms to make differentiation in environmental quality salient to consumers. However, the social planner has a higher level of control with the label. The label allows the social planner to choose the labeling threshold optimally and thus influence the investments in environmental quality directly. As the award does not offer such an optimization mechanism, this advantage of the label ensures that the label is optimal in a large range of situations.[15] In particular, with the award, emissions are $E_A = e - 11\sigma/(72c)$. The social planner can induce this level of emissions under the label regime with a labeling threshold of $\bar{q} = 11c/(47\sigma)$. Then, although emissions are identical with the label and with the award, consumers' benefits with the label are higher than with the award. Yet, the costs are also higher with the label. For $\sigma < 48/11$, the benefits of the label outweigh the costs. Therefore, the award is never better for any $\sigma < 48/11$.

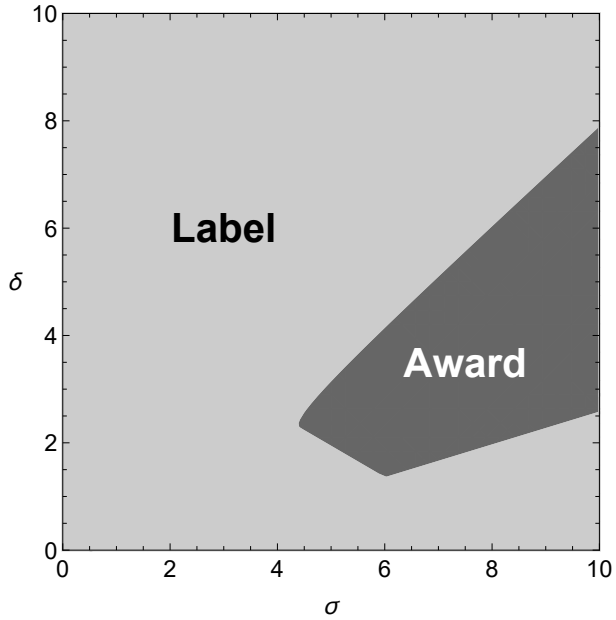

Figure 2: Policy decision dependent on salience σ and marginal damage δ. In the dark gray area, the social planner implements the award. In the light gray area, the social planner implements the label.

5 Discussion

5.1 NGO

Not all awards or labels are implemented by a social planner with the objective to maximize social welfare. Often, awards or labels are introduced by an NGO with the objective

[15] In Section 5, we discuss two extensions where this advantage of the label is less pronounced.

to minimize total damage $D(E)$. In this section, we analyze whether an NGO implements an environmental award or a label.

First, if the NGO implements an environmental award, firms face the same pricing and quality-investment choices as described in Sections 4.1 and 4.2.1. In equilibrium, firms' investments in environmental quality are $q^*_{i,A} = (11\sigma)/(72c)$ (cf. Proposition 1).

Second, if the NGO implements an environmental label, firms face the same pricing and quality-investment choices as described in Sections 4.1 and 4.2.2. However, an NGO with the objective to minimize total damage chooses a different labeling threshold than a social planner with the objective to maximize social welfare. Given the investments in environmental quality dependent on the labeling threshold (cf. Lemma 1), the damage dependent on the labeling threshold $\bar{q}$ is

$$D(E_L) = \begin{cases} \delta\left(e - \frac{4\sigma}{27c}\right) & \text{if } \bar{q} < \frac{2\sigma}{9c} \\ \delta\left(e - \frac{2\bar{q}}{3}\right) & \text{if } \frac{2\sigma}{9c} \leq \bar{q} \leq \frac{4\sigma}{9c} \\ \delta e & \text{if } \bar{q} > \frac{4\sigma}{9c}. \end{cases} \tag{6}$$

Thus damage is lowest for the labeling threshold $\bar{q} = (4\sigma)/(9c)$, resulting in environmental qualities of $q^*_{i,L} = (4\sigma)/(9c)$ and $q^*_{j,L} = 0$.

The NGO implements the policy that yields the lowest damage. Comparing the damage of the award and of the label, the label always results in lower damage:

$$D(E_L) = \delta\left(e - \frac{8\sigma}{27c}\right) < \delta\left(e - \frac{11\sigma}{72c}\right) = D(E_A).$$

With the label, 2/3 of the consumers buy from the high-quality firm with environmental quality $(4\sigma)/(9c)$, whereas 1/3 of the consumers buy from the low-quality firm with environmental quality 0. In contrast, with the award, all consumers buy a good with environmental quality of $(11\sigma)/(72c) < (4\sigma)/(9c)$. Although some consumers buy a low-quality good under the label regime, on average, the environmental quality of goods under the label regime is higher than under the award regime: $2/3 \times (4\sigma)/(9c) > (11\sigma)/(72c)$. Therefore, emissions and damages are lower under the label regime. Proposition 4 summarizes the result.

Proposition 4 (NGO: Award vs. Label) *For all $\sigma > 0$ and $\delta > 0$, an NGO with the incentive to minimize total damage implements a label with labeling threshold $\bar{q}^* = (4\sigma)/(9c)$ instead of an award.*

5.2 Environmental award with different levels of salience

In the baseline model, we assume that consumers' perception of the environmental quality of the non-awarded good is 0, see (2). Yet, the firm losing the contest may also promote

its environmental performance and thereby generate visibility. Nevertheless, compared to the visibility of the awarded firm, the visibility of the non-awarded firm should be lower. In the following, we allow for the environmental quality of the non-awarded good to be at least partially perceived by the consumers. In particular, we assume that the perceived environmental quality of good i in the award regime is

$$\hat{q}_i = \begin{cases} \sigma q_i & \text{if good } i \text{ has received an award} \\ s\sigma q_i & \text{otherwise,} \end{cases}$$

where $s \in [0, 3/5]$.[16] To keep the model tractable, we set the marginal damage to one in this section: $\delta = 1$.

We solve the game by backward induction. In the third stage, firms face the same pricing game as described in Section 4.1. In the second stage, firms invest in environmental quality q_i. We need to distinguish between the label and the award case. The assumptions do not affect the label case. Consequently, for the label, equilibrium environmental qualities and prices are given in Proposition 2. In contrast, the new assumption changes the quality-setting stage if the social planner has implemented an award. The firm that wins the contest is always the firm with the higher perceived environmental quality, i.e., firm h, whereas, the firm that loses the contest is always the firm with the lower perceived environmental quality, i.e., firm l. If firm i wins the award, the perceived environmental qualities of firms $i, j \in \{1, 2\}$ with $i \neq j$ are $\hat{q}_i = \sigma q_i$ and $\hat{q}_j = s\sigma q_j$. The corresponding profit of firm i is $\pi_h(\hat{q}_h = \sigma q_i, \hat{q}_l = s\sigma q_j)$. If firm i loses and firm j wins the award, the perceived environmental qualities of the firms are $\hat{q}_i = s\sigma q_i$ and $\hat{q}_j = \sigma q_j$. The corresponding profit of firm i is $\pi_l(\hat{q}_h = \sigma q_j, \hat{q}_l = s\sigma q_i)$. As in the baseline model, firms maximize their expected profits from winning and losing the contest. To distinguish the results of the main model from the results of this extension, we call the main model *award with a single prize*, denoted by A, and this extension *award with two prizes*, denoted by $A2$. To be able to compare the results to the award with a single prize, we focus only on the equilibrium with symmetric environmental quality investments.

Lemma 2 summarizes the equilibrium outcomes.

Lemma 2 *Let $i \in \{1, 2\}$ and denote by h (l) the firm that wins (loses) the contest and thus has a higher (lower) perceived environmental quality. If the social planner implements an award with two prizes, the symmetric subgame-perfect equilibrium environmental qualities and prices are $q^*_{i,A2} = (11 - 5s)\sigma/(72c)$, $p^*_{h,A2} = (1 - s)(11 - 5s)\sigma^2/(108c)$, and $p^*_{l,A2} = (1 - s)(11 - 5s)\sigma^2/(216c)$.*

The proof is in Appendix D.1. The model with two prizes converges to the baseline model with a single prize if $s \to 0$. Decreasing the salience share s has two effects: First,

[16] This assumption on s ensures that the symmetric solution of the first-order condition is a maximum.

a decrease in the salience share s for the firm losing the contest leads to an increase in equilibrium quality investment of both firms. Consequently, a decrease in the salience share s results in lower damage.[17] Second, a decrease in the salience share s implies a higher degree of perceived product differentiation, resulting in higher equilibrium prices and more market power for the firms.

When comparing the two prize design to the single prize design, for low policy salience σ, consumer surplus with a single prize exceeds consumer surplus with two prizes. The positive effect of an increase in consumers' utility due to higher environmental qualities outweighs the negative effect due to higher prices. For intermediate policy salience σ, the positive effect dominates and thus the single prize design yields higher consumer surplus if and only if the salience share s is sufficiently high. For high policy salience σ, the negative price effect dominates and consumer surplus with the two prizes exceeds consumer surplus with a single prize.

For $s \in [0, 3/5]$, the single prize design is optimal for the firms, as the single prize allows a higher degree of product differentiation resulting in higher profits, compared to the two prize design.

Regarding social welfare, a single prize design is better than a two prize design for $0 < \sigma \leq (54)/(22-5s)$. The positive effects of increasing consumers' utility and decreasing damage due to increased investments in the single prize design outweigh the negative effect of higher investment costs. Figure 3 illustrates the welfare comparison graphically.

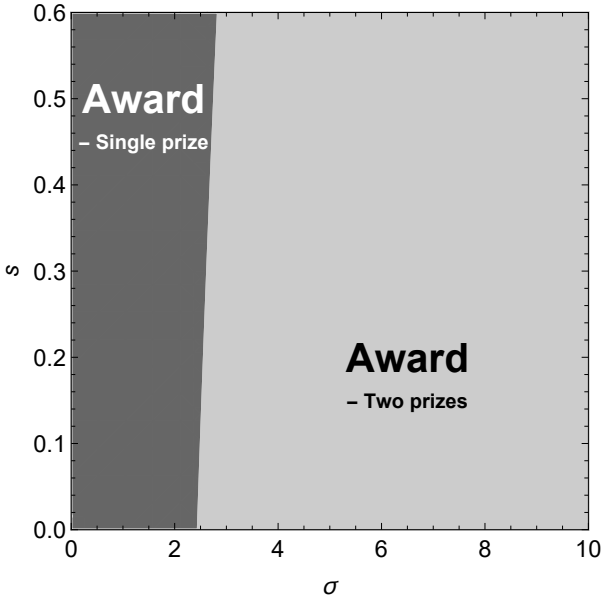

Figure 3: Comparison of social welfare with a single prize design and with a two prize design dependent on the salience σ and s for $\delta = 1$. In the dark gray area, the single prize design yields higher social welfare. In the light gray area, the two prize design yields higher social welfare.

[17] An NGO that has the objective to minimize damages benefits from $s = 0$. Damages with the single prize design ($s = 0$) are lower than damages with the two prize design.

Lemma 3 summarizes the comparison.

Lemma 3 *Comparing the single prize design and the two prize design, the single prize design yields*

(i) lower damage,

(ii) higher consumer surplus for $\sigma \leq 9/26$ *and* $max\{0, (32\sigma - 9)/(10\sigma)\} \leq s \leq 3/5$*,*

(iii) higher producer surplus and

(iv) higher social welfare for $0 < \sigma \leq (54)/(22 - 5s)$*.*

The proof is in Appendix D.2.

According to Proposition 3, the social planner prefers the label to the award with a single prize if $\delta = 1$. Consequently, for $\sigma \leq (54)/(22 - 5s)$, where the single prize design yields a higher social welfare than the two prize design, the social planner always implements the label. For $\sigma > (54)/(22 - 5s)$, where the two prizes design yields a higher social welfare than the single prize design, whether the social planner prefers the label to the award with two prizes depends on the the salience of the awarded good σ and the salience of the non-awarded good $s\sigma$. Proposition 5 summarizes the results.

Proposition 5 *Let the salience of an awarded good be* σ *and the salience of a non-awarded good be* $s \cdot \sigma$ *with* $s \in [0, 3/5]$*. Then, the social planner implements the award with two prizes if and only if* $1/25 < s \leq 3/5$ *and* $(46+270s)/(7+110s-25s^2) < \sigma < (54)/(11-5s)$*. Otherwise, the social planner implements the label.*

The proof is in Appendix D.3. Figure 4 illustrates Proposition 5 graphically. In the main model (Section 4), for $\delta = 1$, the social planner always implements the label. In contrast, in this section, for $\delta = 1$, we identify a range of values where the social planner implements the award. Consequently, for $\delta = 1$, the two-prize regime increases the range of values for which the award generates higher welfare than the label.

For $1/25 < s \leq 3/5$ and $(46 + 270s)/(7 + 110s - 25s^2) < \sigma < (54)/(11 - 5s)$, the social planner implements the award with two prizes. For $1/25 < s \leq 3/5$ and $(46 + 270s)/(7 + 110s - 25s^2) < \sigma \leq 5$, benefits to consumers are higher and damages are lower with the label, but costs are lower with the award. For $1/25 < s \leq 3/5$ and $5 < \sigma < (54)/(11 - 5s)$, benefits to consumers are higher and damages are lower with the award, but costs are lower with the label. In both cases, the positive effects of the award with two prizes dominate such that the social planner implements the award with two prizes.

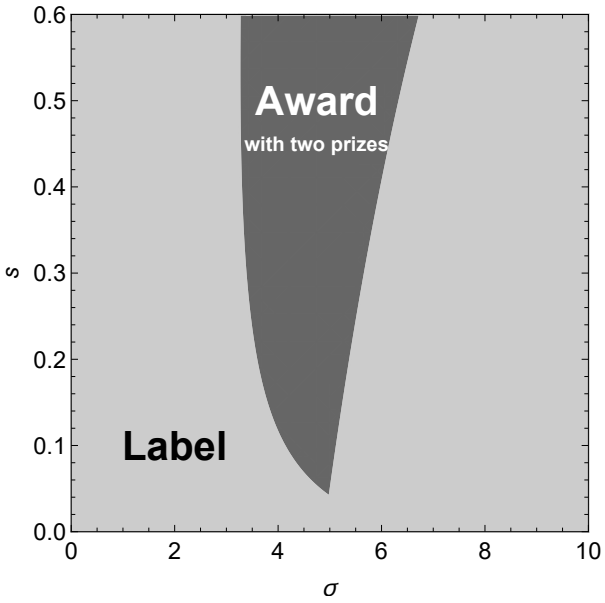

Figure 4: Policy decision dependent on the salience σ and s for $\delta = 1$. In the dark gray area, the social planner implements the award with two prizes. In the light gray area, the social planner implements the label.

5.3 Distinguishing award salience and label salience

Consumers may have a different perception of environmental quality depending on whether a good has received an award or a label. For example, awards and labels may differ in their visibility or their popularity. Therefore, in this section, we allow for different salience parameters depending on the policy instrument: σ_A denotes award salience and σ_L denotes label salience. Price-setting and quality-investment is analogous to Sections 4.1 and 4.2.1 for the award and Sections 4.1 and 4.2.2 for the label. To keep the model tractable, we set the marginal damage to $\delta = 1$.

Whether the social planner implements an award or a label in the first stage depends on label salience and award salience: If $\sigma_L \leq 5/4$, the optimal labeling threshold is $\bar{q}^* = 4\sigma_L/(9c)$ such that, in equilibrium, firms choose $q_i^* = \bar{q}^*$ and $q_j^* = 0$. Then, if award salience is sufficiently high, i.e., $\sigma_A \geq 54/11$, the costs with the award are very high and it is optimal for the social planner to implement the label. If award salience is sufficiently low, i.e., $\sigma_A < 54/11$, whether the social planner implements the label or the award depends on the label salience. A high label salience implies higher investments in environmental quality and thus lower emissions. Then, the social planner implements the label. Otherwise, the social planner implements the award.

If $5/4 < \sigma_L < 5/2$, the optimal labeling threshold is $\bar{q}^* = 5/(9c)$ such that, in equilibrium, firms choose $q_i^* = \bar{q}^*$ and $q_j^* = 0$. Consequently, for sufficiently low award salience, firms invest more into environmental quality with the label than with the award, emissions are lower with the label than with the award, and costs are higher with the label than with the award. However, for all $5/4 < \sigma_L < 5/2$, the positive effects of the label

dominate and the social planner always implements the label.

If $5/2 \leq \sigma_L \leq 5$, any labeling threshold $\bar{q}^* \in [0, 2\sigma_L/(9c)]$ is optimal such that, in equilibrium, firms choose $q_i^* = 2\sigma_L/(9c)$, and $q_j^* = 0$. Consequently, for sufficiently low award salience, firms invest more in environmental quality with the label than with the award, emissions are lower with the label than with the award, and costs are higher with the label than with the award. In sum, if award salience is sufficiently high, i.e., $\sigma_A > 54/11$, the costs with the award are very high and it is optimal for the social planner to implement the label. If the award salience is sufficiently low, i.e., $\sigma_A \leq 54/11$, whether the social planner implements the label or the award depends on the label salience. A low label salience ensures low enough costs with the label. Then, the social planner implements the label. Otherwise, the social planner implements the award.

If $\sigma_L > 5$, any labeling threshold $\bar{q}^* \in (4\sigma_L/(9c), \infty)$ is optimal such that, in equilibrium, firms choose $q_i^* = q_j^* = 0$. Consequently, firms invest more in environmental quality with the award, costs are higher with the award, but emissions are lower with the award. As long as the award salience is sufficiently high, the positive effects of the label dominate and the social planner implements the label. Otherwise, the social planner implements the award.

Proposition 6 summarizes the results.

Proposition 6 *Let the salience of the award be σ_A and the salience of the label be σ_L. Then, the social planner implements the award if and only if $\sigma_A < 54/11$ and $\sigma_L \in [0, 5/4 - \sqrt{121\sigma_A^2 - 594\sigma_A + 800}/(16\sqrt{2})] \cup [5/2 + \sqrt{121\sigma_A^2 - 594\sigma_A + 800}/(8\sqrt{2}), \infty)$. Otherwise, the social planner implements the label.*

The proof is in Appendix E. Figure 5 illustrates Proposition 6 graphically. In contrast to the main result in Proposition 3, where the label is always better for $\delta = 1$, with different salience parameters for awards and labels, a range of values exists where the award is preferable to the label for $\delta = 1$. For high award salience, i.e., $\sigma_A \geq 54/11$, the label is always better, because high award salience implies high investments and thus high costs for both firms. In particular, firms' costs are higher than benefits to consumers plus the reduction in damage. For low award salience, i.e., $\sigma_A < 54/11$, the award is better if label salience is sufficiently low or sufficiently high. For sufficiently low label salience, firms invest little into environmental quality under the label and thus emissions are high. Then, the award is better. For sufficiently high label salience, firms' investments in environmental quality are zero. Then, the award is also better.

6 Conclusion

In this article, we analyze how environmental awards and environmental labels affect firms' investments in environmental quality and social welfare. We show that firms use the award

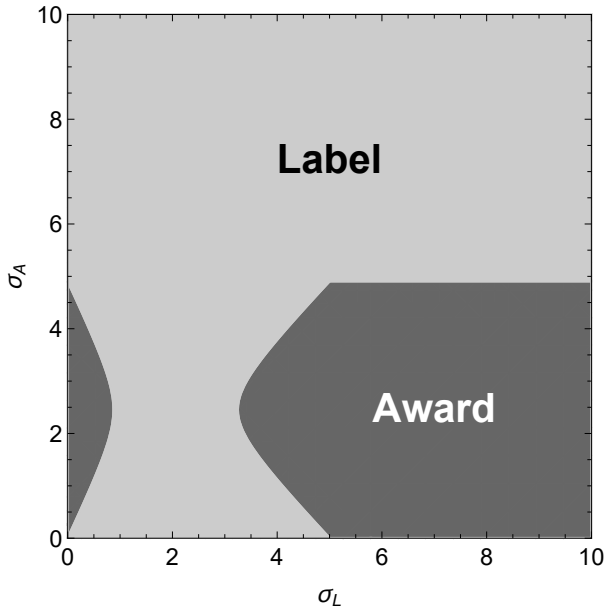

Figure 5: Policy decision dependent on the salience of the label σ_L and the salience of the award σ_A for $\delta = 1$. In the dark gray area, the social planner implements the award. In the light gray area, the social planner implements the label.

and the label to differentiate their products and to generate market power. However, awards and labels provide different incentives to firms. With an award, both firms invest in environmental quality, but only one firm receives the award. That means, even if both firms invest the same amount into environmental quality, consumers perceive only the environmental quality of the winning firm and perceive the goods as differentiated. With a label, at most one firm invests in environmental quality. With a label, if both firms invest the same amount into environmental quality, both firms either receive the label (if their investments exceed the labeling threshold) or do not receive the label (if their investments do not reach the labeling threshold). In both cases, consumers perceive the goods as identical and this leads to intense price competition. Consequently, in equilibrium, to increase perceived product differentiation and thus to avoid intense price competition, only one firm invests to receive the label.

We show that whether the award or the label maximizes social welfare depends on the salience that the award and the label generate and on the marginal damage. The award only results in a higher welfare than the label if marginal damage is sufficiently high and the policies generate sufficiently high salience such that consumers' perception of environmental quality is distorted upwards. Otherwise, the label generates higher social welfare. In particular, if consumers perceive the environmental quality of the labeled/award-winning goods perfectly, the label always results in higher social welfare than the award.

In addition to the main model, we also explore three extensions. First, we investigate the policy choice of an NGO aiming to minimize total damage. We find that an NGO always implements an environmental label. Second, we analyze the effects on social welfare

if the environmental quality of the awarded and of the non-awarded good become salient, but to different extents. We show that the award generates higher social welfare than the label if and only if awards and labels lead to a sufficient overestimation of environmental quality and the salience of the non-awarded good is sufficiently high. Third, we assume that environmental awards and labels affect consumers' attention differently; we allow award salience and label salience to differ. We show that an environmental award results in higher social welfare than an environmental label if and only if award salience is sufficiently low and label salience is either sufficiently low or sufficiently high. Otherwise, the label results in higher social welfare.

To keep the model tractable, we make a number of assumptions that limit the scope of the analysis. First, our model includes an advantage for the label compared to the award. Implementing the label also allows the social planner to set the labeling threshold optimally. The award does not offer such an adjustment mechanism. Nevertheless, in reality we also observe that labels are prevalent. Our results may thus reflect existing biases of the social planner who might prefer more direct control. Second, we do not address the coordination problem that arises under labeling, i.e., how firms decide which firm invests and which firm does not invest. Third, winning an award usually includes winning a monetary prize. We abstract from these monetary prizes and focus on the attention-generating aspect of winning an award. We leave these issues to further research.

A Environmental award: proof of Proposition 1

Firms $i, j \in \{1, 2\}$ with $i \neq j$ maximize their expected profits from winning and losing the contest:

$$\begin{aligned}\mathbb{E}[\pi_i] &= \alpha_i(q_i, q_j) \cdot \pi_h(\hat{q}_h = \sigma q_i, \hat{q}_l = 0) + \Big(1 - \alpha_i(q_i, q_j)\Big) \cdot \pi_l(\hat{q}_h = \sigma q_j, \hat{q}_l = 0) \\ &= \frac{q_i}{q_i + q_j}\frac{4}{9}\sigma q_i + \left(1 - \frac{q_i}{q_i + q_j}\right)\frac{1}{9}\sigma q_j - c q_i^2.\end{aligned}$$

The first-order conditions simplify to

$$\frac{(4q_i^2 + 8q_i q_j - q_j^2)\sigma}{9(q_i + q_j)^2} - 2cq_i = 0.$$

Solving the first-order conditions simultaneously and checking the second-order conditions, yield the following equilibrium environmental qualities:

$$q_{i,A}^* = \frac{11\sigma}{72c} \tag{7}$$

for $i \in \{1, 2\}$. Consequently, using (3) and (7), if the social planner has implemented an award, consumer surplus, producer surplus, and welfare are

$$\begin{aligned}CS_A &= \int_0^{\bar{\theta}} (v + \theta q_l - p_l)\, d\theta + \int_{\bar{\theta}}^1 (v + \theta q_h - p_h)\, d\theta = v + \frac{11(9 - 10\sigma)\sigma}{1296c} \\ PS_A &= \pi_{l,A} + \pi_{h,A} = \frac{11\sigma^2}{288c} \\ W_A &= CS_A + PS_A - D(E_A) = v + \frac{11(18 - 11\sigma)\sigma}{2592c} - \delta\left(e - \frac{11\sigma}{72c}\right).\end{aligned}$$

B Environmental label

B.1 Proof of Lemma 1

The profit of firm i depends on whether firm j receives the label: The profit of firm i is given in (4) if $q_j \geq \bar{q}$ and in (5) if $q_j < \bar{q}$.

(i) Assume $q_j \geq \bar{q}$. If $q_i < q_j$, the profit of firm i is decreasing in $q_i \in [0, q_j)$. Consequently, the candidate for best reply in $[0, q_j)$ is $q_i = 0$. If $q_i \geq q_j$,

$$\frac{\partial \pi_i(q_i, q_j)}{\partial q_i} = \frac{4}{9}\sigma - 2cq_i = 0 \Leftrightarrow q_i = \frac{2\sigma}{9c}.$$

Consequently, the candidate for best reply on the interval $[q_j, \infty)$ is this inner solution or the boundary:

$$q_i(q_j) = \begin{cases} \frac{2\sigma}{9c} & \text{if } q_j \leq \frac{2\sigma}{9c} \\ q_j & \text{if } q_j > \frac{2\sigma}{9c}. \end{cases}$$

Note that

$$\pi_i\left(q_i = 0, q_j \geq \bar{q}\right) \geq \pi_i\left(q_i = \frac{2\sigma}{9c}, q_j \geq \bar{q}\right) \Leftrightarrow \frac{1}{9}\sigma q_j \geq \frac{4}{9}\left(\sigma\frac{2\sigma}{9c} - \sigma q_j\right) - c\left(\frac{2\sigma}{9c}\right)^2$$
$$\Leftrightarrow q_j \geq \frac{4\sigma}{45c}$$

and

$$\pi_i\left(q_i = 0, q_j \geq \bar{q}\right) \geq \pi_i\left(q_i = q_j, q_j \geq \bar{q}\right) \forall q_j > \frac{2\sigma}{9c}.$$

(ii) Assume $q_j < \bar{q}$. If $q_i < \bar{q}$, the profit of firm i is decreasing in $q_i \in [0, \bar{q})$. Consequently, the candidate for best reply in $[0, \bar{q})$ is $q_i = 0$. If $q_i \geq \bar{q}$,

$$\frac{\partial \pi_i(q_i, q_j)}{\partial q_i} = \frac{4}{9}\sigma - 2cq_i = 0 \Leftrightarrow q_i = \frac{2\sigma}{9c}.$$

Consequently, the candidate for best reply on the interval $[\bar{q}, \infty)$ is this inner solution or the boundary:

$$q_i(q_j) = \begin{cases} \frac{2\sigma}{9c} & \text{if } \bar{q} \leq \frac{2\sigma}{9c} \\ \bar{q} & \text{if } \bar{q} > \frac{2\sigma}{9c}. \end{cases}$$

Note that

$$\pi_i\left(q_i = \frac{2\sigma}{9c}, q_j < \bar{q}\right) \geq \pi_i\left(q_i = 0, q_j < \bar{q}\right) \Leftrightarrow \frac{4\sigma^2}{81c} \geq 0 \Leftrightarrow \sigma \geq 0, c \geq 0$$

and

$$\pi_i\left(q_i = 0, q_j < \bar{q}\right) > \pi_i\left(q_i = \bar{q}, q_j < \bar{q}\right) \Leftrightarrow 0 > \frac{4}{9}\sigma\bar{q} - c\bar{q}^2 \Leftrightarrow \bar{q} > \frac{4\sigma}{9c}.$$

Bringing (i) and (ii) together gives the best reply of firm i: If $\bar{q} \leq (4\sigma)/(45c)$, the best reply of firm i is

$$q_i^*(q_j) = \begin{cases} \frac{2\sigma}{9c} & \text{if } q_j \leq \frac{4\sigma}{45c} \\ 0 & \text{if } q_j > \frac{4\sigma}{45c}. \end{cases}$$

If $(4\sigma)/(45c) < \bar{q} \leq (2\sigma)/(9c)$, the best reply of firm i is

$$q_i^*(q_j) = \begin{cases} \frac{2\sigma}{9c} & \text{if } q_j < \bar{q} \\ 0 & \text{if } q_j \geq \bar{q}. \end{cases}$$

If $(2\sigma)/(9c) < \bar{q} \leq (4\sigma)/(9c)$, the best reply of firm i is

$$q_i^*(q_j) = \begin{cases} \bar{q} & \text{if } q_j < \bar{q} \\ 0 & \text{if } q_j \geq \bar{q}. \end{cases}$$

If $\bar{q} > (4\sigma)/(9c)$, the best reply of firm i is

$$q_i^*(q_j) = 0.$$

Consequently, the equilibrium qualities also depend on the labeling threshold:

(i) If $\bar{q} < (2\sigma)/(9c)$, two asymmetric equilibria exist where $q_{i,L}^* = (2\sigma)/(9c)$, $q_{j,L}^* = 0$, $p_{i,L}^* = 2\sigma q_{i,L}^*/3$, and $p_{j,L}^* = \sigma q_{i,L}^*/3$.

(ii) If $(2\sigma)/(9c) \leq \bar{q} \leq (4\sigma)/(9c)$, two asymmetric equilibria exist where $q_{i,L}^* = \bar{q}$, $q_{j,L}^* = 0$, $p_{i,L}^* = 2\sigma q_{i,L}^*/3$, and $p_{j,L}^* = \sigma q_{i,L}^*/3$.

(iii) If $\bar{q} > (4\sigma)/(9c)$, one symmetric equilibrium exists where $q_{i,L}^* = q_{j,L}^* = 0$, $p_{i,L}^* = p_{j,L}^* = 0$.

B.2 Proof of Proposition 2

The social welfare is $W = CS + PS - D(E)$, i.e., the sum of consumer surplus (CS) and producer surplus (PS, the sum of the profits), minus the damage caused by emissions. We assume the following damage function: $D(E) = \delta E$ with $\delta > 0$. As the subgame-perfect equilibria depend on the labeling threshold, consumer surplus, producer surplus, and social welfare also depend on the labeling threshold.

(i) If $\bar{q} < (2\sigma)/(9c)$, two asymmetric equilibria exist where $q^*_{i,L} = (2\sigma)/(9c)$, $q^*_{j,L} = 0$, $p^*_{i,L} = 2\sigma q^*_{i,L}/3$, and $p^*_{j,L} = \sigma q^*_{i,L}/3$. Consequently, consumer surplus, producer surplus, and welfare are

$$\begin{aligned} CS_L &= \int_0^{\bar{\theta}} (v + \theta q_j - p_j) d\theta + \int_{\bar{\theta}}^1 (v + \theta q_i - p_i) d\theta = v + \frac{8\sigma - 10\sigma^2}{81c} \\ PS_L &= \pi_i + \pi_j = \frac{2\sigma^2}{27c} \\ W_L &= v + \frac{8\sigma - 4\sigma^2}{81c} - \delta \left(e - \frac{4\sigma}{27c} \right). \end{aligned}$$

(ii) If $(2\sigma)/(9c) \leq \bar{q} \leq (4\sigma)/(9c)$, two asymmetric equilibria exist where $q^*_{i,L} = \bar{q}$, $q^*_{j,L} = 0$, $p^*_{i,L} = 2\sigma q^*_{i,L}/3$, and $p^*_{j,L} = \sigma q^*_{i,L}/3$. Consequently, consumer surplus, producer surplus, and welfare are

$$\begin{aligned} CS_L &= \int_0^{\bar{\theta}} (v + \theta q_j - p_j) d\theta + \int_{\bar{\theta}}^1 (v + \theta q_i - p_i) d\theta = v + \frac{1}{9} \bar{q} (4 - 5\sigma) \\ PS_L &= \pi_i + \pi_j = \frac{5\bar{q}\sigma}{9} - c\bar{q}^2 \\ W_L &= v - c\bar{q}^2 + \frac{4\bar{q}}{9} - \delta \left(e - \frac{2\bar{q}}{3} \right). \end{aligned}$$

(iii) If $(4\sigma)/(9c) < \bar{q}$, one symmetric equilibrium exists where $q^*_{i,L} = q^*_{j,L} = 0$, $p^*_{i,L} = p^*_{j,L} = 0$. Consequently, consumer surplus, producer surplus, and welfare are

$$\begin{aligned} CS_L &= v \\ PS_L &= \pi_i + \pi_j = 0 \\ W_L &= v - \delta e. \end{aligned}$$

Optimal labeling threshold: Welfare is constant in $\bar{q} \in [0, (2\sigma)/(9c))$ and in $\bar{q} \in [(4\sigma)/(9c), \infty)$. If $(2 + 3\delta)/(9c) \leq (2\sigma)/(9c)$, welfare is decreasing for all $\bar{q} \in [(2\sigma)/(9c), (4\sigma)/(9c)]$. If $(2\sigma)/(9c) < (2 + 3\delta)/(9c) < (4\sigma)/(9c)$, welfare is increasing for all $\bar{q} \in [(2\sigma)/(9c), (2 + 3\delta)/(9c))$ and decreasing for all $\bar{q} \in ((2 + 3\delta)/(9c), (4\sigma)/(9c)]$. If $(2 + 3\delta)/(9c) \geq (4\sigma)/(9c)$, welfare is increasing for all $\bar{q} \in [(2\sigma)/(9c), (4\sigma)/(9c)]$. In addition,

- if $(2 + 3\delta)/(9c) \leq (2\sigma)/(9c) \Leftrightarrow \sigma \geq (2 + 3\delta)/2$

$$W\left(\bar{q} = \frac{2\sigma}{9c}\right) = W\left(\bar{q} < \frac{2\sigma}{9c}\right) \text{ and } W\left(\bar{q} = \frac{2\sigma}{9c}\right) \geq W\left(\bar{q} > \frac{4\sigma}{9c}\right) \Leftrightarrow \sigma \leq 2 + 3\delta.$$

- if $(2\sigma)/(9c) < (2 + 3\delta)/(9c) < (4\sigma)/(9c) \Leftrightarrow (2 + 3\delta)/4 < \sigma < (2 + 3\delta)/2$

$$W\left(\bar{q} = \frac{2 + 3\delta}{9c}\right) > W\left(\bar{q} < \frac{2\sigma}{9c}\right) \text{ and } W\left(\bar{q} = \frac{2 + 3\delta}{9c}\right) > W\left(\bar{q} > \frac{4\sigma}{9c}\right).$$

- if $(2+3\delta)/(9c) \geq (4\sigma)/(9c) \Leftrightarrow \sigma \leq (2+3\delta)/4$

$$W\left(\bar{q} = \frac{4\sigma}{9c}\right) > W\left(\bar{q} < \frac{2\sigma}{9c}\right) \text{ and } W\left(\bar{q} = \frac{4\sigma}{9c}\right) > W\left(\bar{q} > \frac{4\sigma}{9c}\right).$$

Consequently, the optimal labeling threshold depends on the salience σ and the marginal damage δ:

(i) If $\sigma \leq (2+3\delta)/4$, $\bar{q}^* = (4\sigma)/(9c)$.

(ii) If $(2+3\delta)/4 < \sigma < (2+3\delta)/2$, $\bar{q}^* = (2+3\delta)/(9c)$.

(iii) If $(2+3\delta)/2 \leq \sigma \leq 2+3\delta$, $\bar{q}^* \in [0, 2\sigma/(9c)]$.

(iv) If $\sigma > 2+3\delta$, $\bar{q}^* \in ((4\sigma)/(9c), \infty)$.

C Proof of Proposition 3

If the social planner implements the award, social welfare is

$$W_A = v + \frac{11(18-11\sigma)\sigma}{2592c} - \delta\left(e - \frac{11\sigma}{72c}\right).$$

If the social planner implements the label, social welfare given the optimal labeling threshold is

$$W_L(\bar{q}^*) = \begin{cases} v + \frac{16(\sigma-\sigma^2)}{81c} - \delta\left(e - \frac{8\sigma}{27c}\right) & \text{if } \sigma \leq \frac{2+3\delta}{4} \\ v + \frac{4+9\delta^2}{81c} - \delta\left(e - \frac{4}{27c}\right) & \text{if } \frac{2+3\delta}{4} < \sigma < \frac{2+3\delta}{2} \\ v + \frac{8\sigma-4\sigma^2}{81c} - \delta\left(e - \frac{4\sigma}{27c}\right) & \text{if } \frac{2+3\delta}{2} \leq \sigma \leq 2+3\delta \\ v - \delta e & \text{if } 2+3\delta < \sigma. \end{cases}$$

The social planner implements the policy that maximizes social welfare. We assume that, if indifferent, the social planner implements the label. As the social welfare of the label depends on the optimal labeling threshold, we need to distinguish four cases:

(i) If $\sigma \leq (2+3\delta)/4$,

$$\begin{aligned} & W_L(\bar{q}^*) \geq W_A \\ \Leftrightarrow\ & v + \frac{16(\sigma-\sigma^2)}{81c} - \delta\left(e - \frac{8\sigma}{27c}\right) \geq v + \frac{11(18-11\sigma)\sigma}{2592c} - \delta\left(e - \frac{11\sigma}{72c}\right) \\ \Leftrightarrow\ & \sigma \leq \frac{372\delta + 314}{391}. \end{aligned}$$

As

$$\frac{372\delta + 314}{391} > \frac{2+3\delta}{4},$$

for any $\sigma \in [0, (2+3\delta)/4]$, the social planner implements the label.

(ii) If $(2+3\delta)/4 < \sigma < (2+3\delta)/2$,

$$\begin{aligned} & W_L(\bar{q}^*) \geq W_A \\ \Leftrightarrow\ & v + \frac{4+9\delta^2}{81c} - \delta\left(e - \frac{4}{27c}\right) \geq v + \frac{11(18-11\sigma)\sigma}{2592c} - \delta\left(e - \frac{11\sigma}{72c}\right). \end{aligned} \tag{8}$$

If $\delta \leq (6\sqrt{2}+5)/6$, (8) is always fulfilled. If $\delta > (6\sqrt{2}+5)/6$, (8) is fulfilled if and only if

$$\sigma \leq \frac{9+18\delta}{11} - \frac{\sqrt{36\delta^2 - 60\delta - 47}}{11} \text{ or } \sigma \geq \frac{9+18\delta}{11} + \frac{\sqrt{36\delta^2 - 60\delta - 47}}{11}.$$

Note that

$$\forall \delta > (6\sqrt{2}+5)/6 : \frac{9+18\delta}{11} + \frac{\sqrt{36\delta^2-60\delta-47}}{11} > \frac{2+3\delta}{2},$$
$$\forall \delta > (6\sqrt{2}+5)/6 : \frac{9+18\delta}{11} - \frac{\sqrt{36\delta^2-60\delta-47}}{11} > \frac{2+3\delta}{4}, \text{ and}$$
$$\frac{9+18\delta}{11} - \frac{\sqrt{36\delta^2-60\delta-47}}{11} < \frac{2+3\delta}{2} \Leftrightarrow \delta > \frac{34}{15}.$$

Consequently, in the range $(2+3\delta)/4 < \sigma < (2+3\delta)/2$, if and only if (a) $\delta \leq 34/15$ or (b) $\delta > 34/15$ and $\sigma \leq (9+18\delta)/11 - (\sqrt{36\delta^2-60\delta-47})/11$, the social planner implements the label. In contrast, in the range $(2+3\delta)/4 < \sigma < (2+3\delta)/2$, if and only if $\delta > 34/15$ and $\sigma > (9+18\delta)/11 - (\sqrt{36\delta^2-60\delta-47})/11$, the social planner implements the award.

(iii) If $(2+3\delta)/2 \leq \sigma \leq 2+3\delta$,

$$W_L(\bar{q}^*) \geq W_A \Leftrightarrow v + \frac{8\sigma-4\sigma^2}{81c} - \delta\left(e - \frac{4\sigma}{27c}\right) \geq v + \frac{11(18-11\sigma)\sigma}{2592c} - \delta\left(e - \frac{11\sigma}{72c}\right)$$
$$\Leftrightarrow \sigma \leq \frac{58-12\delta}{7}.$$

Note that

$$\frac{2+3\delta}{2} \leq \frac{58-12\delta}{7} \Leftrightarrow \delta \leq \frac{34}{15} \text{ and}$$
$$\frac{58-12\delta}{7} \leq 2+3\delta \Leftrightarrow \delta \geq \frac{4}{3}.$$

Consequently, in the range $(2+3\delta)/2 \leq \sigma \leq 2+3\delta$, if and only if (a) $\delta \leq 4/3$ or (b) $4/3 < \delta \leq 34/15$ and $\sigma \leq (58-12\delta)/7$, the social planner implements the label. In contrast, in the range $(2+3\delta)/2 \leq \sigma \leq 2+3\delta$, if and only if (a) $4/3 < \delta \leq 34/15$ and $\sigma > (58-12\delta)/7$ or (b) $\delta > 34/15$, the social planner implements the award.

(iv) If $\sigma > 2+3\delta$,

$$W_L(\bar{q}^*) \geq W_A \Leftrightarrow v - \delta e \geq v + \frac{11(18-11\sigma)\sigma}{2592c} - \delta\left(e - \frac{11\sigma}{72c}\right) \Leftrightarrow \sigma \geq \frac{18+36\delta}{11}.$$

Note than

$$\frac{18+36\delta}{11} > 2+3\delta \Leftrightarrow \delta > \frac{4}{3}.$$

Consequently, in the range $\sigma > 2+3\delta$, if and only if (a) $\delta > 4/3$ and $\sigma \geq (18+36\delta)/11$ or (b) $\delta \leq 4/3$, the social planner implements the label. In the range $\sigma > 2+3\delta$, if and only if $\delta > 4/3$ and $\sigma < (18+36\delta)/11$, the social planner implements the award.

Combining (i)-(iv), the social planner implements the award if and only if $4/3 < \delta \leq 34/15$ and $(58 - 12\delta)/7 < \sigma < (18 + 36\delta)/11$ or if $\delta > 34/15$ and $(9 + 18\delta)/11 - (\sqrt{36\delta^2 - 60\delta - 47})/11 < \sigma < (18 + 36\delta)/11$. Otherwise, the social planner implements the label.

Rearranging yields: The social planner implements the award if and only if $48/11 < \sigma \leq 22/5$ with $(33\sigma{-}32)/48{-}\sqrt{121\sigma^2 - 528\sigma}/48 < \delta < (33\sigma{-}32)/48{+}\sqrt{121\sigma^2 - 528\sigma}/48$ or $\sigma > 22/5$ with $\max\{(58{-}7\sigma)/12, (11\sigma{-}18)/36\} < \delta < (33\sigma{-}32)/48{+}\sqrt{121\sigma^2 - 528\sigma}/48$. Otherwise, the social planner implements the label.

D Environmental award organized as lottery contest with two prizes

In the following the index $A2$ denotes the award design with two prizes and A the award design with a single prize. We set $\delta = 1$.

D.1 Proof of Lemma 2

Firms $i, j \in \{1, 2\}$ with $i \neq j$ maximize their expected profits from winning and losing the contest:

$$\begin{aligned}\mathbb{E}[\pi_i] &= \alpha_i(q_i, q_j) \cdot \pi_h(\hat{q}_h = \sigma q_i, \hat{q}_l = s\sigma q_j) + \Big(1 - \alpha_i(q_i, q_j)\Big) \cdot \pi_l(\hat{q}_h = \sigma q_j, \hat{q}_l = s\sigma q_i) \\ &= \frac{q_i}{q_i + q_j}\frac{4}{9}(\sigma q_i - s\sigma q_j) + \left(1 - \frac{q_i}{q_i + q_j}\right)\frac{1}{9}(\sigma q_j - s\sigma q_i) - cq_i^2.\end{aligned}$$

The first-order conditions simplify to

$$\frac{\Big(4q_i^2 + 8q_iq_j - q_j^2(1 + 5s)\Big)\sigma}{9(q_i + q_j)^2} - 2cq_i = 0$$

For symmetry $q_i = q_j$ and checking the second-order conditions, in equilibrium:

$$q_{i,A2}^* = \frac{(11 - 5s)\sigma}{72c} \tag{9}$$

for $i \in \{1, 2\}$. Then consumer surplus, producer surplus and welfare are

$$\begin{aligned}CS_{A2} &= \int_0^{\bar{\theta}} (v + \theta q_l - p_l)\, d\theta + \int_{\bar{\theta}}^1 (v + \theta q_h - p_h)\, d\theta = v + \frac{(11 - 5s)\Big(9 + 10(s - 1)\sigma\Big)\sigma}{1296c} \\ PS_{A2} &= \pi_{l,A2} + \pi_{h,A2} = \frac{(11 - 5s)(3 - 5s)\sigma^2}{864c} \\ W_{A2} &= v + \frac{(11 - 5s)(18 - (11 - 5s)\sigma)\sigma}{2592c} - \left(e - \frac{(11 - 5s)\sigma}{72c}\right)\end{aligned}$$

where l (h) denotes the non-awarded (awarded) firm with low (high) perceived environmental quality.

D.2 Proof of Lemma 3

Comparing equilibrium outcomes of an award organized with a single prize and an award organized with two prizes for $0 \leq s \leq 3/5$ yields:

(i) For damages:

$$D(E_A) \leq D(E_{A2}) \Leftrightarrow e - \frac{11\sigma}{72c} \leq e - \frac{(11-5s)\sigma}{72c}.$$

For $\sigma > 0$ and $0 \leq s \leq 3/5$, the single prize design generates lower damage than the two prize design.

(ii) For consumer surplus:

$$\begin{aligned} CS_A \geq CS_{A2} &\Leftrightarrow v + \frac{11(9-10\sigma)\sigma}{1296c} \geq v + \frac{(11-5s)(9+10(s-1)\sigma)\sigma}{1296c} \\ &\Leftrightarrow s \geq \frac{32\sigma - 9}{10\sigma}. \end{aligned}$$

For (a) $0 < \sigma \leq 9/32$ and $0 \leq s \leq 3/5$ and for (b) $9/32 < \sigma \leq 9/26$ and $(32\sigma - 9)/(10\sigma) \leq s \leq 3/5$, the single prize design yields higher consumer surplus than the two prize design. Otherwise, the two prize design yields higher consumer surplus.

(iii) For producer surplus:

$$PS_A \geq PS_{A2} \Leftrightarrow \frac{11\sigma^2}{288c} \geq \frac{(11-5s)(3-5s)\sigma^2}{864c} \Leftrightarrow 0 < s \leq \frac{3}{5}.$$

For $\sigma > 0$ and $0 \leq s \leq 3/5$, the single prize design yields higher producer surplus than the two prize design.

(iv) For welfare:

$$\begin{aligned} & W_A \geq W_{A2} \\ \Leftrightarrow\ & v + \frac{11(18-11\sigma)\sigma}{2592c} - \left(e - \frac{11\sigma}{72c}\right) \\ & \geq v + \frac{(11-5s)(18-(11-5s)\sigma)\sigma}{2592c} - \left(e - \frac{(11-5s)\sigma}{72c}\right) \\ \Leftrightarrow\ & \sigma \leq \frac{54}{22-5s}. \end{aligned}$$

For $0 < \sigma \leq (54)/(22-5s)$ and $0 \leq s \leq 3/5$, the single prize design yields higher welfare than the two prize design. Otherwise, the two prize design yields higher welfare.

D.3 Proof of Proposition 5

If the social planner implements the award, the social welfare is

$$W_{A2} = v + \frac{(11-5s)(18-(11-5s)\sigma)\sigma}{2592c} - \left(e - \frac{(11-5s)\sigma}{72c}\right).$$

If the social planner implements the label, the social welfare given the optimal labeling threshold is

$$W_L(\bar{q}^*) = \begin{cases} v + \frac{16(\sigma-\sigma^2)}{81c} - \left(e - \frac{8\sigma}{27c}\right) & \text{if } \sigma \leq \frac{5}{4} \\ v + \frac{13}{81c} - \left(e - \frac{4}{27c}\right) & \text{if } \frac{5}{4} < \sigma < \frac{5}{2} \\ v + \frac{8\sigma-4\sigma^2}{81c} - \left(e - \frac{4\sigma}{27c}\right) & \text{if } \frac{5}{2} \leq \sigma \leq 5 \\ v - e & \text{if } 5 < \sigma. \end{cases}$$

The social planner implements the policy that maximizes social welfare. We assume that, if indifferent, the social planner implements the label. As the social welfare of the label depends on the optimal labeling threshold, we need to distinguish four cases:

(i) If $\sigma \leq 5/4$,

$$\begin{aligned} & W_L(\bar{q}^*) \geq W_{A2} \\ \Leftrightarrow\ & v + \frac{16(\sigma-\sigma^2)}{81c} - \left(e - \frac{8\sigma}{27c}\right) \\ & \geq v + \frac{(11-5s)(18-(11-5s)\sigma)\sigma}{2592c} - \left(e - \frac{(11-5s)\sigma}{72c}\right) \\ \Leftrightarrow\ & \sigma \leq \frac{686+270s}{391+110s-25s^2}. \end{aligned}$$

As

$$\frac{686+270s}{391+110s-25s^2} \geq \frac{5}{4},$$

for any $\sigma \in [0, 5/4]$, the social planner implements the label.

(ii) If $5/4 < \sigma < 5/2$,

$$\begin{aligned} & W_L(\bar{q}^*) \geq W_{A2} \\ \Leftrightarrow\ & v + \frac{13}{81c} - \left(e - \frac{4}{27c}\right) \geq v + \frac{(11-5s)(18-(11-5s)\sigma)\sigma}{2592c} - \left(e - \frac{(11-5s)\sigma}{72c}\right) \\ \Leftrightarrow\ & -\frac{71}{(11-5s)^2} \leq \left(\sigma + \frac{27}{5s-11}\right)^2. \end{aligned}$$

Consequently, for any $\sigma \in (5/4, 5/2)$, the social planner implements the label.

(iii) If $5/2 \leq \sigma \leq 5$,

$$\begin{aligned} & W_L(\bar{q}^*) \geq W_{A2} \\ \Leftrightarrow\ & v + \frac{8\sigma - 4\sigma^2}{81c} - \left(e - \frac{4\sigma}{27c}\right) \\ & \geq v + \frac{(11-5s)(18-(11-5s)\sigma)\sigma}{2592c} - \left(e - \frac{(11-5s)\sigma}{72c}\right) \\ \Leftrightarrow\ & \sigma \leq \frac{46+270s}{7+110s-25s^2}. \end{aligned}$$

As

$$\begin{aligned} & \frac{46+270s}{7+110s-25s^2} > \frac{5}{2} \text{ and} \\ & \frac{46+270s}{7+110s-25s^2} < 5 \Leftrightarrow s > \frac{1}{25}, \end{aligned}$$

in the range $5/2 \leq \sigma \leq 5$, if and only if (a) $s \leq 1/25$ or (b) $s > 1/25$ and $\sigma \leq (46+270s)/(7+110s-25s^2)$, the social planner implements the label. Otherwise, the social planner implements the award.

(iv) If $\sigma > 5$,

$$\begin{aligned} W_L(\bar{q}^*) \geq W_{A2} \Leftrightarrow & v - e \geq v + \frac{(11-5s)(18-(11-5s)\sigma)\sigma}{2592c} - \left(e - \frac{(11-5s)\sigma}{72c}\right) \\ \Leftrightarrow & \sigma \geq \frac{54}{11-5s}. \end{aligned}$$

As

$$\frac{54}{11-5s} > 5 \Leftrightarrow s > \frac{1}{25},$$

in the range $\sigma > 5$, if and only if (a) $s \leq 1/25$ or (b) $s > 1/25$ and $\sigma \geq 54/(11-5s)$, the social planner implements the label. The social planner implements the award otherwise.

Combining (i)-(iv), the social planner implements the award if and only if $1/25 < s \leq 3/5$ and $(46+270s)/(7+110s-25s^2) < \sigma < (54)/(11-5s)$. Otherwise, the social planner implements the label.

E Distinguishing award salience and label salience: proof of Proposition 6

We set $\delta = 1$. If the social planner implements the award, the social welfare is

$$W_A = v + \frac{11(18 - 11\sigma_A)\sigma_A}{2592c} - \left(e - \frac{11\sigma_A}{72c}\right).$$

If the social planner implements the label, the social welfare given the optimal labeling threshold is

$$W_L(\bar{q}^*) = \begin{cases} v + \frac{16(\sigma_L - \sigma_L^2)}{81c} - \left(e - \frac{8\sigma_L}{27c}\right) & \text{if } \sigma_L \leq \frac{5}{4} \\ v + \frac{13}{81c} - \left(e - \frac{4}{27c}\right) & \text{if } \frac{5}{4} < \sigma_L < \frac{5}{2} \\ v + \frac{8\sigma_L - 4\sigma_L^2}{81c} - \left(e - \frac{4\sigma_L}{27c}\right) & \text{if } \frac{5}{2} \leq \sigma_L \leq 5 \\ v - e & \text{if } \sigma_L > 5. \end{cases}$$

The social planner implements the policy that maximizes social welfare. As the social welfare of the label depends on the optimal labeling threshold, we need to distinguish four cases:

(i) If $\sigma_L \leq 5/4$,

$$\begin{aligned} & W_L(\bar{q}^*) \geq W_A \\ \Leftrightarrow\ & v + \frac{16(\sigma_L - \sigma_L^2)}{81c} - \left(e - \frac{8\sigma_L}{27c}\right) \geq v + \frac{11(18 - 11\sigma_A)\sigma_A}{2592c} - \left(e - \frac{11\sigma_A}{72c}\right) \\ \Leftrightarrow\ & \frac{5}{4} - \frac{\sqrt{121\sigma_A^2 - 594\sigma_A + 800}}{16\sqrt{2}} \leq \sigma_L \leq \frac{5}{4} + \frac{\sqrt{121\sigma_A^2 - 594\sigma_A + 800}}{16\sqrt{2}}. \end{aligned}$$

As

$$\begin{aligned} & \frac{5}{4} - \frac{\sqrt{121\sigma_A^2 - 594\sigma_A + 800}}{16\sqrt{2}} \leq 0 \Leftrightarrow \sigma_A \geq \frac{54}{11} \text{ and} \\ & \frac{5}{4} + \frac{\sqrt{121\sigma_A^2 - 594\sigma_A + 800}}{16\sqrt{2}} > \frac{5}{4}, \end{aligned}$$

in the range $\sigma_L \leq 5/4$, if and only if (a) $\sigma_A \geq 54/11$ or (b) $\sigma_A < 54/11$ and $\sigma_L \geq 5/4 - \sqrt{121\sigma_A^2 - 594\sigma_A + 800}/(16\sqrt{2})$, the social planner implements the label. Otherwise, the social planner implements the award.

(ii) If $5/4 < \sigma_L < 5/2$,

$$W_L(\bar{q}^*) \geq W_A \Leftrightarrow v + \frac{13}{81c} - \left(e - \frac{4}{27c}\right) \geq v + \frac{11(18 - 11\sigma_A)\sigma_A}{2592c} - \left(e - \frac{11\sigma_A}{72c}\right)$$

is always fulfilled. Consequently, in the range $5/4 < \sigma_L < 5/2$, the social planner implements the label.

(iii) If $5/2 \leq \sigma_L \leq 5$,

$$\begin{aligned} & W_L(\bar{q}^*) \geq W_A \\ & \Leftrightarrow v + \frac{8\sigma_L - 4\sigma_L^2}{81c} - \left(e - \frac{4\sigma_L}{27c}\right) \geq v + \frac{11(18 - 11\sigma_A)\sigma_A}{2592c} - \left(e - \frac{11\sigma_A}{72c}\right) \\ & \Leftrightarrow \frac{5}{2} - \frac{\sqrt{121\sigma_A^2 - 594\sigma_A + 800}}{8\sqrt{2}} \leq \sigma_L \leq \frac{5}{2} + \frac{\sqrt{121\sigma_A^2 - 594\sigma_A + 800}}{8\sqrt{2}}. \end{aligned}$$

As

$$\begin{aligned} & \frac{5}{2} - \frac{\sqrt{121\sigma_A^2 - 594\sigma_A + 800}}{8\sqrt{2}} \leq \frac{5}{2} \text{ and} \\ & \frac{5}{2} + \frac{\sqrt{121\sigma_A^2 - 594\sigma_A + 800}}{8\sqrt{2}} \geq 5 \Leftrightarrow \sigma_A \geq \frac{54}{11}, \end{aligned}$$

in the range $5/2 \leq \sigma_L \leq 5$, if and only if (a) $\sigma_A > 54/11$ or (b) $\sigma_A \leq 54/11$ and $\sigma_L \leq 5/2 + \sqrt{121\sigma_A^2 - 594\sigma_A + 800}/(8\sqrt{2})$, the social planner implements the label. Otherwise, the social planner implements the award.

(iv) If $\sigma_L > 5$,

$$W_L(\bar{q}^*) \geq W_A \Leftrightarrow v - e \geq v + \frac{11(18 - 11\sigma_A)\sigma_A}{2592c} - \left(e - \frac{11\sigma_A}{72c}\right) \Leftrightarrow \sigma_A \geq \frac{54}{11}$$

Consequently, in the range $\sigma_L > 5$, if and only if $\sigma_A \geq 54/11$, the social planner implements the label. Otherwise, the social planner implements the award.

Combining (i)-(iv), the social planner implements the label if and only if (a) $\sigma_A \geq 54/11$ or (b) $\sigma_A < 54/11$ and $5/4 - \sqrt{121\sigma_A^2 - 594\sigma_A + 800}/(16\sqrt{2}) \leq \sigma_L \leq 5/2 + \sqrt{121\sigma_A^2 - 594\sigma_A + 800}/(8\sqrt{2})$. The social planner implements the award if and only if $\sigma_A < 54/11$ and $\sigma_L \in [0, 5/4 - \sqrt{121\sigma_A^2 - 594\sigma_A + 800}/(16\sqrt{2})] \cup [5/2 + \sqrt{121\sigma_A^2 - 594\sigma_A + 800}/(8\sqrt{2}), \infty]$.

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