Fighting over Environmental Salience

Stephan Eitel

Stefanie Y. Schmitt

March 2026

Fighting over Environmental Salience[*]

Stephan Eitel[†]   Stefanie Y. Schmitt[‡]

March 17, 2026

Abstract

When consumers prefer to buy goods with high environmental quality and firms differ in their environmental qualities, firms have incentives to fight over environmental salience and thereby influence consumers' attention to the environmental dimension of the goods. A green firm prefers environmental quality to be salient, while a brown firm prefers environmental quality to remain shrouded. We model the firms' fight over salience as an advertising contest. We show that the firm with the competitive advantage invests more into the salience contest. Whether such a contest increases social welfare depends on the level of environmental differentiation and the marginal damage of emissions. In addition, we show that the contest is an (imperfect) substitute for emission taxes and subsidies and that minimum standards may increase emissions and decrease welfare.

KEYWORDS: contest, emissions, environmental quality, environmental policies, salience.

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

1 Introduction

In many markets, goods differ in their environmental quality. Although consumers are in general willing to pay more for goods with higher environmental quality,[1] consumers do not always take environmental quality into account at the time of the consumption decision.[2] Instead, consumers focus on differences in prices, taste, or design. Whether

---

[†]University of Bamberg, Feldkirchenstr. 21, 96052 Bamberg, Germany, stephan.eitel@uni-bamberg.de.

[‡]University of Bamberg, Feldkirchenstr. 21, 96052 Bamberg, Germany, stefanie.schmitt@uni-bamberg.de.

[1]See for example Ward et al. (2011), Hulshof & Mulder (2020), Morone et al. (2021), Bartling et al. (2022), Ruggeri et al. (2024).

[2]See for example Allcott & Taubinsky (2015), Palmer & Walls (2015), Keefer & Rustamov (2018), Boogen et al. (2022), Andor et al. (2020), and Sejas-Portillo et al. (2025).

consumers consider environmental quality or not depends on the salience of environmental quality.[3] Firms can influence the salience of environmental quality through advertising.[4] As a green firm produces goods with higher environmental quality than its brown competitor, a green firm has an incentive to use advertising to make environmental quality salient and thus to draw consumers' attention towards the environmental dimension of the goods. In contrast, a brown firm has an incentive to draw consumers' attention away from environmental quality. The brown firm might, for example, advertise its product's design, taste, some discount they are giving, or they might even distract consumers with some likable celebrity.[5]

Our objective is to analyze this competition over environmental salience. In particular, we analyze the effects of such a salience contest on market outcomes and social welfare. We consider two firms, a green firm that fights for environmental salience, and a brown firm that fights against environmental salience. Consumers take environmental quality into account in their consumption decision if and only if environmental quality is salient. We model the fight over salience as a lottery contest (Tullock 1980), where both firms invest costly resources to win the contest. The probabilistic formulation of the lottery contest reflects that the fight over salience is, from the firms' perspective, probabilistic in nature: Whether environmental quality is salient to consumers also depends, for example, on political issues or a recent natural disaster, over which the firm has limited control.

We show that firms' investments into the contest depend on a central condition in our model: The green firm invests more than the brown firm if the green firm has a competitive advantage, i.e., if the green firm's environmental quality is high compared to its marginal cost of production. In this case, the green firm has a larger market share conditional on winning the salience contest and thus generates higher expected profits. In addition, as a higher degree of market power implies that firms fight for a larger share of total surplus, a higher degree of firms' market power increases equilibrium investments into the salience contest.

Although such a salience contest creates additional costs for firms, the salience contest may increase social welfare. Overall, we identify two opposing effects how the salience contest affects social welfare. As the salience contest increases the salience of environmental quality in expectation, the quality effect ensures that more consumers buy an environmentally friendly good, which lowers total emissions and increases social welfare. In contrast, the cost effect ensures that more consumer buy a good from the green firm which has higher production cost. This inefficiency lowers social welfare. Which of these effects dominates depends on the marginal damage of emissions, the environmental dif-

---

[3]See, for example, Sexton (2015), Gilbert & Graff Zivin (2014), Tiefenbeck et al. (2018), Andor et al. (2019), Lohmann et al. (2022), Fang & Singhal (2024), and Singhal (2024) for evidence on salience.

[4]See, for example, Shen et al. (2020).

[5]See Pelau et al. (2022) for evidence how advertisements which use celebrities capture consumers' attention.

ferentiation between the firms, and the marginal cost of green production.

An increase in the marginal damage of emissions increases the weight that emissions receive in the social welfare function. As the salience contest ensures that more consumers buy an environmentally friendly good and thus emissions decrease with the contest, an increase in the marginal damage of emissions ensures that the contest is optimal for a larger range of values. Similarly, an increase in environmental differentiation between the firms increases the range of values for which the welfare with the contest is larger than the welfare without the contest. With the contest more consumers buy the environmentally friendlier good: If the environmental differentiation between the goods increases, consumers benefit more from buying the environmental friendlier good and emissions decrease more such that the welfare increases. An increase in the marginal cost of the green good reduces the range of values for which the existence of the contest increases social welfare. With the salience contest, the expected market share of the green firm increases. If the production of the green good becomes more expensive the social welfare decreases and a situation without the contest where more consumers buy the brown good which is cheaper to produce becomes optimal for a larger range of values.

As the firms are asymmetric, we focus on a duopoly in the main model to keep the analysis tractable. In Section 5, we include an extension where the green firm competes against a competitive fringe of brown firms. We identify three effects of competition on the brown side of the market on social welfare: First, the existence of the fringe reduces aggregate investments into the salience contest compared to the duopoly, which positively impacts social welfare as these investments are socially wasteful. Second, environmental quality is always salient under the competitive fringe. This shifts expected market shares towards the green firm, which lowers emissions and is, therefore, beneficial for social welfare. Third, the brown firms in the competitive fringe must engage in intense price competition, which shifts market shares towards the brown firms. Whether the fringe overall increases or decreases social welfare compared to the duopoly depends on the level of environmental differentiation between the green firm and the brown fringe, the marginal damage of emissions, and the production cost of the green good.

In Section 6, we discuss the effect of policy interventions on equilibrium outcomes and social welfare. In particular, we focus on the interplay of emission taxes and subsidies with the salience contest. We show that an increase in the emission tax rate affects contest intensity through its effect on prize asymmetry: If the green firm has a competitive advantage in the market, an emission tax amplifies this advantage. This increased asymmetry lowers aggregate investment into the salience contest. If the brown firm has a competitive advantage in the market, an emission tax can increase investment into the salience contest, as in this case the emission tax reduces the asymmetry in the market. The welfare maximizing tax rate depends on the marginal damage and the green firm's competitive advantage. If emissions are not very damaging and green production is expensive, it is

3

inefficient from a welfare perspective to produce the green good and the optimal tax rate on emissions is zero. Otherwise, the optimal tax rate is positive and for some range of parameters it is socially optimal to fully internalize the emissions from brown production. When the policymaker subsidizes green production, the results are similar: Aggregate investment into the salience contest is highest if the subsidy minimizes asymmetries in the market. From a social welfare perspective, we show that the emission tax and the subsidy for green production are equivalent, as they generate the same welfare in optimum.

We also address the effects of introducing a minimum environmental quality standard, such that also the brown firm must produce goods with some positive environmental quality and firms are less environmentally differentiated. We show that lower environmental differentiation may increase investments into the salience contest by the brown firm. In this case, it becomes more likely that environmental quality is not salient for consumers, which increases expected market shares for the brown firm. Therefore, the minimum quality standard may paradoxically increase emissions and decrease welfare.

The article is organized as follows: Section 2 discusses our contributions to the literature. Section 3 introduces the main model. In Section 4, we analyze the market equilibria. Section 5 provides a welfare analysis. Section 6 discusses policy interventions and their impact on welfare. Section 7 concludes.

2   Related literature

In this article, we analyze a model where consumers have preferences over the environmental quality of goods and firms with conflicting interests fight over the salience of environmental quality. In particular, the green firm has an incentive to make environmental quality salient and thus draw consumers' attention to the environmental dimensions of the goods. The brown firm has an incentive to shroud environmental quality and thus deflect consumers' attention away from the environmental dimension of the goods.[6]

Therefore, we contribute primarily to the literature on green preferences. Earlier literature on green preferences, for example, found that green preferences of consumers incentivize firms to invest in emission abatement (Arora & Gangopadhyay 1995), market failure may still occur (Eriksson 2004, Kaufmann et al. 2024), standards may increase aggregate emissions (Moraga-González & Padrón-Fumero 2002), subsidies may outperform taxes (Bansal & Gangopadhyay 2003), commodity taxes may increase welfare (Cremer & Thisse 1999), emission standards are more cost-effective than emission taxes (Ambec & De Donder 2022), emission taxes may be preferable to quantity regulations (Herweg & Schmidt 2022), and firms' investments depend on the cost structure (Amacher et al.

---

[6]For articles on salient and shrouded attributes of goods without environmental externalities see, for example Gabaix & Laibson (2006), Ghosh & Galbreth (2013), Bordalo et al. (2016), Heidhues et al. (2016, 2017), Herweg et al. (2017), Apfelstaedt & Mechtenberg (2021), Hefti et al. (2022), Carroni et al. (2023), Inderst & Obradovits (2023), Janssen & Kasinger (2024).

2004). Whether emissions increase or decrease when consumers have preferences about environmental quality depends on the degree of product differentiation (Rodríguez-Ibeas 2007) and the type of innovation (Schmutzler 2024).

However, although consumers have green preferences, consumers also often display limited attention. To model limited attention, we follow DellaVigna (2009) and Gabaix (2019). The majority of the literature that accounts for limited attention in markets with environmental externalities investigates the optimal policy: Houde & Myers (2015) show that minimum standards are preferable to taxes and Allcott et al. (2014) and van der Ploeg (2025) show that the optimal policy includes taxes and subsidies. Farhi & Gabaix (2020) and Gilbert & Graff Zivin (2020) show that, if consumers pay only limited attention to the environmental dimension of goods, corrective taxes need to be higher than if consumers pay full attention. Gerster & Kramm (2024) show that the optimal commodity tax is nonlinear and exploits that consumers' demand reveals information about consumers' biases (e.g., their attention). We contribute to this literature on limited attention in markets with environmental externalities by incorporating that firms are able to influence consumers' attention allocation.[7] We show that the salience contest between the firms may mitigate the effect of limited attention on the optimal tax. We identify circumstances under which the optimal tax under limited attention is lower than under full attention. In addition, in our model, subsidies are only weakly preferable to taxes and optimal subsidies and taxes lead to the same welfare in a large range of circumstances. Therefore, we contribute to this literature by incorporating firms' competition over salience into the model and by showing that such a salience contest significantly changes the results and optimal policies.

Heyes et al. (2018) also address the competition over salience under limited attention. In contrast to Heyes et al. (2018), where firms fight against an NGO over the attention of consumers, in our model, firms with conflicting interest fight over the attention of consumers. We show that the incentives of green and brown firms to invest into the competition over consumers' limited attention depends on the competitive advantage of the green firm. This competition over limited attention affects firms' profits and the resulting market equilibrium.

To model firms' competition over salience, we follow the approaches of Friedman (1958), Schmalensee (1978), and Haan & Moraga-González (2011), who model competition in advertising as a probabilistic contest (see Tullock 1980). In Friedman (1958) and Schmalensee (1978), firms' relative advertising determines firms' sales. In Haan & Moraga-González (2011), advertising influences the order in which consumers visit firms in their search for goods. In contrast, in our model, advertising influences the proba-

---

bility for the narrative of a specific firm to dominate, i.e., whether consumers take the environmental quality of goods into account in their consumption decision. A different interpretation is that the two firms exert effort to persuade consumers (Skaperdas & Vaidya 2012).

Overall, our main contribution lies in extending the analysis of the effects of consumers' limited attention on emissions and welfare by accounting for firms' competition over consumers' limited attention. We identify circumstances under which allowing firms to compete for attention increases welfare. In addition, we show that this competition affects the optimal emission tax, subsidy, and minimum quality standard.

3   Model

We consider a market with two horizontally differentiated firms, firm 1 and firm 2, and a unit mass of consumers. We model horizontal product differentiation as a real line $[0, 1]$, where firm 1 is located at 0 and firm 2 is located at 1. Firms produce goods with identical base value $v \in \mathbb{R}_0^+$ to consumers. Goods differ in their prices $p_i \in \mathbb{R}_0^+$ and environmental quality $q_i \in \mathbb{R}_0^+$ with $i \in \{1, 2\}$. We assume $q_1 > q_2$ and set $q_2 = 0$. Therefore, the environmental quality of firm 1's good, q_1, is a measure of environmental differentiation. We call firm 1 *green* firm and firm 2 *brown* firm. Producing environmentally friendly goods is costly. Therefore, we assume that firms differ in their marginal cost of production c_i, where $c_1 \equiv c > c_2 = 0$. The production of one unit of a good causes emissions $e - q_i$, where $e > q_1$. That means, the higher the environmental quality of a good, the lower the per-unit emissions.

Consumers are distributed uniformly on $[0, 1]$ and buy exactly one unit of the good. A consumer located at $x \in [0, 1]$ who buys the good from firm $i \in \{1, 2\}$ receives utility

$$u_x(i) = v + q_i - p_i - t|y_i - x|, \tag{1}$$

where y_i is the location of firm i and $t > 0$ are the transportation costs. The parameter t captures horizontal product differentiation between the firms and thus also serves as a measure of market power. Although consumers prefer goods with a higher level of environmental quality, observing the level of environmental quality is difficult. We assume that consumers' perception of environmental quality depends on the salience of environmental quality $s \in \{0, 1\}$. In particular, we assume that the perceived environmental quality of the good of firm i is[8]

$$\hat{q}_i = sq_i.$$

---

[8]See DellaVigna (2009) and Gabaix (2019) for similar approaches.

Consequently, if environmental quality is salient, i.e., if $s = 1$, consumers perceive the environmental quality of the goods perfectly. If environmental quality is not salient, i.e., if $s = 0$, consumers do not perceive the environmental quality of the goods.

We distinguish between the experience utility given in (1) and the perceived utility which consumers use in their consumption decision:

$$\hat{u}_x(i) = v + \hat{q}_i - p_i - t|y_i - x|.$$

Consumers buy the good which yields the higher perceived utility. The indifferent consumer is located at

$$\bar{x} \equiv \frac{p_2 - p_1 + \hat{q}_1 - \hat{q}_2 + t}{2t}.$$

Therefore, all consumers with $x \leq \bar{x}$ buy from firm 1 and all consumers with $x > \bar{x}$ buy from firm 2. The demand for the goods of firm 1 and firm 2 is thus

$$x_1^D(p_1, p_2) = \bar{x}$$
$$x_2^D(p_1, p_2) = 1 - \bar{x}.$$

Firms have conflicting interests about salience s: The green firm, firm 1, prefers environmental quality to be salient ($s = 1$). The brown firm, firm 2, prefers environmental quality to be shrouded ($s = 0$).[9] We assume that firms are able to compete to influence the salience s of environmental quality and thus also influence consumers' perception and consumption decisions. We model this competition over salience as a lottery contest (Tullock 1980) and call it *salience contest*: Firm i invests $\sigma_i \in \mathbb{R}_0^+$ to influence the salience of environmental quality s at cost σ_i. The probability that salience takes firm i's preferred level is given by firm i's relative investment:

$$\Pr\left(s = 1\right) = \begin{cases} \frac{\sigma_1}{\sigma_1 + \sigma_2} & \text{if } \sigma_1 \neq \sigma_2 \\ \frac{1}{2} & \text{if } \sigma_1 = \sigma_2 \end{cases}$$

$$\Pr\left(s = 0\right) = \begin{cases} 1 - \frac{\sigma_1}{\sigma_1 + \sigma_2} & \text{if } \sigma_1 \neq \sigma_2 \\ \frac{1}{2} & \text{if } \sigma_1 = \sigma_2. \end{cases}$$

We define social welfare as $W = PS + CS - D(E)$, where PS is the producer surplus (sum of profits), CS is the consumer surplus, and $D(E)$ are the damages caused by total emissions $E = (e - q_1)x_1^D(p_1, p_2) + (e - q_2)x_2^D(p_1, p_2)$. We assume the following linear damage function $D(E) = \delta E$, where $\delta \in \mathbb{R}_0^+$ is the marginal damage. We assume that consumers also derive utility from the environmental quality of the green good in the case

---

[9]We exclude the possibility of overestimating the environmental quality, so the maximum salience firm 1 can set (if it wins the contest) is $s = 1$.

that environmental quality is not salient, i.e., for the consumer surplus we use the utility given in (1).[10]

To ensure that the market is covered and that both firms receive some demand in equilibrium, i.e., that $\bar{x} \in [0, 1]$, we make the following assumptions:

Assumption 1 $v > 3t \geq q_1$.

Assumption 2 $3t \geq c$.

We consider the following game between the firms (see Figure 1): In the first stage, both firms simultaneously choose their investments in the salience contest. In the second stage, firms observe the salience of environmental quality and 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.
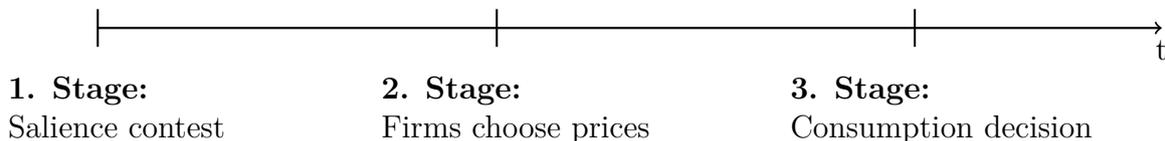

| **1. Stage:** | **2. Stage:** | **3. Stage:** |
| Salience contest | Firms choose prices | Consumption decision |

Figure 1: Timeline.

4 Results

4.1 Price-setting stage

In the price-setting stage, firms choose their prices simultaneously to maximize their profits

$$\pi_1(p_1, p_2, \sigma_1, \sigma_2) = (p_1 - c)x_1^D(p_1, p_2) - \sigma_1$$
$$\pi_2(p_1, p_2, \sigma_1, \sigma_2) = p_2 x_2^D(p_1, p_2) - \sigma_2.$$

Consequently, in equilibrium, firms choose prices

$$p_1^* = \frac{1}{3}\left(3t + 2c + \hat{q}_1 - \hat{q}_2\right)$$
$$p_2^* = \frac{1}{3}\left(3t + c + \hat{q}_2 - \hat{q}_1\right).$$

---

[10]For example, consumers buying an electrical appliance also derive utility from lower energy consumption even if energy consumption was not salient during the consumption decision and thus consumers did not take energy consumption into account in their consumption decision. In addition, over time, consumers may learn the true environmental quality of the good that they bought. With this assumption, we refrain from capturing *warm glow*.

The equilibrium prices depend on the perceived difference in environmental quality. If the brown firm wins the salience contest, environmental quality remains shrouded, $s = 0$, and consumers do not perceive a difference in environmental quality. Consequently, both firms choose prices $p_1^* = t + 2c/3$ and $p_2^* = t + c/3$ in equilibrium. As firms are horizontally differentiated, firms choose strictly positive prices. If the green firm wins the contest, environmental quality becomes salient, $s = 1$, and consumers perceive a difference of $\hat{q}_1 - \hat{q}_2 = q_1$ in environmental quality. Then, prices are $p_1^* = (3t + 2c + q_1)/3$ and $p_2^* = (3t + c - q_1)/3$.

The corresponding equilibrium profits are

$$\pi_1(\sigma_1, \sigma_2) = \frac{1}{18t}(3t + \hat{q}_1 - \hat{q}_2 - c)^2 - \sigma_1$$

$$\pi_2(\sigma_1, \sigma_2) = \frac{1}{18t}(3t + \hat{q}_2 - \hat{q}_1 + c)^2 - \sigma_2.$$

4.2   Contest stage

In the first stage, firms compete in a lottery contest over the salience of environmental quality, taking the prices from the price-setting stage into account. The perceived environmental quality of firm 1 is $\hat{q}_1 = sq_1$ and the perceived environmental quality of firm 2 is $\hat{q}_2 = sq_2 = 0$ as $q_2 = 0$. Therefore, firms' profits depend on the salience of environmental quality:

$$\pi_1(\sigma_1, \sigma_2) = \frac{1}{18t}(3t + sq_1 - c)^2 - \sigma_1$$

$$\pi_2(\sigma_1, \sigma_2) = \frac{1}{18t}(3t - sq_1 + c)^2 - \sigma_2.$$

We verify that, under Assumptions 1 and 2, $(\partial \pi_1)/(\partial s) > 0$ and $(\partial \pi_2)/(\partial s) < 0$. That means, firm 1 prefers salient environmental quality ($s = 1$) and firm 2 prefers shrouded environmental quality ($s = 0$). In the contest stage, firms simultaneously choose their investments to maximize their expected profits

$$\mathbb{E}[\pi_1(\sigma_1, \sigma_2)] = \frac{\sigma_1}{\sigma_1 + \sigma_2}\pi_1^{s=1}(\sigma_1, \sigma_2) + \left(1 - \frac{\sigma_1}{\sigma_1 + \sigma_2}\right)\pi_1^{s=0}(\sigma_1, \sigma_2)$$

$$= \frac{\sigma_1}{\sigma_1 + \sigma_2}\frac{(3t + q_1 - c)^2}{18t} + \left(1 - \frac{\sigma_1}{\sigma_1 + \sigma_2}\right)\frac{(3t - c)^2}{18t} - \sigma_1$$

$$\mathbb{E}[\pi_2(\sigma_1, \sigma_2)] = \frac{\sigma_2}{\sigma_1 + \sigma_2}\pi_2^{s=0}(\sigma_1, \sigma_2) + \left(1 - \frac{\sigma_2}{\sigma_1 + \sigma_2}\right)\pi_2^{s=1}(\sigma_1, \sigma_2)$$

$$= \frac{\sigma_2}{\sigma_1 + \sigma_2}\frac{(3t + c)^2}{18t} + \left(1 - \frac{\sigma_2}{\sigma_1 + \sigma_2}\right)\frac{(3t - q_1 + c)^2}{18t} - \sigma_2.$$

Proposition 1 summarizes the subgame-perfect equilibrium.

Proposition 1 *In the subgame-perfect equilibrium, firms' investments into the salience*

contest are

$$\sigma_1^* = \frac{q_1(6t - q_1 + 2c)(6t + q_1 - 2c)^2}{2592t^3}$$

$$\sigma_2^* = \frac{q_1(6t - q_1 + 2c)^2(6t + q_1 - 2c)}{2592t^3}.$$

The corresponding equilibrium prices $p_i^*(s)$ depend on salience $s \in \{0,1\}$. If $s = 1$, equilibrium prices are $p_1^*(1) = (3t + 2c + q_1)/3$ and $p_2^*(1) = (3t + c - q_1)/3$. If $s = 0$, equilibrium prices are $p_1^*(0) = t + 2c/3$ and $p_2^*(0) = t + c/3$.

The proof is in Appendix A. Investing in the salience contest is costly, but firms have two reasons to invest into the salience contest: (i) firms can charge higher prices if they win (i.e., $p_1^*(1) > p_1^*(0)$ and $p_2^*(0) > p_2^*(1)$), and (ii) firms attract a higher market share if they win. If environmental quality is not salient, the consumers do not take environmental quality into account in their consumption decision. If environmental quality becomes salient, consumers take environmental quality into account. Then, as $q_1 > 0$, consumers are willing to pay more for the good of firm 1. Yet, as $q_2 = 0$, the willingness to pay for the good of firm 2 remains unchanged. Consequently, if environmental quality is salient, firm 1 receives a larger market share and is able to charge higher prices. To dampen this effect on market shares, firm 2 reduces its price.

Let $\bar{x}_{s=s'}$ be the indifferent consumer for a salience level $s' \in \{0,1\}$. As all consumers with $x \leq \bar{x}_{s=s'}$ buy from firm 1 and all consumers with $x > \bar{x}_{s=s'}$ buy from firm 2, the market share of firm 1 is $\bar{x}_{s=s'}$ and the market share of firm 2 is $1 - \bar{x}_{s=s'}$. If environmental quality is salient, i.e., if $s = 1$, the indifferent consumer and thus the market share of firm 1 is

$$\bar{x}_{s=1} = \frac{1}{2} + \frac{q_1 - c}{6t}.$$

If environmental quality is shrouded, i.e., if $s = 0$, the market share of firm 1 is

$$\bar{x}_{s=0} = \frac{1}{2} - \frac{c}{6t}.$$

As firm 1 wins the salience contest with probability

$$\Pr(s = 1) = \frac{\sigma_1^*}{\sigma_1^* + \sigma_2^*} = \frac{6t + q_1 - 2c}{12t},$$

the expected market share of firm 1 is

$$\mathbb{E}[\bar{x}] = \Pr(s = 1)\bar{x}_{s=1} + \left(1 - \Pr(s = 1)\right)\bar{x}_{s=0} = \frac{q_1^2 + 6q_1t + 36t^2 - 2c(q_1 + 6t)}{72t^2}.$$

The expected market share of firm 1 is increasing in environmental quality and in the

degree of horizontal product differentiation and is decreasing in marginal cost:

$$(i) \quad \frac{\partial \mathbb{E}[\bar{x}]}{\partial q_1} > 0, \quad (ii) \quad \frac{\partial \mathbb{E}[\bar{x}]}{\partial c} < 0, \quad (iii) \quad \frac{\partial \mathbb{E}[\bar{x}]}{\partial t} > 0 \iff q_1 < 2c.$$

Properties (i) and (ii) are straightforward: As environmental quality q_1 is a competitive advantage for firm 1 and the marginal cost c is a competitive disadvantage for firm 1, an increase in environmental quality increases the market share of firm 1 and an increase in marginal cost decreases the market share of firm 1. Property (iii) states that an increase in the degree of horizontal product differentiation t, which drives market shares closer to $1/2$, on average benefits firm 1 if q_1 is small in comparison to c, that is if firm 1 is overall at a competitive disadvantage in the market.

For the analysis of the effects of environmental quality, marginal costs, and market power on equilibrium investments, rewriting the equilibrium investments as a function of the firms' valuations, i.e., the effective prizes of winning the contest, is helpful. The firms' valuations V_i are

$$V_1 \equiv \pi_1^{s=1}(\sigma_1, \sigma_2) - \pi_1^{s=0}(\sigma_1, \sigma_2) = \frac{q_1(6t + q_1 - 2c)}{18t}$$

$$V_2 \equiv \pi_2^{s=0}(\sigma_1, \sigma_2) - \pi_2^{s=1}(\sigma_1, \sigma_2) = \frac{q_1(6t - q_1 + 2c)}{18t}.$$

Then, the equilibrium investments are

$$\sigma_1^* = \frac{V_1^2 V_2}{(V_1 + V_2)^2}$$

$$\sigma_2^* = \frac{V_1 V_2^2}{(V_1 + V_2)^2}.$$

Valuations influence the firms' investments in two ways. First, a firm increases its investment if its valuation increases (valuation effect). This direct effect reflects that the more firms value winning, the harder they fight in order to win. Second, a firm increases its investment if the firms' valuations become more similar (symmetry effect). In a highly asymmetric situation, the firm with the lower valuation is discouraged from fighting. As the probability of winning depends on the relative investments, if a firm's competitor reduces its investment, the firm finds it optimal to reduce its investment as well.

Proposition 2 summarizes the properties of the firms' equilibrium investments.

Proposition 2 *The equilibrium investments of firm 1, σ_1^*, and of firm 2, σ_2^*, and the aggregate investment $\bar{\sigma} = \sigma_1^* + \sigma_2^*$ have the following properties:*

(i) The green firm invests more if and only if its environmental quality is large compared

to its cost of production:

$$\sigma_1^* \geq \sigma_2^* \quad \Leftrightarrow \quad V_1 \geq V_2 \quad \Leftrightarrow \quad q_1 \geq 2c.$$

(ii) Whether aggregate investments are increasing or decreasing in the marginal cost c depends on the environmental quality q_1:

$$\frac{\partial \bar{\sigma}}{\partial c} \geq 0 \Leftrightarrow q_1 \geq 2c.$$

(iii) Aggregate investments are increasing in the environmental quality of the green firm:

$$\frac{\partial \bar{\sigma}}{\partial q_1} > 0.$$

(iv) Aggregate investments are increasing in the degree of horizontal product differentiation:

$$\frac{\partial \bar{\sigma}}{\partial t} \geq 0.$$

The proof is in Appendix A.

In equilibrium, firm 1 invests more than firm 2 if and only if $V_1 > V_2$ and, consequently, if and only if the competitive advantage of firm 1 is sufficiently large, i.e., the marginal cost of green production is sufficiently small relative to the environmental quality of firm 1. As the market share is independent of q_1 if environmental quality is shrouded, the relationship between q_1 and c only affects the market share if environmental quality is salient. If $q_1 = 2c$, firm 1 and firm 2 have the same market share conditional on winning, i.e., if $q_1 = 2c$, $\bar{x}_{s=1} = 1 - \bar{x}_{s=0}$. If $q_1 > 2c$, conditional on winning, firm 1 has a higher market share than firm 2. Therefore, if firm 1 wins, firm 1 is able to exploit more consumers with higher prices than firm 2 is able to exploit if firm 2 wins. Consequently, firm 1 has a larger incentive to invest in the salience contest. Figure 2 illustrates the equilibrium investments of firm 1 and firm 2 graphically.

The effect of the marginal cost on the individual investments are ambiguous and depend on the degree of horizontal product differentiation. Aggregate investments are increasing as long as firm 1 invests more than firm 2 and thus as long as firm 1 maintains its competitive advantage.

An increase in the environmental quality of the green firm q_1 increases firm 1's investment; the effect on firm 2's investment is ambiguous. The valuation effect incentivizes both firms to invest: As q_1 is a direct measure of the true difference in environmental quality, if q_1 increases, both firms fight harder in order to make this difference salient, respectively not salient. However, as V_1 increases in q_1 and V_2 decreases in q_1, for firm 2,
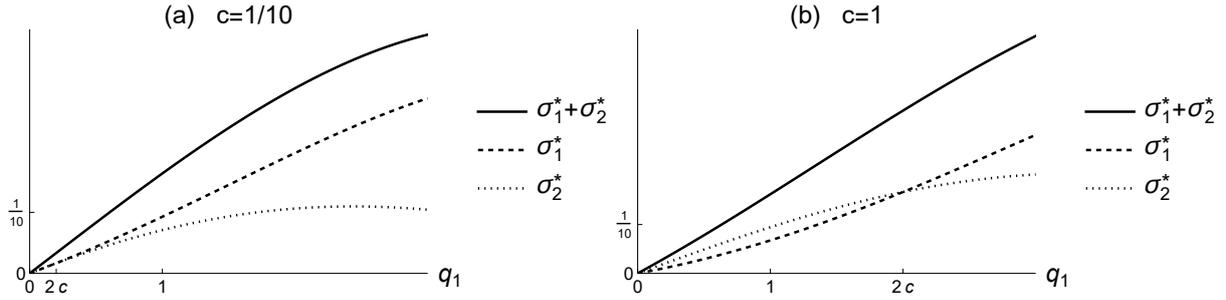
Figure 2: Aggregate equilibrium investments (solid) and individual equilibrium investments in the salience contest of firm 1 (dashed) and of firm 2 (dotted) as a function of firm 1's environmental quality q_1 for $t = 1$ and (a) $c = 1/10$ and (b) $c = 1$.

the symmetry effect may dominate. In particular, if q_1 is large relative to c, the asymmetry in valuations may become large enough such that firm 2 is discouraged from investing (see Figure 2). However, aggregate investments always increase in q_1. Even in the case where the symmetry effect dominates for firm 2, the valuation effect encourages firm 1 to increase its investment further with an increasing q_1. This more than offsets firm 2's reduced investment.

The effect of the degree of horizontal product differentiation t on individual equilibrium investments is nonmonotonic. The green firm's valuation V_1 increases in t if $q_1 < 2c$, and the valuation effect ensures that the green firm's investment into the salience contest also increases in t in this case. For $q_1 \in [2c, 6c]$ the (in this case negative) valuation effect ensures that the green firm's investment into the salience contest decreases in t. For $q_1 > 6c$, the symmetry effect becomes relevant: The green firm's valuation is much larger than the brown firm's valuation, and an increase in t implies that the gap between the two valuations shrinks. Whether firm 1 increases or decreases its investment as t increases depends on whether the valuation or the symmetry effect dominates. If $t < (q_1 - 2c)/2$, the investment of firm 1 increases in t and if $t > (q_1 - 2c)/2$, the investment of firm 1 decreases in t. By the same logic, the brown firm's investment increases in t if $q_1 > 2c$, decreases in t if $q_1 \in [6c/5, 2c]$, and has a maximum at $t^* = (2c - q_1)/2$ if $q_1 < 6c/5$.

In contrast, irrespective of the marginal cost c, aggregate investments increase in the degree of horizontal product differentiation t. As a high degree of market power allows firms to keep a larger share of total surplus, firms fight harder for this surplus. While an increase in market power creates different incentives for firms' individual investment decisions, for aggregate investments, the valuation effect dominates and aggregate investments are increasing in t. Consequently, firms fight harder over salience if there is a high degree of market power.

Corollary 1 summarizes the properties of the firms' expected equilibrium profits.

Corollary 1 *The expected equilibrium profits $\mathbb{E}[\pi_1^*]$ and $\mathbb{E}[\pi_2^*]$ have the following properties:*

13

(i) $\mathbb{E}[\pi_1^*] \geq \mathbb{E}[\pi_2^*] \quad \Leftrightarrow \quad q_1 \geq 2c$

(ii) $\partial\mathbb{E}[\pi_1^*]/(\partial q_1) > 0, \quad \partial\mathbb{E}[\pi_1^*]/(\partial c) < 0$

(iii) $\partial\mathbb{E}[\pi_2^*]/(\partial q_1) < 0, \quad \partial\mathbb{E}[\pi_2^*]/(\partial c) > 0$

The proof is in Appendix A. Figure 3 illustrates the firms' expected equilibrium profits graphically.
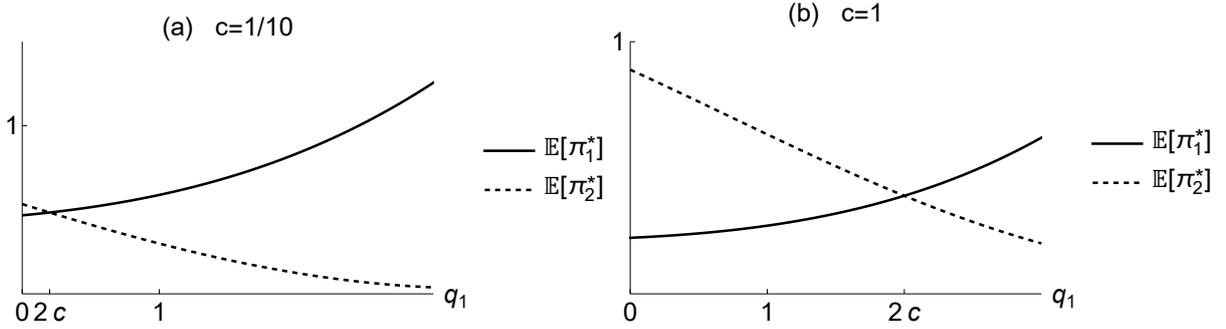

Figure 3: Expected equilibrium profits of firm 1 (solid) and firm 2 (dashed) as a function of firm 1's environmental quality q_1 for $t = 1$ and (a) $c = 1/10$ and (b) $c = 1$.

The expected profit of firm 1 is larger than the expected profit of firm 2 if the environmental quality of firm 1 is large relative to its marginal cost of production. The intuition follows from Proposition 2: If $q_1 > 2c$, the green firm invests more and will, therefore, win the contest and attract a higher market share with a higher probability. Consequently, firm 1 generates a higher expected profit than firm 2.

The expected equilibrium profits depend on the environmental quality of firm 1 q_1, marginal cost of green production c, and the degree of horizontal product differentiation t. The impact of q_1 and c on individual profits is straightforward: Environmental quality of the green firm q_1 improves the competitive situation of firm 1 relative to firm 2 and thus increases the profit of firm 1 and decreases the profit of firm 2. The marginal cost of environmental production c reduces the competitive situation of firm 1 relative to firm 2 and thus decreases the profit of firm 1 and increases the profit of firm 2. The impact of the degree of horizontal product differentiation t on profits is ambiguous. A higher degree of market power (i) allows firms to charge higher prices and thus increases profits; (ii) draws market shares towards $1/2$ and thus increases profits of the firm with a competitive disadvantage and decreases profits of the firm with a competitive advantage; (iii) incentivizes firms to fight harder for salience and thus decreases profits.

5   Discussion

In this section, we analyze the effects of a salience contest on social welfare and extend the analysis from a duopoly to the competition between one green firm and a brown

competitive fringe.

5.1 Welfare analysis

5.1.1 Welfare with a salience contest

We define social welfare as $W = PS + CS - D(E)$, where PS is producer surplus, CS is consumer surplus, and $D(E) = \delta E$ are the damages caused by emissions E. As prices and consumption decisions depend on the outcome of the salience contest, we focus on expected welfare: $\mathbb{E}[W] = \mathbb{E}[PS] + \mathbb{E}[CS] - \delta\mathbb{E}[E]$.

The expected producer surplus is

$$\mathbb{E}[PS] = \mathbb{E}[\pi_1^*] + \mathbb{E}[\pi_2^*] = \frac{2c^2 - 2cq_1 + q_1^2}{18t} + \frac{q_1(q_1 - 2c)^2}{72t^2} - \frac{q_1}{6} + t.$$

The effect of the degree of horizontal product differentiation t on producer surplus is ambiguous. On the one hand, horizontal product differentiation gives firms market power to charge higher prices, which increases expected producer surplus. On the other hand, horizontal product differentiation incentivizes firms to fight harder for their preferred salience levels, which decreases expected producer surplus.

The effect of environmental quality q_1 on expected producer surplus is also ambiguous: First, firm 1 increases its price and firm 2 reduces its price in response to higher environmental quality. Second, the expected market share of firm 1 increases in environmental quality q_1. However, an increase in environmental quality q_1 leads to higher aggregate investments, which reduces expected producer surplus. For sufficiently large marginal cost c, this investment effect dominates such that expected producer surplus is always decreasing in q_1. In contrast, for sufficiently small marginal cost c, expected producer surplus is convex in q_1 and has a unique minimum. In sum, expected producer surplus reaches its highest value either at the extreme $q_1 = 0$ or at the other extreme $q_1 = 3t$.

With respect to the marginal cost c, expected producer surplus has a unique minimum in c at $c = q_1/2$ and reaches its highest value at $c = 3t$, where aggregate investments are lowest.

The consumer surplus depends on whether environmental quality is salient or shrouded. As this is uncertain and depends on the firms' investment decision, expected consumer surplus is

$$\mathbb{E}[CS] = \Pr(s = 1) \left(\int_0^{\bar{x}_{s=1}} v + q_1 - p_1 - tx \; \mathrm{dx} \; + \int_{\bar{x}_{s=1}}^1 v - p_2 - t(1 - x)\mathrm{dx} \right)$$

$$+ \left(1 - \Pr(s = 1) \right) \left(\int_0^{\bar{x}_{s=0}} v + q_1 - p_1 - tx \; \mathrm{dx} \; + \int_{\bar{x}_{s=0}}^1 v - p_2 - t(1 - x)\mathrm{dx} \right)$$

$$= v + \frac{q_1^2(2c + 6t) + q_1 \left(216t^2 - 8c^2 - 48ct \right) + 12c^2t - 216ct^2 + q_1^3 - 540t^3}{432t^2}.$$

Expected consumer surplus is decreasing in the degree of horizontal product differentiation t and the marginal cost c and increasing in environmental quality q_1. An increase in the degree of horizontal product differentiation t directly decreases the utility of consumers who buy a non-optimal version of the good and thus decreases expected consumer surplus. In addition, horizontal product differentiation allows firms to charge higher prices, which reduces expected consumer surplus. Higher environmental quality of the green firm increases the utility of the consumers who buy the green good, irrespective of whether environmental quality is salient or not (this effect dominates the price increase of the green good). The marginal cost of green production is partially passed on to consumers and drives prices upwards, which decreases expected consumer surplus.

Expected emissions are

$$\mathbb{E}[E] = \Pr(s=1)\Big((e-q_1)\bar{x}_1 + e(1-\bar{x}_1)\Big) + \Big(1 - \Pr(s=1)\Big)\Big((e-q_1)\bar{x}_2 + e(1-\bar{x}_2)\Big)$$
$$= e - \frac{q_1^3 + 6q_1^2 t - 2cq_1(q_1 + 6t) + 36q_1 t^2}{72t^2}.$$

Expected emissions are increasing in marginal cost and decreasing in environmental quality. Environmental quality q_1 directly reduces emissions, while marginal cost of green production c moves market shares in the direction of firm 2. Whether expected emissions are increasing or decreasing in the degree of horizontal product differentiation t depends on the competitive advantage of firm 1: $\partial\mathbb{E}[E]/(\partial t) > 0 \Leftrightarrow q_1 > 2c$. The condition is the same condition for which firm 1 wins the contest with higher probability than firm 2. As an increase in t brings market shares closer to $1/2$, for $q_1 > 2c$ this results in expectations in larger market shares for firm 2, which increases emissions.

Adding expected producer surplus, expected consumer surplus, and the expected damage caused by emissions yields expected social welfare

$$\mathbb{E}[W] = \mathbb{E}[PS] + \mathbb{E}[CS] - \delta\mathbb{E}[E].$$

5.1.2 Welfare effects of the salience contest

In this section, we analyze the effects of the contest on social welfare. To distinguish the game without the contest from the game with the contest, we use superscript N for no-contest. We assume that without the contest, environmental quality is not salient, i.e., $\hat{q}_1 = \hat{q}_2 = 0$. Therefore, in their consumption decision, consumers take only horizontal product differentiation and prices into account. Nonetheless, firm 1 produces goods which are more environmentally friendly and has higher marginal cost of production $c_1 = c > c_2 = 0$. Then, equilibrium prices are $p_1^N = t + 2c/3$ and $p_2^N = t + c/3$. Consequently, the

profits of the firms and the producer surplus are

$$\pi_1^N = \frac{1}{18t}(3t - c)^2$$

$$\pi_2^N = \frac{1}{18t}(3t + c)^2$$

$$PS^N = \pi_1^N + \pi_2^N = t + \frac{c^2}{9t}.$$

The indifferent consumer is located at $\bar{x}^N = 1/2 - c/(6t)$. Therefore, as consumers do not take environmental quality into account in their consumption decision and firm 1 has higher marginal cost, the market share of the brown firm 2 is always larger than the market share of the green firm 1.

Consumer surplus is

$$CS^N = \int_0^{\bar{x}^N} v + q_1 - p_1^N - tx \; \mathrm{dx} \; + \int_{\bar{x}^N}^1 v - p_2^N - t(1 - x) \; \mathrm{dx}$$

$$= v + \frac{q_1(18t - 6c) + c^2 - 18ct - 45t^2}{36t}$$

and emissions are

$$E^N = e - \frac{q_1(3t - c)}{6t}.$$

Although environmental quality q_1 is absent in producer surplus because it is not salient, as consumers derive utility from the real quality, q_1 still impacts emissions and consumer surplus.

Lemma 1 summarizes the effects of the salience contest on producer surplus, consumer surplus, and emissions.

Lemma 1 *Effects of the salience contest on consumer surplus, producer surplus and emissions.*

(i) *Consumer surplus is always higher with the contest than without the contest.*

(ii) *Emissions are always lower with the contest than without the contest.*

(iii) *Producer surplus is higher with the contest than without the contest if and only if $q_1 > 2t$ and $c < (q_1 - 2t)/2$.*

The proof is in Appendix A.

With the salience contest consumers are more likely to take environmental quality into account in their consumption decision. Therefore, the contest moves market shares into the direction of the green firm, firm 1. Consequently, emissions decrease. In addition, as more consumers buy from the green firm, more consumers receive utility from buying an

17

environmentally friendly good which increases consumer surplus. Furthermore, if environmental quality is salient, firm 1 increases its price, which harms consumers, and firm 2 decreases its price, which benefits consumers. Nevertheless, in sum the effect of the contest on consumer surplus is positive.

As the contest increases firm 1's market share and allows firm 1 to increase its prices (if it wins), the contest increases the expected profit of firm 1. As the contest decreases firm 2's market share and firm 2 charges lower prices in expectations, the expected profit of firm 2 decreases. The contest increases producer surplus if the effect on firm 1 dominates which is the case if firm 1 has a competitive advantage, i.e., if firm 1 produces a good with high environmental quality at low cost.

In sum, the salience contest results in a welfare gain compared to the game without contest if and only if $\mathbb{E}[W] > W^N$, where $W^N = PS^N + CS^N - \delta E^N$ (see Proposition 3).

Proposition 3 *The salience contest increases welfare if and only if*

$$\delta \geq \bar{\delta} \equiv max\left\{0, \frac{8c - 7q_1 + 12t}{6q_1}\right\}.$$

The proof is in Appendix A. Figure 4 illustrates Proposition 3 graphically. The threshold $\bar{\delta}$ above which the salience contest between the firms yields a welfare gain depends on the environmental quality of the green firm 1, q_1, the marginal cost of firm 1, c, and the degree of horizontal product differentiation, t. If q_1 is sufficiently high, i.e., $q_1 \geq (8c + 12t)/7$ such that $\bar{\delta} = 0$, the benefits to consumers outweigh the costs to the firms such that the contest results in a welfare gain even without any damages from emissions. Otherwise, i.e., if $q_1 < (8c + 12t)/7$, the contest only results in a welfare gain if the marginal damage from emissions δ is sufficiently high.

In general, an increase in the environmental quality of firm 1 weakly reduces the threshold $\bar{\delta}$ such that the contest yields a welfare gain for a larger range of values ($\partial \bar{\delta}/(\partial q_1) \leq 0$), while an increase in the marginal cost weakly increases the threshold $\bar{\delta}$ such that the contest yields a welfare gain for a smaller range of values ($\partial \bar{\delta}/(\partial c) \geq 0$). The salience contest shifts market shares in expectation towards firm 1. If q_1 increases (if c increases), the production of firm 1's good causes less emissions (is more costly), so the shift towards firm 1 means that welfare from green production increases (decreases). An increase in the transportation cost t implies that firms have more market power, so the effect of the contest on market shares is smaller. At the same time, aggregate investments into the contest are increasing in t (Proposition 2). As these investments are socially wasteful, the contest yields a welfare gain for a smaller range of values ($\partial \bar{\delta}/(\partial t) \geq 0$).
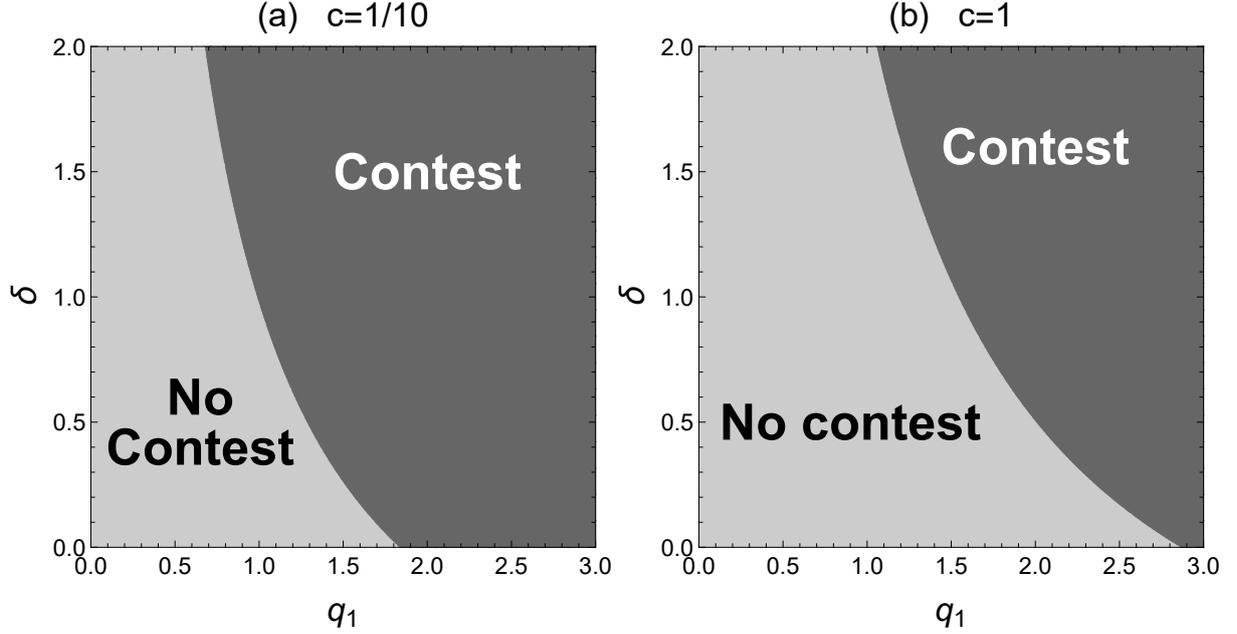
18

Figure 4: Comparison of the welfare with and without the salience contest for $t = 1$, $v = 10$, $e = 2$ and (a) $c = 1/10$ and (b) $c = 1$. In the dark gray area, the welfare is higher with the contest. In the light gray area, the welfare is higher without the contest.

5.2   Market concentration

In this section, we relax the assumption that there are only two firms in the market, where each level of environmental quality (brown or green) is occupied by exactly one firm. In particular, we analyze how a competitive fringe of n firms on the brown side of the market affects equilibrium behavior. We assume that one green firm, firm 1, with environmental quality $q_1 > 0$ is located at 0 and n brown firms with an environmental quality of zero are located at 1 in the product space $[0, 1]$. In addition, we assume that the probability that environmental quality is salient is given by:

$$\Pr\left(s = 1\right) = \begin{cases} \frac{\sigma_1}{\sigma_1 + \sum_i \sigma_i} & \text{if } \sigma_1 \neq \sum_i \sigma_i \\ \frac{1}{2} & \text{if } \sigma_1 = \sum_i \sigma_i \end{cases}$$

where $i \in \{2, 3, ..., n + 1\}$, so all brown firms fight against environmental salience. The probability that environmental quality remains shrouded is then $1 - Pr(s = 1)$. To ensure that the green and the brown firms participate in the market, we tighten the assumption on the marginal cost of production in this section: $c \leq t$.

The firms in the competitive fringe are neither horizontally not vertically differentiated. Consequently, consumers observe no difference between the firms in the competitive fringe and these firms have to engage in intense price competition, which drives prices down to marginal costs and ensures that the fringe earns zero profit. Due to the horizontal product differentiation between the green firm and the competitive fringe, the green firm is able to

19

charge a positive price. However, as the competitive fringe of brown firms sells at a lower price than a single brown firm, the green firm reduces its price compared to a situation where the green firm competes only against one brown firm.

In the investment stage, the fringe firms anticipate this price-setting. As price competition eliminates their profits irrespective of whether environmental quality is salient or not, the brown firms have no incentive to invest costly resources to win the contest. The green firm retains its incentive to win the contest, but anticipates that the brown firms do not invest into the salience contest. Therefore, the green firm only invests the smallest possible amount, which we define as ε with $\varepsilon \to 0$, to win the salience contest with certainty.

Introducing a competitive fringe on the brown side affects social welfare in two ways. First, the fringe affects market shares: On the one hand, the green firm now wins the salience contest with certainty, so the expected market share of the green firm increases. On the other hand, intense price competition between the firms on the fringe moves market shares into the direction of the brown firms. If the salience (price) effect dominates, emissions decrease (increase), which increases (decreases) social welfare. Second, the existence of the fringe implies that the investments into the salience contest, which are detrimental to social welfare, reduce to approximately zero.

Proposition 4 describes the overall effect of the fringe on social welfare.

Proposition 4 *Let W_F be social welfare if there is a competitive fringe on the brown side and let $\varepsilon \to 0$. Then, the expected welfare with the duopoly is higher than the welfare with the competitive fringe, i.e., $\mathbb{E}[W] > W_F$, if and only if the environmental quality of the green firm is sufficiently low and the marginal damage of emissions is sufficiently large, i.e., if and only if*

$$q_1 < 6t + c - \sqrt{c^2 + 6ct + 18t^2} \ \ and$$
$$\delta > max \left\{ 0, \frac{1}{12} \left(\frac{7c - 3t}{q_1} + \frac{q_1 \left(37c - 14q_1 + 105t \right) - 18c(c + 3t)}{-2q_1(c + 6t) + 6t(c + 3t) + q_1^2} \right) \right\}.$$

The proof is in Appendix A. Figure 5 illustrates the results of Proposition 4 graphically. If the green firm's environmental quality q_1 is sufficiently large, i.e., if $q_1 > 6t + c - \sqrt{c^2 + 6ct + 18t^2}$, the fringe moves market shares to the green firm and thus the fringe increases welfare for all δ. In contrast, if q_1 is small enough such that market shares move into the brown firm's direction, i.e., if $q_1 < 6t + c - \sqrt{c^2 + 6ct + 18t^2}$, the fringe only increases welfare for sufficiently small marginal damage δ. If the marginal damage is large, emissions receive a high weight in the social welfare. Then, the welfare with the duopoly where more consumers buy from the green firm is higher than the welfare with the competitive fringe where more consumers buy from one of the brown firms. As q_1 decreases, the range of values for the marginal damage δ for which the fringe increases

welfare shrinks, because the market share of the brown firm increases further. However, for sufficiently large marginal cost and very low values of environmental quality q_1, the range of values for the marginal damage δ for which the fringe increases welfare increases again. The reason for this last shift is that for very low environmental quality q_1, brown and green goods are only barely environmentally differentiated such that they cause similarly high emissions. However, the green firm has significantly higher marginal cost such that a decrease in the market share of the green firm increases social welfare. In addition, with the fringe investments into the salience contest are lower which increases social welfare.
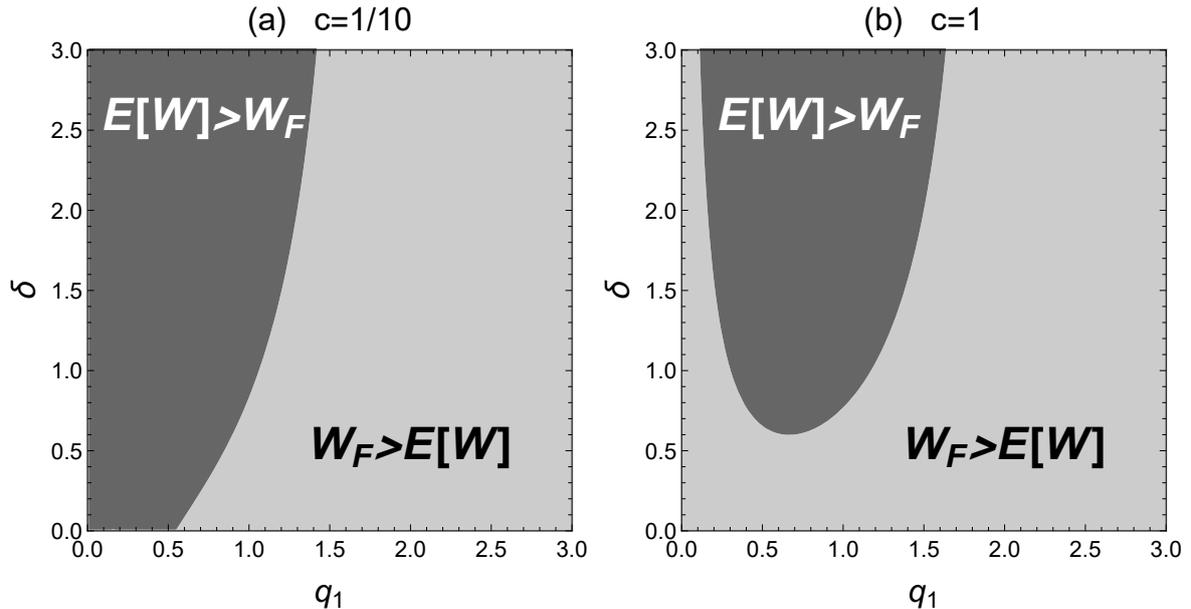

Figure 5: Comparison of the expected welfare in the duopoly ($\mathbb{E}[W]$) with the welfare with a competitive fringe (W_F) for $t = 1$, $\varepsilon \to 0$, and (a) $c = 1/10$ and (b) $c = 1$. In the dark gray area, welfare is higher in the duopoly. In the light gray area, welfare is higher with a competitive fringe.

6 Policy interventions

In this section, we analyze whether policy interventions are necessary or obsolete in the presence of a salience contest. In particular, we analyze the implications of emission taxes, subsidies, and minimum standards.

6.1 Emission tax

In this section, we assume that the policymaker introduces an emission tax on production. Producing one unit of the good of firm i causes emissions of $e - q_i$, where $q_1 > q_2 = 0$. Both firms pay a per-unit tax proportional to their emissions: $\tau \cdot (e - q_i)$ with tax rate $\tau \in [0, \delta]$. The parameter $\delta > 0$ is the marginal damage of emissions. Therefore, a tax rate of $\tau = \delta$ implies full internalization of emissions. To distinguish the results with

the tax from the results without the tax, we introduce the superscript τ for the results with the tax. To ensure that, in equilibrium, both firms receive a positive demand for all $\tau \in [0, \delta]$ and that the market is covered, we assume $q_1 < (3t + c)/(1 + \delta)$ and $v > 3t + \delta e$.

In the price setting stage, firms maximize the following profits

$$\pi_1^\tau(p_1, p_2, \sigma_1, \sigma_2) = \left(p_1 - c - \tau(e - q_1)\right)x_1^D(p_1, p_2) - \sigma_1$$
$$\pi_2^\tau(p_1, p_2, \sigma_1, \sigma_2) = (p_2 - \tau e)x_2^D(p_1, p_2) - \sigma_2.$$

Consequently, in equilibrium, firms choose prices

$$p_1^\tau = \frac{1}{3}\left(3t + \hat{q}_1 + 2c + \tau(3e - 2q_1)\right)$$
$$p_2^\tau = \frac{1}{3}\left(3t - \hat{q}_1 + c + \tau(3e - q_1)\right)$$

and obtain profits

$$\pi_1^\tau = \frac{1}{18t}\left(3t + \hat{q}_1 - c + \tau q_1\right)^2 - \sigma_1$$
$$\pi_2^\tau = \frac{1}{18t}\left(3t - \hat{q}_1 + c - \tau q_1\right)^2 - \sigma_2.$$

If environmental quality is salient, the market share of firm 1 is

$$\bar{x}_{s=1}^\tau = \frac{1}{2} + \frac{q_1(1 + \tau) - c}{6t}.$$

If environmental quality is not salient, the market share of firm 1 is

$$\bar{x}_{s=0}^\tau = \frac{1}{2} + \frac{q_1\tau - c}{6t}.$$

The market share of firm 2 is $1 - \bar{x}_{s=s'}^\tau$ with $s' \in \{0, 1\}$. As firm 2 has to pay higher taxes per unit of production, the tax moves market shares into the direction of firm 1 irrespective of whether environmental quality is salient or shrouded. Both firms raise their prices in response to the tax, but firm 2 raises its price by a higher amount. Consumers react to these changes in prices and the demand for firm 1 increases.

In the contest stage, firms choose their investments in the salience contest, taking into account the prices from the price-setting stage. Firms maximize the following expected profits

$$\mathbb{E}[\pi_1(\sigma_1, \sigma_2)] = \frac{\sigma_1}{\sigma_1 + \sigma_2}\frac{\left(3t + q_1(1 + \tau) - c\right)^2}{18t} + \left(1 - \frac{\sigma_1}{\sigma_1 + \sigma_2}\right)\frac{(3t + q_1\tau - c)^2}{18t} - \sigma_1$$
$$\mathbb{E}[\pi_2(\sigma_1, \sigma_2)] = \frac{\sigma_2}{\sigma_1 + \sigma_2}\frac{(3t + c - q_1\tau)^2}{18t} + \left(1 - \frac{\sigma_2}{\sigma_1 + \sigma_2}\right)\frac{\left(3t + c - q_1(1 + \tau)\right)^2}{18t} - \sigma_2.$$

In equilibrium, firms invest

$$\sigma_1^\tau = \frac{q_1\Big(6t - q_1(2\tau + 1) + 2c\Big)\Big(6t + q_1(2\tau + 1) - 2c\Big)^2}{2592t^3}$$

$$\sigma_2^\tau = \frac{q_1\Big(6t - q_1(2\tau + 1) + 2c\Big)^2\Big(6t + q_1(2\tau + 1) - 2c\Big)}{2592t^3}.$$

Consequently, firm 1 wins the contest with probability

$$\Pr(s = 1; \tau) = \frac{2q_1\tau - 2c + q_1 + 6t}{12t}.$$

Firm 1 profits from a higher tax: (i) A higher tax allows firm 1 to raise its price and (ii) a higher tax increases the market share of firm 1. These effects are more pronounced if environmental quality is salient. Firm 2 also charges higher prices if the tax rate is higher, but suffers from a lower market share. The valuations of the prizes in the contest are

$$V_1^\tau = \frac{q_1(6t - 2c + 2q_1\tau + q_1)}{18t}, \quad V_2^\tau = \frac{q_1(6t + 2c - 2q_1\tau - q_1)}{18t}$$

with $(\partial V_1^\tau)/(\partial \tau) > 0$ and $(\partial V_2^\tau)/(\partial \tau) = -(\partial V_1^\tau)/(\partial \tau)$. That means, firm 1 has a direct incentive to invest more if taxes increase, while firm 2 has a direct incentive to shirk from competition if taxes increase. However, given a fixed level of their own prize, firms fight hardest when the other firm's prize is of the same size. Otherwise, one firm values winning more than the other, and this asymmetry lowers the incentive to fight. Therefore, the effect of the tax rate τ on individual investment is non-monotonic.

In contrast, the effect of the tax rate τ on aggregate investment is more tractable. The effect of the tax rate τ on aggregate investments is summarized in Corollary 2.

Corollary 2 *The effect of the tax rate τ on aggregate investments is as follows:*

(i) If $q_1 > 2c$, aggregate investment decreases in the tax rate τ.

(ii) If $2c/(1 + 2\delta) \leq q_1 \leq 2c$, aggregate investment has a unique maximum in the tax rate τ at $\tau = (2c - q_1)/(2q_1)$.

(iii) If $q_1 < 2c/(1 + 2\delta)$, aggregate investment increases in the tax rate τ.

The proof is in Appendix B

If the tax rate τ changes, the effect on the prize levels cancel out. Therefore, for the effect on aggregate investment, only the effect on prize asymmetry matters. If the environmental quality q_1 is sufficiently large (relative to the marginal cost c; case (i)), an increase in the tax rate always increases prize asymmetry and thus lowers aggregate investment. For intermediate values of q_1 (relative to c; case (ii)), prize asymmetry has a minimum in τ, which is the maximum of aggregate investment. For sufficiently small

values of q_1 (relative to c; case (iii)), prize asymmetry always decreases in τ and thus aggregate investment always increases in τ.

The policymaker chooses the tax rate to maximize expected social welfare $\mathbb{E}[W^\tau] = \mathbb{E}[PS^\tau] + \mathbb{E}[CS^\tau] - \delta\mathbb{E}[E^\tau] + \mathbb{E}[T]$, where $\mathbb{E}[PS^\tau]$ is the expected producer surplus, $\mathbb{E}[CS^\tau]$ is the expected consumer surplus, $\mathbb{E}[E^\tau]$ are the expected emissions, and $\mathbb{E}[T]$ is the expected tax revenue. The optimal tax rate balances the effects of the tax rate on producer surplus, consumer surplus, emissions, and tax revenues (see Proposition 5).

Proposition 5 *Let*

$$c^\tau \equiv \frac{q_1(4q_1 + 15t)}{5q_1 + 12t}$$

$$\delta^\tau \equiv \frac{5cq_1 + 12ct - 4q_1^2 - 15q_1t}{3q_1^2 + 18q_1t}.$$

The optimal tax rate is

$$\tau^* = \begin{cases} 0 & \text{if } \delta < \delta^\tau \text{ and } c > c^\tau \\ \min\left\{\dfrac{q_1\left((3\delta+4)q_1 + 3t(6\delta+5)\right) - c(5q_1+12t)}{2q_1(3t-q_1)}, \delta\right\} & \text{otherwise.} \end{cases}$$

The proof is in Appendix B.

The effect of the tax rate τ on producer surplus is determined by the effect of the tax rate τ on aggregate investment (Corollary 2). As investments are costly, firms suffer from intense competition over salience. Therefore, producer surplus is increasing in τ if aggregate investment is decreasing in τ. The tax rate τ impacts consumer surplus in two ways. First, it increases the probability that firm 1 wins the contest. Therefore, in expectation, more consumers derive utility from buying an environmentally friendly good, which increases consumer surplus. Second, the tax directly increases prices of both goods, which lowers consumer surplus. In equilibrium, the second effect always dominates and thus consumer surplus is decreasing in τ. In addition, as an increase in the tax rate τ shifts market share to the green firm, expected emissions are decreasing in the tax rate. Tax revenue is given by $T = \tau \cdot E$. As emissions are decreasing in τ, expected tax revenue is concave in τ. The optimal tax rate balances these effects.

If green production is costly and the marginal damage caused by emissions is sufficiently low, the negative effect of the tax on consumer surplus dominates. Then, the policymaker does not impose a tax. Otherwise, a tax is welfare increasing and the policymaker chooses a positive tax rate.

The optimal tax rate depends on the marginal damage δ, the marginal cost of green production c, the environmental quality of the green firm q_1, and the degree of horizontal product differentiation t (see Corollary 3).

Corollary 3 *The optimal tax rate τ^* has the following properties*

$$\frac{\partial \tau^*}{\partial \delta} \geq 0, \quad \frac{\partial \tau^*}{\partial c} \leq 0, \quad \frac{\partial \tau^*}{\partial q_1} \geq 0.$$

The proof is in Appendix B.

First, an increase in the marginal damage gives the effect of the tax on emissions a higher weight in the welfare function. Consequently, as an increase in the tax rate shifts market share to the green firm and thus reduce emission, an increase in marginal damage (weakly) increases the optimal tax rate. Second, as an increase in the marginal cost of green production c increases the cost of green production and thus decreases welfare, an increase in c (weakly) reduces the optimal tax rate such that the market share for the green firm and thus the total production costs are limited. Third, an increase in environmental quality increases the benefits to consumers and decreases emissions. Therefore, a higher market share for the green good is optimal. To facilitate shifting market shares to the green firm, an increase in environmental quality (weakly) increases the optimal tax rate. Fourth, the effects of the degree of horizontal product differentiation t on the optimal tax rate are ambiguous and depend on the marginal cost as well as on the marginal damage.

Proposition 6 summarized the effects of the salience contest on the optimal tax rate.

Proposition 6 *Let τ^* be the optimal tax rate in the game with a salience contest, τ_N^* the optimal tax rate if no contest exists and environmental quality is not salient, and τ_S^* the optimal tax rate if no contest exists and environmental quality is salient. Then, the following relations hold:*

(i) *$\tau_N^* \geq \tau_S^*$, i.e., without any salience contest, the optimal tax rate is higher if consumers never account for environmental quality than if they always account for environmental quality.*

(ii) *$\tau_N^* \geq \tau^*$, i.e. the optimal emission tax is (weakly) lower with the salience contest than without the salience contest, if environmental quality is ex-ante not salient. Therefore, the salience contest and the emission tax are substitutes.*

(iii) *$\tau_S^* > \tau^* \Leftrightarrow c > (2q_1 + 3t)/3$ and $(2c - 2q_1)/(3q_1) < \delta < (9c - 3t - 8q_1)/(9q_1)$, i.e., if environmental quality is salient without the contest, the optimal emission tax without the contest may be lower than the optimal emission tax with the contest.*

The proof is in Appendix B. Figure 6 illustrates Proposition 6 graphically.

In general, without any salience contest, the optimal tax rate is (weakly) higher if consumers account for environmental quality than if consumers do not account for environmental quality. Green preferences and emission taxes are substitutes: Consumers with green preferences are willing to pay more for the green good and thus green preferences shift market shares to the green firm and reduce emissions. An emission tax
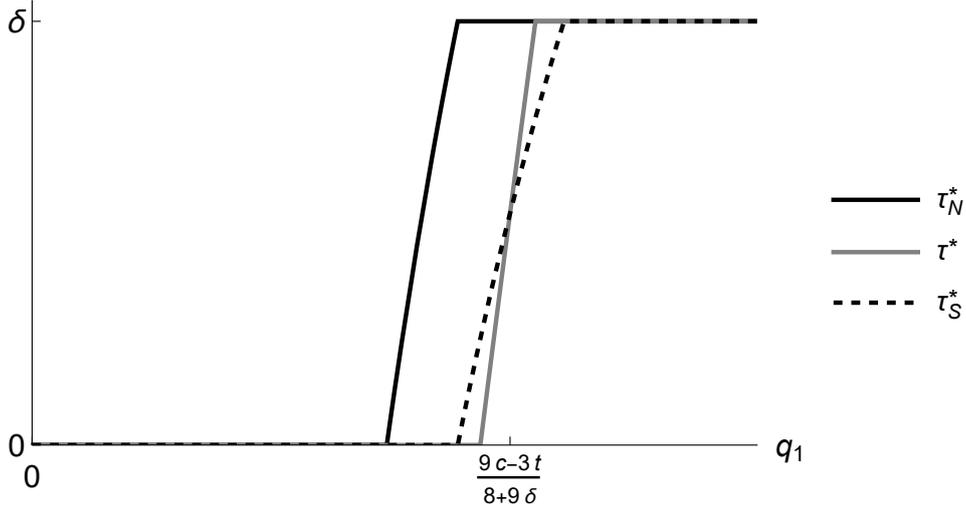
Figure 6: Optimal tax rates with a salience contest (τ^*), without a contest where environmental quality is not salient (τ_N^*), and without a contest where environmental quality is salient (τ_S^*) for $t = 1$, $c = 2.2$, and $\delta = 1$.

increases prices, especially the price of the brown firm, and thus shifts market shares to the green firm and reduces emissions. Consequently, if consumers have green preferences and account fully for the environmental quality, the policymaker is able to reduce the tax rate.

As with the salience contest environmental quality becomes salient with positive probability, we might expect that the optimal tax rate with the salience contest is lower than if consumers never account for environmental quality but higher than if consumers always account for environmental quality. We confirm that the optimal tax rate with the salience contest is lower than if consumers never account for environmental quality. However, whether the optimal tax rate with the salience contest is lower or higher than if consumers always account for environmental quality depends on the marginal cost and the environmental quality.

The emission tax and the salience contest both drive market shares into the direction of the green firm, but through different channels: The salience contest increases consumers' willingness to pay for the green good, while the emission tax directly increases the brown firm's price relative to the green firm's price. Consequently, if firms compete in a salience contest, the optimal tax is lower than without the salience contest, i.e., the salience contest and emission taxes are substitutes (Proposition 6(ii)). Nonetheless, if emissions are damaging, introducing an emission tax is optimal even in the presence of a salience contest.

If consumers always account for environmental quality, the green firm's market shares are higher than under the salience contest. However, the optimal emission tax may be higher if consumers always account for environmental quality than under the contest: As established in Corollary 2, the emission tax increases aggregate investments into the

salience contest if the marginal cost of green production c is sufficiently high. Investments into the salience contest are wasteful from a welfare perspective. This effect ensures that the optimal emission tax if consumers always account for environmental quality may be higher than with the salience contest.

6.2   Subsidy

Instead of introducing an emission tax, the policymaker may consider a subsidy to reduce the production cost of the green firm. The green firm incurs marginal cost of production c. The policymaker can subsidize green production by $s \in [0, c]$ so that the marginal cost of green production is $c^s = c - s$. Then, the analysis from Section 4 is still valid, with updated marginal cost of production (i.e., replacing c by c^s). Comparative statics with respect to s can directly be drawn from the comparative statics with respect to c in Section 4. To distinguish the results with the subsidy from the results without the subsidy, we introduce the superscript s for the result with the subsidy.

The policy maker chooses the subsidy to maximize expected social welfare. Expected social welfare is

$$\mathbb{E}[W^s] = \mathbb{E}[PS^s] + \mathbb{E}[CS^s] - \delta \mathbb{E}[E^s] - \mathbb{E}[S],$$

where $\mathbb{E}[S]$ are the expected cost of the subsidy to the policymaker:

$$\mathbb{E}[S] = s \cdot \mathbb{E}[\bar{x}] = s \cdot \frac{q_1^2 + 2q_1(s + 3t) - 2c(q_1 + 6t) + 12t(s + 3t)}{72t^2}$$

The expected cost of the subsidy is trivially increasing in s.

The optimal subsidy is given in Proposition 7.

Proposition 7 *The optimal subsidy is*

$$s^* = \begin{cases} 0 & \text{if } \delta < \delta^\tau \text{ and } c > c^\tau \\ \min\left\{ \frac{q_1((3\delta+4)q_1 + 3t(6\delta+5)) - c(5q_1 + 12t)}{2(3t - q_1)}, c \right\} & \text{otherwise,} \end{cases}$$

where c^τ and δ^τ are defined in Proposition 5.

The proof is in Appendix B.

The optimal subsidy and the optimal tax rate are closely related (see Corollary 4):

Corollary 4 *For the inner solution of the optimal subsidy s^* and the inner solution of the optimal emission tax τ^*, the following holds:*

(i) $s^* = q_1 \cdot \tau^*$.

(ii) $\mathbb{E}[W^s] = \mathbb{E}[W^\tau]$.

Following from part (i) of Corollary 4 and the discussion of the optimal tax rate (see Corollary 3), the optimal subsidy is (weakly) increasing in the marginal damage δ and the environmental quality q_1 and (weakly) decreasing in the marginal cost c.

6.3 Minimum standard

In this section, we analyze a minimum standard: The environmental quality of all goods that are offered on the market must be at least $\bar{q} \geq 0$. A value of $\bar{q} = 0$ is equivalent to the analysis of the previous sections, while under $\bar{q} > 0$, firms who participate in the market must produce goods of positive environmental quality and incur cost of production. We keep the assumption that the brown firm produces the lowest possible environmental quality to participate in the market: Under the minimum standard, the brown firm produces $q_2 = \bar{q}$, while the green firm produces $q_1 \geq \bar{q}$. As the brown firm produces goods of positive environmental quality under the minimum standard, it incurs marginal cost of production c_2, which we normalize to zero. In this way, we interpret the green firm's marginal cost of production $c_1 \equiv c \geq 0$ as the difference in marginal cost. To keep the analysis tractable, we assume that $\delta = 1$ in this section.

Therefore, the following analysis is mathematically equivalent to a decrease in q_1 in the main model (with a corresponding adjustment of e). Consequently, the equilibrium prices are still given in Section 4.1 and the optimal investment decisions are influenced by the minimum standard. Equilibrium investments into the salience contest are[11]

$$\sigma_1^* = \frac{(q_1 - \bar{q})(6t - q_1 + \bar{q} + 2c)(6t + q_1 - \bar{q} - 2c)^2}{2592t^3}$$
$$\sigma_2^* = \frac{(q_1 - \bar{q})(6t - q_1 + \bar{q} + 2c)^2(6t + q_1 - \bar{q} - 2c)}{2592t^3}.$$

Figure 7 illustrates the equilibrium investments into the salience contest as a function of the minimum standard. As long as $q_1 > \bar{q}$, the green firm has an incentive to fight for salience, while the brown firm has an incentive to fight against salience. However, as firms are less differentiated in environmental quality, the incentives to fight over salience decrease. Therefore, the investment of the green firm is always decreasing in the minimum standard $\bar{q}$. The same effect incentivizes the brown firm to reduce investment. However, the brown firm's investment can also increase in the minimum standard (see panel (a) of Figure 7): If the differentiation in environmental quality is initially high, the discouragement effect (i.e., the difference in valuations is large enough such that firm 2 is discouraged from investing) dampens the brown firm's investment. An increase in $\bar{q}$ alleviates the discouragement effect, which increases the brown firm's investment. However, the firms' aggregate investment is always decreasing in the minimum standard $\bar{q}$.

---

[11]In contrast to the equilibrium investments in the main model, here q_1 is replaced by $q_1 - \bar{q}$.
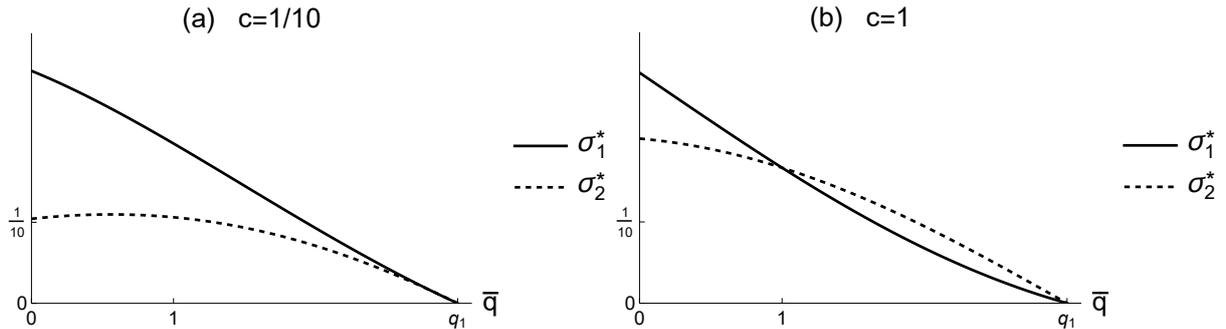
Figure 7: Equilibrium investments into salience contest of firm 1 (solid) and of firm 2 (dashed) as a function of the minimum standard $\bar{q}$ for $t = 1$, $q_1 = 3$, and (a) $c = 1/10$ and (b) $c = 1$.

Proposition 8 summarizes the effects of a minimum standard $\bar{q}$ on emissions and welfare.

Proposition 8 *Assume the policymaker introduces a minimum standard $\bar{q} \in [0, q_1]$.*

(i) The introduction of a minimum standard increases emissions if and only if the marginal cost c and the minimum standard are sufficiently low.

(ii) The introduction of a minimum standard decreases welfare if and only if the marginal cost c and the minimum standard are sufficiently low.

The proof is in Appendix B. Figure 9 illustrates Proposition 8 graphically.

Although the minimum standard aims at encouraging environmentally friendly goods in the market, the introduction of a minimum standard may increase emissions: If environmental differentiation is initially high, the introduction of the minimum standard may mitigate the discouragement effect for the brown firm, i.e., the brown firm increases its investment into the salience contest, which in turn increases the probability that environmental quality is not salient. This increases the market share of firm 2 and although the per-unit emissions of firm 2 are lower with the minimum standard, they are higher than the per-unit emissions of firm 1. Consequently, the minimum standard may lead to higher emissions. In addition, the introduction of a minimum standard may result in lower welfare (see Figure 8 and Figure 9).

7 Conclusion

In this article, we analyze how firms with conflicting interests fight over the salience of environmental quality. Consumers with pro-environmental preferences only pay a premium for environmentally friendly goods if the goods' environmental quality is salient at the time of the consumption decision. We implement a contest over consumers' attention towards environmental quality into a horizontal differentiation model, where a green
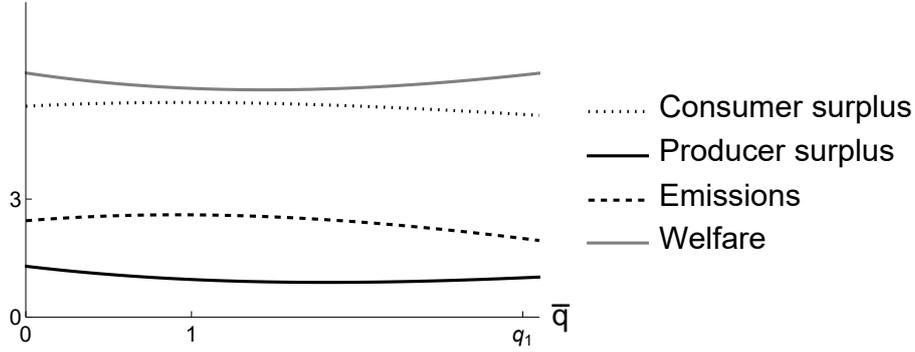
Figure 8: Consumer surplus, producer surplus, emissions, and social welfare as a function of the minimum standard $\bar{q}$ for $t = 1$, $c = 1/10$, $v = 5$, $e = 5$, $q_1 = 3$, and $\delta = 1$.

firm fights to make environmental quality salient and a brown firm fights against making environmental quality salient.

We show that firms' incentives to invest into the salience contest depend on their comparative advantage; the firm with the higher comparative advantage invest more into the salience contest. We show that such a salience contest increases welfare if firms are sufficiently environmentally differentiated and the marginal damage of emissions is sufficiently large. Consequently, the salience contest and emission taxes as well as subsidies are (imperfect) substitutes. In contrast, minimum standards on per-unit emissions may increase total emissions and reduce welfare.

Although, we focus on competition over *environmental* salience, our results extend to competition over the salience of any type of credence dimension of goods, for example, in car repairs, financial advice, or medical treatments. Our model captures the more general credence goods as the limiting case where the marginal damage is equal to zero. The results regarding equilibrium investments do not depend on the marginal damage and are thus generally applicable to the salience competition with credence goods.

Our model also captures greenwashing. The green firms' investment in distraction is mathematically equivalent to greenwashing: In our setup, if the brown firm wins in the salience contest, the salience of environmental quality is zero. Consequently, consumers perceive the environmental quality of both goods as zero, i.e., they perceive the environmental quality of the brown firm perfectly and the environmental quality of the green firm as lower than it actually is. If consumers would instead perceive the environmental qualities of both firms as identical but positive, i.e., they perceive the environmental quality of the green firm perfectly and the environmental quality of the brown firm as higher than it actually is (greenwashing), the results are identical.

We make a number of assumptions that limit the scope of our results to keep the model tractable. First, we assume that the salience contest either makes environmental quality salient to all consumers or to none of the consumers. A more realistic assumption would allow for a fraction of consumers to become attentive towards environmental quality.
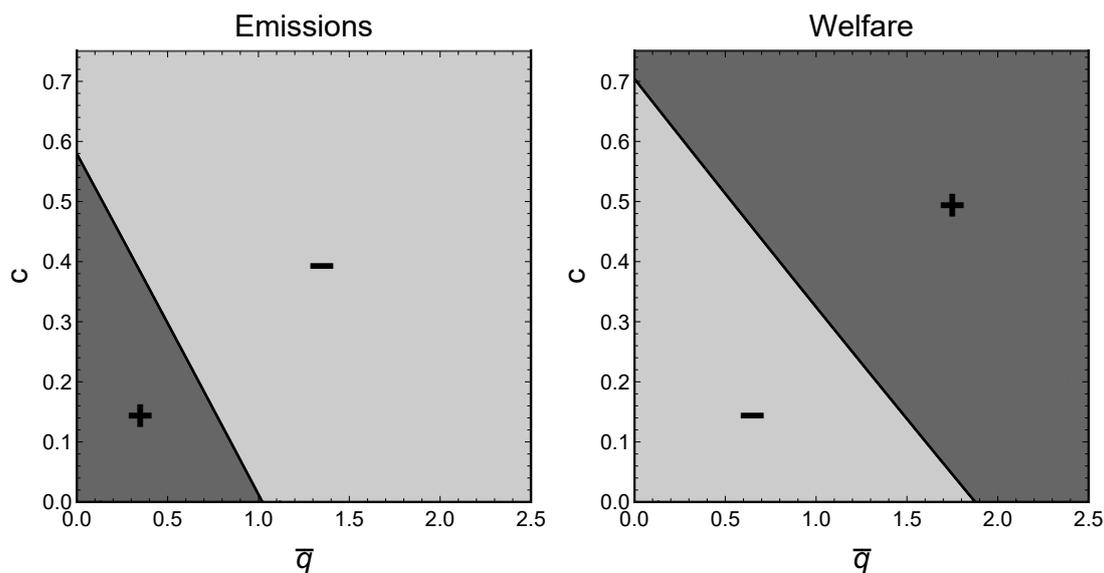
30

Figure 9: Effect of the minimum standard on emissions and welfare for different values of the minimum standard $\bar{q}$ and marginal cost c ($t = 1$, $q_1 = 2.5$ and in the right panel $v = 10$ and $e = 5$). Left panel: In the dark gray area, the minimum standard increases total emissions. In the light gray area, the minimum standard decreases total emissions. Right panel: In the dark gray area, the minimum standard increases welfare. In the light gray area, the minimum standard decreases welfare.

Second, we do not allow firms to invest in environmental quality. Third, we assume a simple linear cost function for the investment into the contest. Introducing a cost parameter would not change the results qualitatively. However, imposing a different cost function (e.g., a quadratic cost function) would make the model intractable. We leave these issues to further research.

A   Proofs

A.1   Proof of Proposition 1

Firms simultaneously choose their investments to maximize their expected profits

$$\mathbb{E}[\pi_1(\sigma_1, \sigma_2)] = \frac{\sigma_1}{\sigma_1 + \sigma_2} \frac{(3t + q_1 - c)^2}{18t} + \left(1 - \frac{\sigma_1}{\sigma_1 + \sigma_2}\right) \frac{(3t - c)^2}{18t} - \sigma_1$$

$$\mathbb{E}[\pi_2(\sigma_1, \sigma_2)] = \frac{\sigma_2}{\sigma_1 + \sigma_2} \frac{(3t + c)^2}{18t} + \left(1 - \frac{\sigma_2}{\sigma_1 + \sigma_2}\right) \frac{(3t - q_1 + c)^2}{18t} - \sigma_2.$$

Consequently, the best replies are

$$\sigma_1(\sigma_2) = \frac{\sqrt{2q_1 t \sigma_2 (6t - 2c + q_1)}}{6t} - \sigma_2$$

$$\sigma_2(\sigma_1) = \frac{\sqrt{2q_1 t \sigma_1 (6t + 2c - q_1)}}{6t} - \sigma_1.$$

and the equilibrium investments are

$$\sigma_1^* = \frac{q_1(6t - q_1 + 2c)(6t + q_1 - 2c)^2}{2592t^3}$$

$$\sigma_2^* = \frac{q_1(6t - q_1 + 2c)^2(6t + q_1 - 2c)}{2592t^3}.$$

As the equilibrium prices depend on the perceived environmental qualities ($p_1^* = (3t + 2c + \hat{q}_1 - \hat{q}_2)/3$ and $p_2^* = (3t + c + \hat{q}_2 - \hat{q}_1)/3$), the equilibrium prices $p_i^*(s)$ depend on the salience $s \in \{0, 1\}$. If $s = 1$, equilibrium prices are $p_1^*(1) = (3t + 2c + q_1)/3$ and $p_2^*(1) = (3t + c - q_1)/3$. If $s = 0$, equilibrium prices are $p_1^*(0) = (3t + 2c)/3$ and $p_2^*(0) = (3t + c)/3$.

A.2   Proof of Proposition 2

The aggregate investments are

$$\bar{\sigma} = \sigma_1^* + \sigma_2^* = \frac{36t^2 q_1 - q_1^3 + 4cq_1^2 - 4c^2 q_1}{216t^2}.$$

(i) $\sigma_1^* \geq \sigma_2^* \Leftrightarrow V_1 \geq V_2 \Leftrightarrow 6t + q_1 - 2c \geq 6t - q_1 + 2c \Leftrightarrow q_1 \geq 2c.$

(ii) As $t > 0$ and $q_1 > 0$,

$$\frac{\partial \bar{\sigma}}{\partial c} = \frac{q_1(q_1 - 2c)}{54t^2} \geq 0 \Leftrightarrow q_1 \geq 2c.$$

32

(iii) As $t > 0$ and, by Assumptions 1 and 2, $3t \geq q_1$ and $3t \geq c$,

$$\frac{\partial \bar{\sigma}}{\partial q_1} = \frac{36t^2 - 3q_1^2 + 8cq_1 - 4c^2}{216t^2} > 0.$$

(iv) As $q_1 > 0$ and $t > 0$,

$$\frac{\partial \bar{\sigma}}{\partial t} = \frac{q_1(q_1 - 2c)^2}{108t^3} > 0.$$

A.3 Proof of Corollary 1

The expected equilibrium profits of firm 1 and firm 2 are

$$\mathbb{E}[\pi_1^*] = \frac{1296t^4 + 216t^3(q_1 - 4c) + 36t^2\left(4c^2 - 6cq_1 + 3q_1^2\right) + 18q_1 t(q_1 - 2c)^2 - q_1(2c - q_1)^3}{2592t^3}$$

$$\mathbb{E}[\pi_2^*] = \frac{1296t^4 + 216t^3(4c - 3q_1) + 36t^2\left(4c^2 - 2cq_1 + q_1^2\right) + 18q_1 t(q_1 - 2c)^2 + q_1(2c - q_1)^3}{2592t^3}.$$

(i) Comparison of expected profits:

$$\mathbb{E}[\pi_1^*] \geq \mathbb{E}[\pi_2^*] \Leftrightarrow q_1 \geq 2c.$$

(ii) As $t > 0$ and, by Assumption 2, $3t \geq c$

$$\frac{\partial \mathbb{E}[\pi_1^*]}{\partial q_1} = \frac{(6t - 2c + 4q_1)(6t - 2c + q_1)^2}{2592t^3} > 0.$$

As $t > 0$ and by Assumption 2 $3t \geq c$

$$\frac{\partial \mathbb{E}[\pi_1^*]}{\partial c} = \frac{-6q_1^3 - 24q_1^2(3t - c) - 288t^2(3t - c) - 24q_1(3t - c)^2}{2592t^3} < 0.$$

(iii) Let $\phi \equiv -45ctq_1 - 2q_1^3 - 12c^2q_1 + 36tc^2 + 27q_1^2t + 36q_1t^2 - 324t^3$. Then,

$$\frac{\partial \mathbb{E}[\pi_2^*]}{\partial q_1} = \frac{-8c(9t^2 - c^2) - 18cq_1(3t - q_1) + 2\phi}{2592t^3}.$$

As $t > 0$ and, by Assumptions 1 and 2, $3t \geq q_1$ and $3t \geq c$, $-8c(9t^2 - c^2) - 18cq_1(3t - q_1) < 0$. In addition, as ϕ is convex in q_1, ϕ reaches its highest value either at $q_1 = 0$ or if $q_1 = 3t$. If $q_1 = 0$, ϕ simplifies to $36t(c^2 - 9t^2)$ which is negative by Assumption 2. If $q_1 = 3t$, ϕ simplifies to $-27t^2(5c + t)$ which is negative. Therefore, in sum, $\partial \mathbb{E}[\pi_2^*]/(\partial q_1) < 0$.

33

As $t > 0$ and, by Assumption 1, $3t \geq q_1$

$$\frac{\partial \mathbb{E}[\pi_2^*]}{\partial c} = \frac{6q_1(2c - q_1)^2 + 144q_1tc + 288ct^2 + 72t(12t^2 - q_1^2 - q_1t)}{2592t^3} > 0.$$

A.4 Proof of Lemma 1

(i) Producer surplus

$$\mathbb{E}[PS] > PS^N \Leftrightarrow c < \frac{q_1 - 2t}{2}.$$

As, by Assumption 2, $0 < c \leq 3t$, $\mathbb{E}[PS] > PS^N$ if and only if $q_1 > 2t$ and $c < (q_1 - 2t)/2$. Otherwise, $\mathbb{E}[PS] \leq PS^N$.

(ii) Consumer surplus:

$$\mathbb{E}[CS] > CS^N \Leftrightarrow q_1^2 + 2cq_1 + 6tq_1 + 8c(3t - c) > 0.$$

As, by Assumption 2, $0 < c \leq 3t$, this is always fulfilled.

(iii) Emissions:

$$\mathbb{E}[E] < E^N \Leftrightarrow q_1^3 + 2q_1^2(3t - c) > 0.$$

As $t > 0$, $q_1 > 0$, and by Assumption 2, $c \leq 3t$, this is always fulfilled.

A.5 Proof of Proposition 3

The salience contest increases welfare if and only if

$$\mathbb{E}[W] > W^N \Leftrightarrow \mathbb{E}[PS] + \mathbb{E}[CS] - \delta\mathbb{E}[E] > PS^N + CS^N - \delta E^N \Leftrightarrow \delta > \frac{8c - 7q_1 + 12t}{6q_1}$$

As $\delta > 0$, if $(8c - 7q_1 + 12t)/(6q_1) \leq 0$, $\mathbb{E}[W] > W^N$ is always fulfilled. If $(8c - 7q_1 + 12t)/(6q_1) > 0$, $\mathbb{E}[W] > W^N \Leftrightarrow \delta > (8c - 7q_1 + 12t)/(6q_1)$. In sum, the salience contest increases welfare if and only if

$$\delta > \bar{\delta} \equiv \max\left\{0, \frac{8c - 7q_1 + 12t}{6q_1}\right\}.$$

A.6 Proof of Proposition 4

Assume the green firm 1 competes against a fringe of n identical brown firms. In the price-setting stage, the intense price competition between the brown firms in the fringe drives

down prices to the marginal cost of 0 for the brown firms: $p_i^* = 0$ for all $i \in \{2, 3, ..., n+1\}$. The green firm thus chooses its price to maximize the following profit

$$\pi_1(p_1, \sigma_1, \sigma_{-1}) = (p_1 - c)\frac{-p_1 + \hat{q}_1 + t}{2t} - \sigma_1.$$

Consequently, the equilibrium price of the green firm is $p_1^* = (t+c+q_1)/2$. The equilibrium profits of firm 1 and firm $i \in \{2, 3, ..., n+1\}$ are

$$\pi_1(\sigma_1, \sigma_{-1}) = \frac{(t - c + \hat{q}_1)^2}{8t} - \sigma_1$$

$$\pi_i(\sigma_1, \sigma_{-1}) = 0 - \sigma_i.$$

In the investment stage, as $\partial\pi_i(\sigma_1, \sigma_{-1})/\partial\sigma_i < 0$, the brown firms equilibrium investments are $\sigma_i = 0$ for all $i \in \{2, 3, ..., n + 1\}$. If firm 1 does not invest into the salience contest, its profit is

$$\pi_1^{s=0}(\sigma_1, \sigma_{-1}) = \frac{(t - c)^2}{8t}.$$

If firm 1 invests a positive amount $\sigma_1 > 0$ into the salience contest, firm 1 wins the contest and environmental quality becomes salient.[12] Firm 1's profit then

$$\pi_1^{s=1}(\sigma_1, \sigma_{-1}) = \frac{(t - c + q_1)^2}{8t} - \sigma_1.$$

As $\partial\pi_1^{s=1}(\sigma_1, \sigma_{-1})/\partial\sigma_1 < 0$ and $\pi_1^{s=1}(\sigma_1, \sigma_{-1}) > \pi_1^{s=0}(\sigma_1, \sigma_{-1}) \Leftrightarrow \sigma_1 < q_1(q_1 + 2t - 2c)/(8t)$, in equilibrium, firm 1 invests the lowest possible amount ε. As $\varepsilon > 0$, in equilibrium, environmental quality is always salient. The producer surplus is then

$$PS_F = \frac{(t - c + q_1)^2}{8t} - \varepsilon.$$

The indifferent consumer is located at $(q_1 + t - c)/(4t)$. All consumers with $x \leq (q_1 + t - c)/(4t)$ buy from firm 1, all consumers with $x > (q_1 + t - c)/(4t)$ buy from one of the n brown firms. The consumer surplus is

$$CS_F = \int_0^{\frac{q_1+t-c}{4t}} v + q_1 - p_1 - tx \; \mathrm{d}x \; + \int_{\frac{q_1+t-c}{4t}}^1 v - p_i - t(1 - x) \; \mathrm{d}x$$

$$= v + \frac{c^2 - 2c(q_1 + t) + q_1^2 + 2q_1 t - 7t^2}{16t}$$

---

[12]$\sigma_1/(\sigma_1 + \sum_i \sigma_i) = 1$ if $\sum_i \sigma_i = 0$.

and emissions are

$$E_F = \frac{q_1 + t - c}{4t}(e - q_1) + \left(1 - \frac{q_1 + t - c}{4t}\right)e = e - \frac{q_1(q_1 + t - c)}{4t}.$$

If $\varepsilon \to 0$, the welfare with the duopoly is larger than the welfare with the competitive fringe if and only if

$$\mathbb{E}[W] > W_F$$
$$\Leftrightarrow \mathbb{E}[W] > PS_F + CS_F - \delta E_F$$
$$\Leftrightarrow \frac{-3t\left(7c^2 - 22cq_1 + 17q_1^2\right) - 18t^2(3c + q_1) + q_1(q_1 - 2c)(7q_1 - 8c) + 27t^3}{432t^2}$$
$$> \delta q_1 \frac{2cq_1 - 6ct - q_1^2 + 12q_1t - 18t^2}{72t^2} \tag{2}$$

If $q_1 > 6t + c - \sqrt{c^2 + 6ct + 18t^2}$, the left hand side of (2) is negative and the right hand side of (2) is positive. Consequently, $W_F > \mathbb{E}[W]$. If $q_1 < 6t + c - \sqrt{c^2 + 6ct + 18t^2}$, the right hand side of (2) is negative. Then,

$$\mathbb{E}[W] > W_F \Leftrightarrow \delta > \frac{1}{12}\left(\frac{7c - 3t}{q_1} + \frac{q_1\left(37c - 14q_1 + 105t\right) - 18c(c + 3t)}{-2q_1(c + 6t) + 6t(c + 3t) + q_1^2}\right).$$

As by assumption $\delta > 0$,

$$\mathbb{E}[W] > W_F \Leftrightarrow \delta > \max\left\{0, \frac{1}{12}\left(\frac{7c - 3t}{q_1} + \frac{q_1\left(37c - 14q_1 + 105t\right) - 18c(c + 3t)}{-2q_1(c + 6t) + 6t(c + 3t) + q_1^2}\right)\right\}.$$

B   Proofs of policy interventions

B.1   Proof of Corollary 2

The aggregate investment is

$$\bar{\sigma}^\tau = \sigma_1^\tau + \sigma_2^\tau = \frac{q_1(6t + 2c - 2q_1\tau - q_1)(6t - 2c + 2q_1\tau + q_1)}{216t^2}.$$

Then,

$$\frac{\partial \bar{\sigma}^\tau}{\partial \tau} = \frac{q_1^2(2c - 2q_1\tau - q_1)}{54t^2} \geq 0 \Leftrightarrow \tau \leq \frac{2c - q_1}{2q_1}.$$

As $\tau \in [0, \delta]$ by assumption, if $(2c - q_1)/(2q_1) < 0 \Leftrightarrow q_1 > 2c$, the aggregate investment is decreasing in $\tau \in [0, \delta]$. If $(2c - q_1)/(2q_1) > \delta \Leftrightarrow q_1 < 2c/(1 + 2\delta)$, the aggregate investment is increasing in $\tau \in [0, \delta]$. If $0 \leq (2c - q_1)/(2q_1) \leq \delta \Leftrightarrow 2c/(1 + 2\delta) \leq q_1 \leq 2c$, aggregate investment has a unique maximum in $\tau = (2c - q_1)/(2q_1)$.

B.2 Proof of Proposition 5

The policymaker chooses the tax rate τ that maximizes social welfare

$$\mathbb{E}[W^\tau] = \mathbb{E}[PS^\tau] + \mathbb{E}[CS^\tau] - \delta\mathbb{E}[E^\tau] + \mathbb{E}[T],$$

where the expected producer surplus is

$$
\begin{aligned}
\mathbb{E}[PS^\tau] =& \mathbb{E}[\pi_1^\tau] + \mathbb{E}[\pi_2^\tau]\\
=& \frac{1}{72t^2}\left(4\tau^2 q_1\left(q_1^2 + 2q_1 t\right) + 4\tau q_1\left(q_1 + 2t\right)\left(q_1 - 2c\right)\right)\\
&+ \frac{1}{72t^2}\left(q_1\left(4c^2 - 8ct - 12t^2\right) + 8c^2 t + q_1^2\left(4t - 4c\right) + q_1^3 + 72t^3\right),
\end{aligned}
$$

the expected consumer surplus is

$$
\begin{aligned}
\mathbb{E}[CS^\tau] =& \Pr(\tau, s=1)\left(\int_0^{\bar{x}_{s=1}^\tau} v + q_1 - p_1 - tx \ \mathrm{dx} \ + \int_{\bar{x}_{s=1}^\tau}^1 v - p_2 - t(1-x)\ \mathrm{dx}\right)\\
&+ \left(1 - \Pr(\tau, s=1)\right)\left(\int_0^{\bar{x}_{s=0}^\tau} v + q_1 - p_1 - tx \ \mathrm{dx} \ + \int_{\bar{x}_{s=0}^\tau}^1 v - p_2 - t(1-x)\ \mathrm{dx}\right)\\
=& v + \tau^2 \frac{q_1^2(3t - 2q_1)}{108t^2} - \tau\left(e - \frac{q_1\left(8cq_1 - 12ct - q_1^2 + 24q_1 t + 108t^2\right)}{216t^2}\right)\\
&+ \frac{6t\left(2c^2 - 8cq_1 + q_1^2\right) + 216t^2(q_1 - c) + q_1(q_1 - 2c)(4c + q_1) - 540t^3}{432t^2},
\end{aligned}
$$

expected emissions are

$$
\begin{aligned}
\mathbb{E}[E^\tau] =& \Pr(\tau, s=1)\left((e - q_1)\bar{x}_{s=1}^\tau + e(1 - \bar{x}_{s=1}^\tau)\right) + \left(1 - \Pr(\tau, s=1)\right)\left((e - q_1)\bar{x}_{s=0}^\tau + e(1 - \bar{x}_{s=0}^\tau)\right)\\
=& e - \frac{q_1\left(q_1^2 + 6q_1 t + 36t^2 - 2c(q_1 + 6t)\right) + 2q_1^2\tau(q_1 + 6t)}{72t^2},
\end{aligned}
$$

and expected tax revenues are

$$\mathbb{E}[T] = \tau\mathbb{E}[E^\tau].$$

Note that

$$
\frac{\partial\mathbb{E}[W^\tau]}{\partial\tau} = 0 \Leftrightarrow \frac{q_1^2\left(2q_1\left(\tau + 2\right) + 3t\left(5 - 2\tau\right) - 5c\right)}{108t^2} - \frac{cq_1}{9t} + \delta\left(\frac{q_1^3 + 6tq_1^2}{36t^2}\right) = 0
$$

$$
\Leftrightarrow \tau = \tau' \equiv \frac{q_1\left((3\delta + 4)q_1 + 3t\left(6\delta + 5\right)\right) - c\left(5q_1 + 12t\right)}{2q_1(3t - q_1)}
$$

and

$$\tau' < 0 \Leftrightarrow \delta < \delta^\tau \equiv \frac{5cq_1 + 12ct - 4q_1^2 - 15q_1 t}{3q_1^2 + 18q_1 t}.$$

In addition, by assumption $\delta > 0$. That means, $\tau' < 0$ if and only if $0 < \delta < \delta^\tau$. Note that

$$\delta^\tau > 0 \Leftrightarrow c > c^\tau \equiv \frac{q_1(4q_1 + 15t)}{5q_1 + 12t}.$$

Therefore, if $\delta < \delta^\tau$ and $c > c^\tau$, the optimal tax rate is $\tau^* = 0$. Otherwise, as $\tau \in [0, \delta]$, the optimal tax rate is

$$\tau^* = \min \left\{ \frac{q_1((3\delta + 4)q_1 + 3t(6\delta + 5)) - c(5q_1 + 12t)}{2q_1(3t - q_1)}, \delta \right\}.$$

B.3   Proof of Corollary 3

If $\delta < \delta^\tau$ and $c > c^\tau$, $\tau^* = 0$. Then,

$$\frac{\partial \tau^*}{\partial \delta} = \frac{\partial \tau^*}{\partial c} = \frac{\partial \tau^*}{\partial q_1} = 0.$$

Otherwise, $\tau^* = \min\{\tau', \delta\}$ where

$$\tau' = \frac{q_1 \left((3\delta + 4)q_1 + 3t(6\delta + 5)\right) - c(5q_1 + 12t)}{2q_1(3t - q_1)}.$$

If $\min\{\tau', \delta\} = \delta$, then

$$\frac{\partial \tau^*}{\partial \delta} = \frac{\partial \tau^*}{\partial c} = \frac{\partial \tau^*}{\partial q_1} = 0.$$

If $\min\{\tau', \delta\} = \tau'$, then, as by Assumption 1 $q_1 \leq 3t$,

$$\frac{\partial \tau^*}{\partial \delta} = \frac{3q_1^2 + 18tq_1}{2q_1(3t - q_1)} > 0,$$

$$\frac{\partial \tau^*}{\partial c} = \frac{-(5q_1 + 12t)}{2q_1(3t - q_1)} < 0,$$

$$\frac{\partial \tau^*}{\partial q_1} = \frac{27(\delta + 1)q_1^2 t - c(5q_1 - 6t)(q_1 + 6t)}{2q_1^2(3t - q_1)^2} > 0.$$

Therefore, in sum,

$$\frac{\partial \tau^*}{\partial \delta} \geq 0, \quad \frac{\partial \tau^*}{\partial c} \leq 0, \quad \frac{\partial \tau^*}{\partial q_1} \geq 0.$$

B.4 Proof of Proposition 6

Optimal tax without salience contest if consumers never take environmental quality into account: Without contest but with a per-unit tax of $\tau_N(e - q_i)$, in the price-setting stage, firms maximize the following profits

$$\pi_1^{N,\tau}(p_1, p_2, \sigma_1, \sigma_2) = \Big(p_1 - c - \tau_N(e - q_1)\Big)x_1^D(p_1, p_2)$$
$$\pi_2^{N,\tau}(p_1, p_2, \sigma_1, \sigma_2) = (p_2 - \tau_N e)x_2^D(p_1, p_2)$$

Consequently, in equilibrium, firms choose prices

$$p_1^{N,\tau} = \frac{1}{3}\Big(3t + 2c + \tau_N(3e - 2q_1)\Big)$$
$$p_2^{N,\tau} = \frac{1}{3}\Big(3t + c + \tau_N(3e - q_1)\Big)$$

and obtain profits

$$\pi_1^{N,\tau} = \frac{1}{18t}\left(3t - c + \tau_N q_1\right)^2$$
$$\pi_2^{N,\tau} = \frac{1}{18t}\left(3t + c - \tau_N q_1\right)^2.$$

The social welfare is then

$$W^{N,\tau} = PS^{N,\tau} + CS^{N,\tau} - \delta E^{N,\tau} + T^{N,\tau},$$

where

$$PS^{N,\tau} = \pi_1^{N,\tau} + \pi_2^{N,\tau} = \frac{(c - q_1\tau_N)^2}{9t} + t$$
$$CS^{N,\tau} = v + \frac{c^2 - 2c(q_1(\tau_N + 3) + 9t) - 36et\tau_N + q_1^2\tau_N(\tau_N + 6) + 18q_1 t(\tau_N + 1) - 45t^2}{36t}$$
$$E^{N,\tau} = e - \frac{q_1(3t - c + q_1\tau_N)}{6t}$$
$$T^{N,\tau} = \tau_N E^{N,\tau}.$$

Then,

$$\frac{\partial W^{N,\tau}}{\partial \tau_N} = 0 \Leftrightarrow \frac{q_1^2(6\delta - 2\tau_N + 6) - 4cq_1}{36t} = 0 \Leftrightarrow \tau_N = \frac{3\delta q_1 + 3q_1 - 2c}{q_1}.$$

Note that

$$\frac{3\delta q_1 + 3q_1 - 2c}{q_1} < 0 \Leftrightarrow \delta < \frac{2c - 3q_1}{3q_1}.$$

In addition, by assumption $\delta > 0$. That means, $(3\delta q_1 + 3q_1 - 2c)/q_1 < 0$ if and only if $0 < \delta < (2c - 3q_1)/(3q_1)$. Note that

$$\frac{2c - 3q_1}{3q_1} > 0 \Leftrightarrow c > \frac{3q_1}{2}.$$

Therefore, as by assumption $\tau \in [0, \delta]$, the optimal tax rate is

$$\tau_N^* = \begin{cases} 0 & \text{if } \delta < \frac{2c-3q_1}{3q_1} \text{ and } c > \frac{3q_1}{2} \\ \min\left\{\frac{3\delta q_1 + 3q_1 - 2c}{q_1}, \delta\right\} & \text{otherwise.} \end{cases} \tag{3}$$

Optimal tax without salience contest if consumers always take environmental quality into account: Without contest but with a per-unit tax of $\tau_S(e - q_i)$, in the price-setting stage, firms maximize the following profits

$$\pi_1^{S,\tau}(p_1, p_2, \sigma_1, \sigma_2) = \left(p_1 - c - \tau_S(e - q_1)\right)x_1^D(p_1, p_2)$$
$$\pi_2^{S,\tau}(p_1, p_2, \sigma_1, \sigma_2) = (p_2 - \tau_S e)x_2^D(p_1, p_2).$$

Consequently, in equilibrium, firms choose prices

$$p_1^{S,\tau} = \frac{1}{3}\left(3t + 2c + q_1 + \tau_S(3e - 2q_1)\right)$$
$$p_2^{S,\tau} = \frac{1}{3}\left(3t + c - q_1 + \tau_S(3e - q_1)\right)$$

and obtain profits

$$\pi_1^{S,\tau} = \frac{1}{18t}\left(3t - c + q_1 + \tau_S q_1\right)^2$$
$$\pi_2^{S,\tau} = \frac{1}{18t}\left(3t + c - q_1 - \tau_S q_1\right)^2.$$

The social welfare is then

$$W^{S,\tau} = PS^{S,\tau} + CS^{S,\tau} - \delta E^{S,\tau} + T^{S,\tau},$$

where

$$PS^{S,\tau} = \pi_1^{S,\tau} + \pi_2^{S,\tau} = \frac{(c - q_1(1 + \tau_S))^2}{9t} + t$$
$$CS^{S,\tau} = v + \frac{c^2 - 2c(q_1\tau_S + q_1 + 9t) - 36et\tau_S + q_1^2(\tau_S + 1)^2 + 18q_1 t(\tau_S + 1) - 45t^2}{36t}$$
$$E^{S,\tau} = e - \frac{q_1(3t - c + q_1(1 + \tau_S))}{6t}$$
$$T^{S,\tau} = \tau_S E^{S,\tau}.$$

Then,

$$\frac{\partial W^{S,\tau}}{\partial \tau_S} = 0 \Leftrightarrow \frac{q_1^2(3\delta - \tau_S + 2) - 2cq_1}{18t} = 0 \Leftrightarrow \tau_S = \frac{3\delta q_1 + 2q_1 - 2c}{q_1}.$$

Note that

$$\frac{3\delta q_1 + 2q_1 - 2c}{q_1} < 0 \Leftrightarrow \delta < \frac{2c - 2q_1}{3q_1}.$$

In addition, by assumption $\delta > 0$. That means, $(3\delta q_1 + 3q_1 - 2c)/q_1 < 0$ if and only if $0 < \delta < (2c - 2q_1)/(3q_1)$. Note that

$$\frac{2c - 2q_1}{3q_1} > 0 \Leftrightarrow c > q_1.$$

Therefore, as by assumption $\tau \in [0, \delta]$, the optimal tax rate is

$$\tau_S^* = \begin{cases} 0 & \text{if } \delta < \frac{2c-2q_1}{3q_1} \text{ and } c > q_1 \\ \min\left\{\frac{3\delta q_1 + 2q_1 - 2c}{q_1}, \delta\right\} & \text{otherwise.} \end{cases} \tag{4}$$

(i) Comparison of the optimal tax without the salience contest where environmental quality remains shrouded τ_N^* and the optimal tax without salience contest where environmental quality is always salient τ_S^*:

(a) If $\delta < (2c - 2q_1)/(3q_1)$, $\tau_S^* = 0$. As $\tau_N^* \geq 0$ by assumption, for $\delta < (2c - 2q_1)/(3q_1)$, $\tau_N^* \geq \tau_S^*$.

(b) If $\delta \geq (2c - 2q_1)/(3q_1)$, $\tau_N^* = \min\left\{(3\delta q_1 + 3q_1 - 2c)/q_1, \delta\right\}$ and $\tau_S^* = \min\left\{(3\delta q_1 + 2q_1 - 2c)/q_1, \delta\right\}$. As

$$\frac{3\delta q_1 + 3q_1 - 2c}{q_1} > \frac{3\delta q_1 + 2q_1 - 2c}{q_1},$$

$\tau_N^* \geq \tau_S^*$.

(ii) Comparison of the optimal tax with the salience contest τ^* and the optimal tax without salience contest when environmental quality remains shrouded τ_N^*:

(a) If $\tau^* = 0$, as by assumption $\tau_N^* \geq 0$, $\tau_N^* \geq 0$.

(b) If $\tau^* = \tau' \equiv (q_1((3\delta + 4)q_1 + 3t(6\delta + 5)) - c(5q_1 + 12t))/(2q_1(3t - q_1))$, i.e., if $0 \leq \tau' \leq \delta$, then $\tau_N^* > 0$.[13] That means, $\tau_N^* = \min\left\{(3\delta q_1 + 3q_1 - 2c)/q_1, \delta\right\}$. If $\tau_N^* =$

---

[13] As $c^\tau < 3q_1/2$ and $\delta^\tau > (2c - 3q_1)/(3q_1)$, it is not possible that $\tau_N^* = 0$ and $\tau^* > 0$.

$(3\delta q_1 + 3q_1 - 2c)/q_1,$

$$\tau_N^* > \tau^*$$
$$\Leftrightarrow \frac{3\delta q_1 + 3q_1 - 2c}{q_1} > \frac{q_1\left((3\delta + 4)\,q_1 + 3t\,(6\delta + 5)\right) - c\,(5q_1 + 12t)}{2q_1(3t - q_1)}$$
$$\Leftrightarrow \frac{9c - (9\delta + 10)q_1 + 3t}{2(3t - q_1)} > 0$$
$$\Leftrightarrow \delta < \frac{9c - 10q_1 + 3t}{9q_1}.$$

If $\tau_N^* = (3\delta q_1 + 3q_1 - 2c)/q_1$, then $\tau_N^* < \delta \Leftrightarrow \delta < (2c - 3q_1)/(2q_1)$. As $(9c - 10q_1 + 3t)/(9q_1) > (2c - 3q_1)/(2q_1)$, $\tau_N^* > \tau^*$ is always fulfilled if $\tau_N^* = (3\delta q_1 + 3q_1 - 2c)/q_1$. In addition, if $\tau_N^* = \delta$, $\tau^* = \tau' < \delta$ and thus $\tau_N^* > \tau^*$.

(c) If $\tau^* = \delta$, then $\tau_N^* = \delta$.[14] Consequently $\tau^* = \tau_N^*$.

(iii) Comparison of the optimal tax with the salience contest τ^* and the optimal tax without salience contest where environmental quality is always salient τ_N^*:

(a) If $\delta < (2c - 2q_1)/(3q_1)$, $\tau_S^* = 0$. Then, as by assumption $\tau^* \geq 0$, $\tau_S > \tau^*$ is never fulfilled.

(b) If $(2c - 2q_1)/(3q_1) \leq \delta \leq (5cq_1 + 12ct - 4q_1^2 - 15q_1t)/(5q_1^2 + 12q_1t)$,

$$\tau^* = \max\left\{0, \frac{q_1\left((3\delta + 4)\,q_1 + 3t\,(6\delta + 5)\right) - c\,(5q_1 + 12t)}{2q_1(3t - q_1)}\right\}$$

and

$$\tau_S^* = \frac{3\delta q_1 + 2q_1 - 2c}{q_1} > 0.$$

If $\tau^* = 0$, $\tau_S^* > \tau^*$. Otherwise,

$$\frac{3\delta q_1 + 2q_1 - 2c}{q_1} > \frac{q_1\left((3\delta + 4)\,q_1 + 3t\,(6\delta + 5)\right) - c\,(5q_1 + 12t)}{2q_1(3t - q_1)} \Leftrightarrow \delta < \frac{9c - 3t - 8q_1}{9q_1}$$

and

$$\frac{9c - 8q_1 - 3t}{9q_1} < \frac{5cq_1 + 12ct - 4q_1^2 - 15q_1t}{5q_1^2 + 12q_1t} \text{ and}$$
$$\frac{9c - 8q_1 - 3t}{9q_1} > \frac{2c - 2q_1}{3q_1} \Leftrightarrow c > \frac{2q_1 + 3t}{3}.$$

---

[14]It is not possible that $\tau_N^* < \delta$ and $\tau^* = \delta$.

(c) If $\delta > (5cq_1 + 12ct - 4q_1^2 - 15q_1 t)/(5q_1^2 + 12q_1 t)$, $\tau^* = \delta$. Then, as by assumption $\tau_S^* \leq \delta$, $\tau_S > \tau^*$ is never fulfilled.

In sum, $\tau_S^* > \tau^* \Leftrightarrow c > (2q_1 + 3t)/3$ and$(2c - 2q_1)/(3q_1) < \delta < (9c - 3t - 8q_1)/(9q_1)$.

B.5   Proof of Proposition 7

The policy maker chooses the subsidy optimally to maximize expected social welfare. Expected social welfare is

$$\mathbb{E}[W^s] = \mathbb{E}[PS] + \mathbb{E}[CS] - \delta\mathbb{E}[E] - \mathbb{E}[S],$$

where

$$\mathbb{E}[PS^s] = \frac{2(c-s)^2 - 2(c-s)q_1 + q_1^2}{18t} + \frac{q_1(q_1 - 2c + 2s)^2}{72t^2} - \frac{q_1}{6} + t$$

$$\mathbb{E}[CS^s] = v + \frac{1}{432t^2}\left(q_1\left(-8(c-s)^2 - 48(c-s)t + 216t^2\right) + 12(c-s)^2 t + q_1^2(2(c-s) + 6t)\right)$$

$$+ \frac{1}{432t^2}\left(-216(c-s)t^2 + q_1^3 - 540t^3\right)$$

$$\mathbb{E}[E^s] = e - \frac{q_1^3 + 6q_1^2 t + 36q_1 t^2 - 2(c-s)q_1(q_1 + 6t)}{72t^2}$$

$$\mathbb{E}[S] = s \cdot \mathbb{E}[\bar{x}] = s\frac{q_1^2 + 2q_1(s + 3t) + 12t(s + 3t) - 2c(q_1 + 6t)}{72t^2}.$$

As

$$\frac{\partial\mathbb{E}[W^s]}{\partial s} = \frac{q_1\left((3\delta + 4)q_1 + 3t(6\delta + 5)\right) - c(5q_1 + 12t) + 2s(q_1 - 3t)}{108t^2} = 0$$

$$\Leftrightarrow s = \frac{q_1\left((3\delta + 4)q_1 + 3t(6\delta + 5)\right) - c(5q_1 + 12t)}{2(3t - q_1)},$$

$s \in [0, c]$ by assumption, and

$$\frac{q_1\left((3\delta + 4)q_1 + 3t(6\delta + 5)\right) - c(5q_1 + 12t)}{2(3t - q_1)} < 0 \Leftrightarrow \delta < \delta^\tau \text{ and } c > c^\tau,$$

the optimal subsidy is

$$s^* = \begin{cases} 0 & \text{if } \delta < \delta^\tau \text{ and } c > c^\tau \\ \min\left\{\frac{q_1((3\delta+4)q_1+3t(6\delta+5))-c(5q_1+12t)}{2(3t-q_1)}, c\right\} & \text{otherwise,} \end{cases}$$

B.6 Proof of Proposition 8

(i) The minimum standard increases emissions if and only if

$$
\mathbb{E}[E(\bar{q} > 0)] > \mathbb{E}[E(\bar{q} = 0)]
$$

$$
\Leftrightarrow e - \frac{36q_1t^2 + 36\bar{q}t^2 - 6t(q_1 - \bar{q})(2c - q_1 + \bar{q}) - (q_1 - \bar{q})^2(2c - q_1 + \bar{q})}{72t^2} >
$$

$$
e - \frac{q_1\left(q_1^2 + 6q_1t + 36t^2 - 2c(q_1 + 6t)\right)}{72t^2}
$$

$$
\Leftrightarrow \bar{q} < \frac{1}{2}\left(6t - 2c + 3q_1 - \sqrt{4c^2 + 4c(q_1 + 6t) - 3(q_1 - 6t)(q_1 + 10t)}\right).
$$

As $\bar{q} \in [0, q_1]$, the minimum standard increases emissions if and only if

$$
c < \frac{3q_1^2 + 12q_1t - 36t^2}{4q_1 + 12t} \text{ and}
$$

$$
\bar{q} < \min\left\{q_1, \frac{1}{2}\left(6t - 2c + 3q_1 - \sqrt{4c^2 + 4c(q_1 + 6t) - 3(q_1 - 6t)(q_1 + 10t)}\right)\right\}.
$$

(ii) The minimum standard decreases welfare if and only if

$$
\mathbb{E}[W(\bar{q} > 0)] < \mathbb{E}[W(\bar{q} = 0)]
$$

$$
\Leftrightarrow v + \frac{6t\left(10c^2 + 4c(\bar{q} - 4q_1) + (q_1 - \bar{q})(5q_1 + \bar{q})\right) + 72t^2(-3c + 2q_1 + \bar{q}) + (q_1 - \bar{q})(-2c + q_1 - \bar{q})(-8c + 7q_1 - \bar{q}) - 108t^3}{432t^2}
$$

$$
- \left(e - \frac{36q_1t^2 + 36\bar{q}t^2 - 6t(q_1 - \bar{q})(2c - q_1 + \bar{q}) - (q_1 - \bar{q})^2(2c - q_1 + \bar{q})}{72t^2}\right)
$$

$$
< v + \frac{6t\left(10c^2 + 4c(-4q_1) + 5q_1^2\right) + 72t^2(-3c + 2q_1) + q_1(-2c + q_1)(-8c + 7q_1) - 108t^3}{432t^2}
$$

$$
- \left(e - \frac{q_1\left(q_1^2 + 6q_1t + 36t^2 - 2c(q_1 + 6t)\right)}{72t^2}\right)
$$

$$
\Leftrightarrow \left(\bar{q} - \frac{1}{14}(27q_1 + 30t - 22c)\right)^2 > \frac{36c^2 + 380cq_1 + 1368ct - 195q_1^2 - 1068q_1t + 8964t^2}{14^2}
$$

$$
\Leftrightarrow \bar{q} < \bar{q}' \equiv \frac{1}{14}(27q_1 + 30t - 22c) - \frac{1}{14}\sqrt{36c^2 + 380cq_1 + 1368ct - 195q_1^2 - 1068q_1t + 8964t^2} \text{ or}
$$

$$
\bar{q} > \bar{q}'' \equiv \frac{1}{14}(27q_1 + 30t - 22c) + \frac{1}{14}\sqrt{36c^2 + 380cq_1 + 1368ct - 195q_1^2 - 1068q_1t + 8964t^2}.
$$

Note that by assumption $\bar{q} \in [0, q_1]$ and $\bar{q}'' > q_1$. Therefore, the minimum standard decreases welfare if $\bar{q} < \bar{q}'$ and increases welfare if $\bar{q} > \bar{q}'$. However, $\bar{q}' \in [0, q_1]$ is not always satisfied:

$$
\bar{q}' > 0 \Leftrightarrow \frac{4t}{11}\sqrt{82} - \frac{16t}{11} < q_1 \le 3t \wedge 0 < c < \frac{1}{4}(7q_1 + 12t) - \frac{\sqrt{2q_1^2 + 9q_1t + 54t^2}}{\sqrt{2}}.
$$

Consequently, the minimum standard decreases welfare if and only if

$$
\frac{4t\sqrt{82} - 16t}{11} < q_1 \le 3t, c < \frac{7q_1 + 12t - 2\sqrt{2}\sqrt{2q_1^2 + 9q_1t + 54t^2}}{4}, \text{ and } \bar{q} < \min\{q_1, \bar{q}'\}.
$$

References

Allcott, H., Mullainathan, S. & Taubinsky, D. (2014), 'Energy policy with externalities and internalities', *Journal of Public Economics* **112**, 72–88.

Allcott, H. & Taubinsky, D. (2015), 'Evaluating Behaviorally Motivated Policy: Experimental Evidence from the Lightbulb Market', *American Economic Review* **105**(8), 2501–2538.

Amacher, G. S., Koskela, E. & Ollikainen, M. (2004), 'Environmental quality competition and eco-labeling', *Journal of Environmental Economics and Management* **47**(2), 284–306.

Ambec, S. & De Donder, P. (2022), 'Environmental policy with green consumerism', *Journal of Environmental Economics and Management* **111**, 102584.

Andor, M. A., Gerster, A., Gillingham, K. T. & Horvath, M. (2020), 'Running a car costs much more than people think—stalling the uptake of green travel', *Nature* **580**(7804), 453–455.

Andor, M. A., Gerster, A. & Götte, L. (2019), 'How effective is the european union energy label? evidence from a real-stakes experiment', *Environmental Research Letters* **14**(4), 044001.

Apffelstaedt, A. & Mechtenberg, L. (2021), 'Competition for Context-Sensitive Consumers', *Management Science* **67**(5), 2828–2844.

Arora, S. & Gangopadhyay, S. (1995), 'Toward a theoretical model of voluntary overcompliance', *Journal of Economic Behavior & Organization* **28**(3), 289–309.

Bansal, S. & Gangopadhyay, S. (2003), 'Tax/subsidy policies in the presence of environmentally aware consumers', *Journal of Environmental Economics and Management* **45**(2, Supplement), 333–355.

Bartling, B., Valero, V. & Weber, R. A. (2022), 'The Causal Effect of Income on Market Social Responsibility', *Available at SSRN 3249788* .

Boogen, N., Daminato, C., Filippini, M. & Obrist, A. (2022), 'Can information about energy costs affect consumers' choices? Evidence from a field experiment', *Journal of Economic Behavior & Organization* **196**, 568–588.

Bordalo, P., Gennaioli, N. & Shleifer, A. (2016), 'Competition for Attention', *Review of Economic Studies* **83**(2), 481–513.

Carroni, E., Mantovani, A. & Minniti, A. (2023), 'Price signaling with salient-thinking consumers', *Games and Economic Behavior* **138**, 238–253.

Cremer, H. & Thisse, J.-F. (1999), 'On the taxation of polluting products in a differentiated industry', *European Economic Review* **43**(3), 575–594.

DellaVigna, S. (2009), 'Psychology and Economics: Evidence from the Field', *Journal of Economic Literature* **47**(2), 315–372.

Eriksson, C. (2004), 'Can green consumerism replace environmental regulation?—a differentiated-products example', *Resource and Energy Economics* **26**(3), 281–293.

Fang, X. & Singhal, P. (2024), 'Weather to pay attention to energy efficiency on the housing market', *Economics Letters* **245**, 112041.

Farhi, E. & Gabaix, X. (2020), 'Optimal Taxation with Behavioral Agents', *American Economic Review* **110**(1), 298–336.

Friedman, L. (1958), 'Game-Theory Models in the Allocation of Advertising Expenditures', *Operations Research* **6**(5), 699–709.

Gabaix, X. (2019), Behavioral inattention, *in* B. D. Bernheim, S. DellaVigna & D. Laibson, eds, 'Handbook of Behavioral Economics: Foundations and Applications', Vol. 2, Elsevier Science & Technology, Amsterdam, pp. 261–343.

Gabaix, X. & Laibson, D. (2006), 'Shrouded Attributes, Consumer Myopia, and Information Suppression in Competitive Markets', *The Quarterly Journal of Economics* **121**(2), 505–540.

Gerster, A. & Kramm, M. (2024), 'Optimal Internality Taxation of Product Attributes', *American Economic Journal: Economic Policy* **16**(3), 394–419.

Ghosh, B. & Galbreth, M. R. (2013), 'The Impact of Consumer Attentiveness and Search Costs on Firm Quality Disclosure: A Competitive Analysis', *Management Science* **59**(11), pp. 2604–2621.

Gilbert, B. & Graff Zivin, J. (2014), 'Dynamic salience with intermittent billing: Evidence from smart electricity meters', *Journal of Economic Behavior & Organization* **107**, 176–190.

Gilbert, B. & Graff Zivin, J. S. (2020), 'Dynamic corrective taxes with time-varying salience', *Journal of Environmental Economics and Management* **103**, 102356.

Haan, M. A. & Moraga-González, J. L. (2011), 'Advertising for Attention in a Consumer Search Model', *The Economic Journal* **121**(552), 552–579.

Hefti, A., Liu, S. & Schmutzler, A. (2022), 'Preferences, Confusion and Competition', *Economic Journal* **132**(645), 1852–1881.

Heidelmeier, L. & Schmitt, S. Y. (2025), 'Awards vs. labels: Incentivizing investments in environmental quality', *BERG Working Paper Series No. 206* .

Heidhues, P., Köszegi, B. & Murooka, T. (2016), 'Exploitative Innovation', *American Economic Journal: Microeconomics* **8**(1), 1–23.

Heidhues, P., Kőszegi, B. & Murooka, T. (2017), 'Inferior Products and Profitable Deception', *The Review of Economic Studies* **84**(1), 323–356.

Herweg, F., Müller, D. & Weinschenk, P. (2017), 'Salience, competition, and decoy goods', *Economics Letters* **153**, 28–31.

Herweg, F. & Schmidt, K. M. (2022), 'How to Regulate Carbon Emissions with Climate-Conscious Consumers', *Economic Journal* **132**(648), 2992–3019.

Heyes, A., Lyon, T. P. & Martin, S. (2018), 'Salience games: Private politics when public attention is limited', *Journal of Environmental Economics and Management* **88**, 396–410.

Houde, S. & Myers, E. (2015), 'Heterogeneous (Mis)perceptions of Energy Costs: Implications for Measurement and Policy Design', *Journal of Political Economy Microeconomics* **forthcoming**.

Hulshof, D. & Mulder, M. (2020), 'Willingness to Pay for CO_2 Emission Reductions in Passenger Car Transport', *Environmental and Resource Economics* **75**(4), 899–929.

Inderst, R. & Obradovits, M. (2023), 'Excessive competition on headline prices', *International Economic Review* **64**(2), 783–808.

Janssen, A. & Kasinger, J. (2024), 'Obfuscation and Rational Inattention', *The Journal of Industrial Economics* **72**(1), 390–428.

Kaufmann, M., Andre, P. & Kőszegi, B. (2024), 'Understanding Markets with Socially Responsible Consumers', *The Quarterly Journal of Economics* **139**(3), 1989–2035.

Keefer, Q. & Rustamov, G. (2018), 'Limited attention in residential energy markets: a regression discontinuity approach', *Empirical Economics* **55**(3), 993–1017.

Lohmann, P. M., Gsottbauer, E., Doherty, A. & Kontoleon, A. (2022), 'Do carbon footprint labels promote climatarian diets? Evidence from a large-scale field experiment', *Journal of Environmental Economics and Management* **114**, 102693.

Moraga-González, J. L. & Padrón-Fumero, N. (2002), 'Environmental Policy in a Green Market', *Environmental and Resource Economics* **22**(3), 419–447.

Morone, P., Caferra, R., D'Adamo, I., Falcone, P. M., Imbert, E. & Morone, A. (2021), 'Consumer willingness to pay for bio-based products: Do certifications matter?', *International Journal of Production Economics* **240**, 108248.

Palmer, K. & Walls, M. (2015), 'Limited Attention and the Residential Energy Efficiency Gap', *American Economic Review* **105**(5), 192–195.

Pelau, C., Nistoreanu, P., Lazar, L. & Badescu, R. (2022), 'Celebrity vs. Product: A Neuroscientific Approach to the Distractors in Food Advertising for Sustainable Marketing', *Sustainability* **14**(19), 12768.

Rodríguez-Ibeas, R. (2007), 'Environmental Product Differentiation and Environmental Awareness', *Environmental and Resource Economics* **36**(2), 237–254.

Ruggeri, G., Mazzocchi, C., Bergamelli, C. & Tosca, A. (2024), 'Plant the pot! Understanding consumer willingness to pay for sustainability in garden shop products', *Journal of Cleaner Production* **477**, 143855.

Schmalensee, R. (1978), 'A Model of Advertising and Product Quality', *Journal of Political Economy* **86**(3), 485–503.

Schmitt, S. Y. (2025), 'Investments in environmental quality under limited attention', *BERG Working Paper Series No. 202* .

Schmutzler, A. (2024), 'Providing innovation incentives for the green transition', *University of Zurich Working Paper No. 462* .

Sejas-Portillo, R., Moro, M. & Stowasser, T. (2025), 'The simpler the better? threshold effects of energy labels on property prices and energy efficiency investments', *American Economic Journal: Applied Economics* **17**(1), 41–89.

Sexton, S. (2015), 'Automatic Bill Payment and Salience Effects: Evidence from Electricity Consumption', *Review of Economics and Statistics* **97**(2), 229–241.

Shen, W., Gu, H., Ball, L. J., Yuan, Y., Yu, C., Shi, R. & Huang, T. (2020), 'The impact of advertising creativity, warning-based appeals and green dispositions on the attentional effectiveness of environmental advertisements', *Journal of Cleaner Production* **271**, 122618.

Singhal, P. (2024), 'Inform me when it matters: Cost salience, energy consumption, and efficiency investments', *Energy Economics* **133**, 107484.

Skaperdas, S. & Vaidya, S. (2012), 'Persuasion as a contest', *Economic Theory* **51**, 465–486.

Tiefenbeck, V., Goette, L., Degen, K., Tasic, V., Fleisch, E., Lalive, R. & Staake, T. (2018), 'Overcoming Salience Bias: How Real-Time Feedback Fosters Resource Conservation', *Management Science* **64**(3), 1458–1476.

Tullock, G. (1980), Efficient rent seeking, *in* G. Tullock, J. M. Buchanan & R. D. Tollison, eds, 'Toward a Theory of the Rent-seeking Society', Texas A&M University Press College Station, TX, pp. 97–112.

van der Ploeg, F. (2025), 'Why green subsidies are preferred to carbon taxes: Climate policy with heightened carbon tax salience', *Journal of Environmental Economics and Management* **130**, 103129.

Ward, D. O., Clark, C. D., Jensen, K. L. & Yen, S. T. (2011), 'Consumer willingness to pay for appliances produced by Green Power Partners', *Energy Economics* **33**(6), 1095–1102.