Subsidy salience and the effectiveness of green policies *

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Abstract

Governments provide incentives for the transition to green economy. Often, such policies include the subsidization of the purchase of green products. We examine the effectiveness of such green policies when consumers are environmentally aware but do not respond to subsidies in the same way as they do to price changes. We study the effect of subsidy salience on firms' environmental product qualities, pollution and subsidy pass through. Moreover, we find the optimal policy mix when subsidy salience is endogenous.

Keywords: tax/subsidies, tax salience, vertically differentiated market, environmentally aware consumers

*We would like to thank Frago Kourandi and the participants of the ASSET 2023 conference for valuable comments and suggestions. The usual disclaimer applies.

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1 Introduction

The transition to green economy has been a major issue for governments around the world. Policies to encourage the adoption of environmentally friendly products include incentives in the form of subsidies for the adoption of solar panels, energy-efficient appliances, electric vehicles, heat pumps etc.[1] However, when governments offer ad valorem price subsidies on green goods, consumers often do not realize the exact amount of the subsidy when they decide which version of the green good to buy.

In this paper, we examine the effectiveness of subsidies when they are less (or more) salient than prices. That is, consumers may either underreact or even overreact to subsidies. We use the standard vertical differentiation model (Shaked and Sutton (1982)) to analyze the welfare implications of green subsidies in imperfect competitive markets with heterogeneous consumers who differ in their environmental consciousness.

In the absence of pollution a small ad valorem tax increases welfare (Cremer and Thisse (1994)). When the government cares about pollution, it chooses to subsidize the products. The reason for this is that a subsidy increases the environmental quality of the products and reduces the level of pollution. We show that the optimal subsidy decreases as the degree of salience increases. This result stems from a different channel than the one explored in the tax salience literature. Increasing consumers' attention to subsidies reduces the optimal subsidy, not because it increases the number of people who buy the green products, but because firms improve the environmental quality of them. We also find that the subsidy pass through increases as subsidy salience increases. Finally, we analyze the optimal policy mix when subsidy salience is endogenous.

In the literature on optimal taxes/subsidies in vertically differentiated markets, consumers respond to subsidies in the same way they respond to price changes (Bansal and Gangopadhyay 2003, Bansal 2008, Moraga-Gonzalez and Padron-Fumero 2002, Galera et al. 2014 and Koonsed 2015). In this paper, we assume that subsidies can be less or more salient than prices. Empirical evidence suggests that consumers have limited tax attention and their responsiveness to taxation may depend on whether taxes are framed in a way that makes them less salient (Gallagher & Muehlegger (2011), Goldin & Homonoff (2013), Chetty et al (2009) and Taubinsky & Rees-Jones (2018)). For example, in the USA sales taxes are only added to the shelf price at the register. As a result, people don't fully incorporate sales taxes when making purchasing decisions. Taxes can also be more salient than prices. Rivers (2015) and Li (2014) provide evidence that gasoline and carbon taxes are more salient than prices. This may be due to the extensive media coverage of such tax increases. Over the past few years, researchers have developed theoretical tools to explore the welfare effects of taxes with limited tax attention (Goldin (2015), Taubinsky and Rees-Jones (2018) and Farhi and Gabaix (2020)).

The effects of tax/subsidy salience when consumers are environmentally aware and firms choose the

[1] For example, US subsidized purchases of energy-efficient home appliances (Houde and Aldy (2017). North Carolina offered rebate incentives for residential heat pump adoption (Shen et al. 2022). Greece subsidized energy efficiency home improvements (Drivas et al. 2019).

environmental friendliness of their products have been completely ignored in the literature. Moreover, the literature on tax salience treats the degree of salience as exogenous. The aim of this paper is to fill these gaps.

2 The model

The market consists of two firms that produce a good of different environmental quality. The one produces a high environmental product quality variant, which is denoted by the superscript h. The variant of the other firm, with lower environmental quality, is denoted by the superscript l. The higher the environmental quality of a variant is, the lower its damage to the environment. For example, household appliances differ in their energy efficiency. The higher their energy efficiency class, the lower the environmental damage. Similarly, different types of solar panels have different efficiency rates.

We consider a model of vertical differentiation in which consumers differ in their marginal willingness to pay for the environmental quality of the product. The utility that a consumer derives by the consumption of one unit of the variant i at price p_i is given by

$$u_i = \theta q_i - p_i (1 - s) \;\; i = h, l.$$

q_i denotes the environmental product quality level of the good and θ is the consumer's willingness to pay for an increase in the environmental quality of the good by one unit. θ is distributed uniformly on the interval $[a, a+1]$. The government offers an ad valorem subsidy s.

As consumers do not realize the exact amount of the subsidy, they decide which version of the green good to buy according to

$$u_i = \theta q_i - p_i (1 - ms) \;\; i = h, l \tag{1}$$

where m is the degree of subsidy salience, with $m \in [\underline{m}, \overline{m}]$ with $\underline{m} > 0$. The subsidy can be more salient ($m > 1$) or less salient ($m < 1$) than the price. For positive qualities we require $ms < 1$ and $a > \frac{1}{4}$.

There is a consumer, denoted by $\widehat{\theta}$, who is indifferent between consuming the high or the low quality version of the product. The value of $\widehat{\theta}$ is obtained by setting $u_h = u_l$. Following (1), we obtain

$$\widehat{\theta} = \frac{p_h - p_l}{q_h - q_l}. \tag{2}$$

Consumers with strong preferences for environmental quality (i.e., with $\theta > \widehat{\theta}$) prefer the high quality version, while consumers with $\theta < \widehat{\theta}$ prefer the more polluting version. The demand functions are given by

$$d_h = a + 1 - \widehat{\theta}, \;\; d_l = \widehat{\theta} - a. \tag{3}$$

We assume that all consumers buy, that is the market is covered.

The per unit pollution of a variant of quality q_i is $E - q_i$ (where E denotes the pollution per unit of consumption if the environmental product quality was zero). By multiplying the per unit emissions by each variant, we get the total pollution that is generated

$$Z = (E - q_h)\, d_h + (E - q_l)\, d_l \tag{4}$$

The profit function of each firm is given by

$$\Pi_i = \left[p_i - c q_i^2\right] d_i \quad i = h, l. \tag{5}$$

The production cost increases in both quality and quantity. We assume for simplicity that $c = 1/2$.

Consumer surplus is the sum of the surplus of the consumption of high-and low-environmental quality goods, given by

$$CS = \int_a^{\widehat{\theta}} \left(\theta q_l - p_l\,(1 - s_l)\right) df(\theta) + \int_{\widehat{\theta}}^{a+1} \left(\theta q_h - p_h\,(1 - s_h)\right) df(\theta). \tag{6}$$

The government's expenses for providing the subsidy are:

$$R = s \sum_i p_i d_i, \;\; i = h, l. \tag{7}$$

The government can increase the subsidy salience with a cost $C = C(m)$, where C is a convex function.[2] The welfare is given by the sum of the consumer surplus, the profits of the two firms minus the government's expenses for the subsidy, the pollution and the cost of the government's campaign to increase the subsidy salience.

$$W = CS + \Pi_h + \Pi_l - R - Z - C, \tag{8}$$

The game consists of three stages. In the first stage, the government chooses the optimal level of subsidy and the level of salience. In the second stage, the firms choose the environmental quality of their products and, in the last stage, they maximize their profits by choosing prices. We solve the game using backward induction.

3 Optimal policy

By maximizing profits with respect to prices, given quality levels, degree of salience and subsidy rates, we obtain the optimal prices:

$$\begin{aligned} p_h &= \frac{2\,(-a-2)\,(q_h - q_l) + \left(q_l^2 + 2q_h^2\right)(ms - 1)}{6\,(ms-1)} \\ p_l &= \frac{2\,(a-1)\,(q_h - q_l) + \left(2q_l^2 + q_h^2\right)(ms - 1)}{6\,(ms-1)}. \end{aligned} \tag{9}$$

[2] For small levels of salience the cost of improving salience decreases as m increases. When consumers are almost ignorant about the subsidy, the goverment should exert high effort to make them aware of the impact of its policies. As m increases this cost decreases. When, on the other hand m is very high, it takes a lot of effort from the government to increase its level.

We turn now to the second stage of the game in which firms choose their environmental product quality levels. By solving the first-order conditions for profit maximization simultaneously, we get

$$q_h = \frac{4a+5}{4(1-ms)}, \quad q_l = \frac{4a-1}{4(1-ms)}. \tag{10}$$

The second order conditions are fulfilled. Substituting (10) in (2) and (3) we find $\widehat{\theta} = a + \frac{1}{2}$ and $d_h = d_l = \frac{1}{2}$, that is the two firms split the market and this does not depend on the degree of subsidy salience.

Next, we examine the effects of introducing a "green" subsidy. A subsidy always improves the quality of both variants:

$$\frac{\partial q_h}{\partial s} = \frac{m(4a+5)}{8c(ms-1)^2} > 0, \quad \frac{\partial q_l}{\partial s} = \frac{m(4a-1)}{8c(ms-1)^2} > 0. \tag{11}$$

Furthermore, it reduces the pollution.

$$\frac{\partial Z}{\partial s} = -\frac{1}{4}\frac{(2a+1)m}{c(-ms+1)^2} < 0. \tag{12}$$

Proposition 1 *The higher the subsidy salience, the more the subsidy improves the firms' environmental qualities and reduces the pollution level.*

Proof. Taking the derivatives of (11) and (12) with respect to m, we have

$$\frac{\partial \frac{\partial q_h}{\partial s}}{\partial m} = \frac{1}{8c}m^2\frac{(4a+5)(mt+1)}{(1-ms)^3} > 0, \quad \frac{\partial \frac{\partial q_l}{\partial s}}{\partial m} = \frac{1}{8c}m^2\frac{(4a-1)(mt+1)}{(1-ms)^3} > 0$$

and

$$\frac{\partial \frac{\partial Z}{\partial s}}{\partial m} = \frac{1}{4}\frac{(2a+1)(ms+1)}{c(ms-1)^3} < 0.$$

The higher the subsidy salience (higher m), the greater the reduction in pollution (as m increases, $\frac{\partial Z}{\partial s}$ becomes more negative and its absolute value becomes larger). ■

We now examine how the subsidy and the degree of subsidy salience affect consumer and producer prices. Producer prices rise as the subsidy rate increases:

$$\frac{\partial p_h}{\partial s} = \frac{1}{32c}m\frac{40a+49+16a^2}{(1-ms)^3} > 0, \quad \frac{\partial p_l}{\partial s} = \frac{1}{32c}m\frac{-8a+25+16a^2}{c(1-ms)^3} > 0. \tag{13}$$

Consumer prices $p_i(1-s)$ increase with the subsidy rate:

$$\begin{aligned}\frac{\partial(p_h(1-s))}{\partial s} &= \frac{1}{64c}\frac{(40a+49+16a^2)}{(1-ms)^2} > 0,\\ \frac{\partial(p_l(1-s))}{\partial s} &= \frac{1}{64c}\frac{(-8a+25+16a^2)}{c(ms-1)^2} > 0.\end{aligned} \tag{14}$$

Proposition 2 *The more salient the subsidy, the greater the increases it induces in both producer and consumer prices.*

Proof. Using (13), we find that the higher the subsidy salience, the higher the rise in the producer prices because of the subsidy:

$$\frac{\partial \frac{\partial p_h}{\partial s}}{\partial m} = \frac{1}{32c} \frac{\left(40a + 49 + 16a^2\right)(2ms+1)}{(ms-1)^4} > 0, \quad \frac{\partial \frac{\partial p_l}{\partial s}}{\partial m} = \frac{1}{32c} \frac{\left(-8a + 25 + 16a^2\right)(2ms+1)}{(ms-1)^4} > 0.$$

Using (14), we find that the more the subsidy salience the greater the subsidy pass-through rates on consumer prices:

$$\begin{aligned}
\frac{\partial \frac{\partial (p_h(1-s))}{\partial s}}{\partial m} &= -\frac{1}{64c} \frac{\left(40a + 49 + 16a^2\right)(ms+1)}{(ms-1)^3} > 0, \\
\frac{\partial \frac{\partial (p_l(1-s))}{\partial s}}{\partial m} &= -\frac{1}{64c} \frac{\left(-8a + 25 + 16a^2\right)(ms+1)}{(ms-1)^3} > 0.
\end{aligned}$$

■

Producer prices increase for two reasons. First, both qualities increase, which raises the unit production costs. Second, the subsidy widens the quality gap ($\frac{\partial (q_h - q_l)}{\partial s} = \frac{3m}{4c(ms-1)^2}$), which makes firms to relax price competition. The higher the subsidy salience, the larger the quality gap ($\frac{\partial \frac{\partial (q_h - q_l)}{\partial s}}{\partial m} = -\frac{3}{4c} \frac{s}{(ms-1)^3}$) and the weaker the price competition.

Regarding consumer prices, the subsidy, on the one hand, tends to decrease consumer prices (as part of the price is subsidized by the government), while on the other hand, it tends to increase them as it raises p_i. Overall, consumer prices increase with the subsidy rate, as one can see from the subsidy pass-through rates $\frac{\partial (p_i(1-s))}{\partial s}$ in (14).

Now we turn to the last stage of the game in which the government can choose not only the subsidy, but also the degree of subsidy salience. That is, in this setting, subsidy salience is endogenous. We derive the optimal policy mix:

Proposition 3 *The optimal policy mix is given by eq. (18). The optimal policy for the government is to subsidize the products and choose the level of subsidy salience that minimizes the cost of making it more visible. The optimal subsidy decreases as the degree of salience increases.*

Proof. By maximizing the welfare in (8) with respect to the subsidy s and the degree of subsidy salience m, after using (4), (5), (6) and (7), we get the following first-order conditions.[3]

$$\frac{\partial W}{\partial s} = \frac{m\left[-2(1+8a) + ms(15 + 16a^2 + 32a\right]}{16(ms-1)^3} = 0, \tag{15}$$

$$\frac{\partial W}{\partial m} = \frac{s\left[-2(1+8a) + ms(15 + 16a^2 + 32a\right]}{16(ms-1)^3} - \frac{\partial C}{\partial m} = 0, \tag{16}$$

Solving (15) for s we get

$$s = \frac{2(1+8a)}{m(15 + 16a^2 + 32a)}. \tag{17}$$

[3] The second order conditions for welfare maximization are in the Appendix.

Substituting this in (16) we get $\frac{\partial W}{\partial m} = -\frac{\partial C}{\partial m} = 0$. This allows us to get the optimal degree of salience m^* as $\frac{\partial C}{\partial m}$ does not depend on s. Note that as C is a convex function of m, the m^* we get maximizes welfare. By substituting the optimal degree of salience m^* in (17), we get the optimal subsidy s^*.Therefore, the formula for the optimal policy is:

$$s^* = \frac{2\left(1+8a\right)}{m^*\left(15+16a^2+32a\right)} \text{ and } m^* \text{ such that } \left.\frac{\partial C}{\partial m}\right|_{m=m^*} = 0. \quad (18)$$

We have $s^*m^* = \frac{2(1+8a)}{(15+16a^2+32a)} < 1$, so the condition $sm < 1$ is satisfied.

If m^* such that $\left.\frac{\partial C}{\partial m}\right|_{m=m^*} = 0$ is lower than $\underline{m}$,[4] the optimal policy mix is $m^* = \underline{m}$ and $s^* = \frac{2(1+8a)}{\underline{m}(15+16a^2+32a)}$. ■

The government chooses m^* to minimize the cost for improving the salience rate and the optimal subsidy is a function of this salience rate. As one can see from (18), the optimal subsidy rate is positive, that is the optimal strategy for the government is to subsidize the goods. The higher the subsidy salience, the lower the subsidy.

The duopoly, in a vertically differentiated market with endogenous qualities and prices, yields suboptimal welfare. Cremer and Thisse (1994) show that a small ad valorem tax improves welfare. In our model, this would be the case if the welfare function did not include the level of pollution. However, when the government cares about pollution, it chooses to subsidize the products since a subsidy increases the environmental quality of both variants. Note that in this setting, the government does not subsidize the products to boost the demand for green goods, as one would expect. It subsidizes them to motivate firms to make their products more environmentally friendly. The more salient the subsidy is, the more firms improve their products' environmental quality and the lower the subsidy the government needs to give.

4 Concluding remarks

To promote the use of green products and replace brown ones, many governments offers subsidies. This paper analyzes the subsidy policy for green products in a vertically differentiated market with environmentally conscious consumers, who do not respond to subsidies in the same way as they do to price changes. We look at how the degree of consumers attention to subsidies affect the environmental quality of different variants of the green product. We find that the optimal subsidy rate decreases as the degree of salience increases. This result is driven by a different mechanism than the one in the tax salience literature. Increasing consumers' attention to subsidies reduces the optimal subsidy not because more people buy the product, but because firms increase the environmental product quality of their products.

Policymakers want to increase the effectiveness of the subsidy by making it more salient, but this is costly. We find the optimal mix of subsidy and level of subsidy salience. This paper's findings have important

[4] In that case, as C is convex in $[\underline{m}, \overline{m}]$, we have $\frac{\partial C}{\partial \underline{m}} > 0$.

implications for policy design. A higher subsidy salience reduces the subsidy that the government needs to give. Yet, this increased salience comes at a cost that the government needs to consider.

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5 Appendix

The second order conditions for welfare maximization are:

$$\frac{\partial^2 W}{\partial s^2} = -\frac{m^2\left[\left(9-16a+16a^2\right)+ms(30+32a^2+64a\right]}{16\left(ms-1\right)^4} < 0,$$

$$\frac{\partial^2 W}{\partial m^2} = -\frac{s^2\left[\left(9-16a+16a^2\right)+ms(30+32a^2+64a\right]}{16\left(ms-1\right)^4} - \frac{\partial^2 C}{\partial m^2} < 0,$$

and

$$\frac{\partial^2 W}{\partial s^2}\frac{\partial^2 W}{\partial m^2} - \frac{\partial^2 W}{\partial ms}\frac{\partial^2 W}{\partial sm}$$
$$= \frac{\left[-16a+ms\left(15+16a^2+32a\right)-2\right]\left[-16a-2+\left(45+48a^2+96a\right)m^2s^2+\left(35+48a^2+16a\right)ms\right]}{256\left(ms-1\right)^7}$$
$$+\frac{\partial^2 C}{\partial m^2}\frac{m^2\left(\left(9-16a+16a^2\right)+ms(30+32a^2+64a\right)}{16\left(ms-1\right)^4}.$$

The first two conditions are satisfied because $9-16a+16a^2>0$ and $\frac{\partial^2 C}{\partial m^2}>0$. If we substitute the optimal subsidy given by (18) in the third one, the first term becomes zero and we get

$$\frac{\partial^2 W}{\partial s^2}\frac{\partial^2 W}{\partial m^2} - \frac{\partial^2 W}{\partial ms}\frac{\partial^2 W}{\partial sm} = \frac{\partial^2 C}{\partial m^2}\frac{m^{*2}\left(\left(9-16a+16a^2\right)+m^*s^*(30+32a^2+64a\right)}{16\left(m^*s^*-1\right)^4} > 0.$$