Economics Bulletin

Volume 45, Issue 1

Regulation and eco-innovation

Anna Baranovsky
Ariel University

Artyom Jelnov
Ariel University

Abstract

Consumers are increasingly questioning how their purchasing decisions impact the environment. Technological innovation, which reduces production costs of eco-friendly products, significantly impacts the market. With new technologies, eco-friendly products become more affordable. This study examines where incentives to invest in technology development are higher: in a market with or without obligatory regulation restrictions for non-eco products. We show that incentives to invest in technology development may be higher in a market without obligatory restrictions for non-eco products.

Citation: Anna Baranovsky and Artyom Jelnov, (2025) "Regulation and eco-innovation", *Economics Bulletin*, Volume 45, Issue 1, pages 73-87
Contact: Anna Baranovsky - abaranovskaya@gmail.com, Artyom Jelnov - artyomjel@gmail.com.
Submitted: July 06, 2023. **Published:** March 30, 2025.

1 Introduction

Environmental challenges, such as climate change, water and air pollution, and urban sprawl, are becoming increasingly critical. Modern society is product-oriented, and the rates of production and consumption are growing exponentially, which requires considerable resources and energy.

There are various eco-labelling schemes (see Appendix), all of which share a common assumption: consumer purchasing behavior is not solely motivated by price and mandatory health standards. Instead, consumers also consider product attributes related to environmental and ecological objectives, as well as economic and social causes (e.g., fair trade, support for small farmers, discouragement of child labor).

This paper aims to analyze the incentives for technological innovation in markets with regulatory restrictions versus those with voluntary labelling.

We study a product that may be harmful to the environment. However, this product can be produced using eco-friendly technology, albeit at a higher cost.

Voluntary eco-labels play a crucial role in this scenario. We assume that demand for eco-friendly products is higher than for non-eco-friendly ones due to consumers' environmental awareness. In the absence of government regulation, consumers typically rely on eco-labels to determine the eco-friendliness of a product. A firm that adopts a label commits to producing eco-friendly products, and this becomes common knowledge (we assume that labels are trustworthy). Environmental labelling has been influencing consumer choices since the late 1970s, with the German Blue Angel (Der Blaue Engel) certification being the first eco-label introduced worldwide in 1978.

In contrast, a regulator might intervene and prohibit the production of non-eco-friendly products. The effect of such a restriction on social welfare is ambiguous. On one hand, it reduces environmental damage; on the other hand, customers are forced to pay more than their optimal price. We show that if potential environmental damage is low and social sensitivity to the environment is also low, such regulatory intervention can reduce social welfare.

Technological innovation, which reduces the production costs of eco-friendly products, may have a significant impact on the market.[1]

To summarize, firms must decide whether to produce eco-friendly products and, if so, whether to adopt the new cost-reduction technology.

With new technology, eco-friendly products become more affordable to customers. But where are the incentives to invest in technological innovation stronger: in a market with or without regulatory restrictions on products? At first glance, it might seem that if only eco-friendly products are present in the market, firms would have a higher incentive to invest in reducing production costs. We demonstrate, however, that this is not necessarily the case. If a firm is the only one producing an eco-friendly product while another firm does not, the first firm may have a higher incentive to invest in technological improvements. This is because product differentiation may be more profitable for firms. Additionally, the increase in profit due to reduced production costs may be greater than in a scenario where all firms are forced to adopt the same standard.

The availability of new technology might encourage firms to voluntarily switch to the production of eco-friendly products. Surprisingly, we show that firms may choose not to do so even when technological improvements are significant and social sensitivity to the environment is high. This occurs because firms desire to differentiate their products. If a product is extremely harmful to the environment, this could justify regulatory intervention.

A relevant example involves sustainable alternatives to common disposable products. For instance, compostable cutlery and bowls provide an eco-friendly substitute for single-use plastic items, which significantly contribute to waste. These compostable alternatives are made from materials like cornstarch or sugarcane, which decompose more easily and help

[1] In our model, the eco-friendly product can be produced using either new or old technology. The new technology simply reduces production costs.

reduce plastic pollution. However, for case of cutlery and bowls production costs, both for compostable and plastic products, are relatively low. Then results of our corollary 1 and proposition 2 hold.

Another example is solar-powered chargers, which serve as a replacement for traditional battery packs and chargers. These chargers harness renewable energy, thereby reducing reliance on conventional electricity sources and decreasing overall environmental impact. For this product, technology improvement can lead to a dramatic reduce in production cost. This is a necessary condition for the first part of our proposition 3 to hold.

In general, minimal quality standards are widely discussed in the literature (for example, see Ecchia and Lambertini, 1997). We are addressing a case where there is a negative externality: low-quality (or low-standard, in our terms) products are harmful to the environment. This case has also been studied; for instance, see the theoretical models in Disdier and Marette (2012) and Birg and Voßwinkel (2018). In the current paper we study willingness to pay for the new technology, where the new technology reduces cost of producing an eco-friendly product.

Our research incorporates the aspect of technological innovation. Acemoglu et al. (2016) provide a model of incentives for firms to invest in the development of clean technologies. However, they assume that consumers are ignorant of environmental damage, whereas we analyze how firm decisions are affected by consumer sensitivity to environmental issues. See also Acemoglu et al. (2019) for a model in which resources are allocated between innovation in clean energy and polluting energy.

For a survey of the economics of the eco-label literature, see Yokessa and Marette (2019).

2 Model

2.1 No technology improvement available

Consider a product, which can be of a high or of a low environmental standard. The high standard product is eco-friendly, and a buyer has a utility $t > 0$ from consuming each unit of it.

The low standard product is harmful for the environment. Consumers differ in their sensitivity to the environment. A utility from consuming one unit of product is $t - s$, $s \sim U[0, S]$. Parameter s may be interpreted as buyer's sensitivity to the environment, while $S > 0$ is referred as environmental *sensitivity of the society*.

There is a unit-mass of buyers, each consumes at most one unit of the product. Buyer's surplus from consuming high standard is $t - p_h$, and from consuming low standard it is $t-s-p_l$, where p_h and p_l are prices of one unit of high- and low-standard product, respectively. Buyer buys the low standard product if

$$t - s - p_l \geq \max[0, t - p_h].$$

We assume that a dominated strategy $p_h > t$ is not used. Then the demand Q_l for the low standard product is

$$Q_l = \max[0, \min[\frac{p_h - p_l}{S}, 1]]. \quad (1)$$

Given $t \geq p_h$, the demand for high standard product is

$$Q_h = 1 - Q_l. \quad (2)$$

The total customer surplus is

$$CS = Q_h(t-p_h) + \int_0^{\min[p_h-p_l,S]} \frac{t - s - p_l}{S} \, ds = Q_h(t-p_h) + Q_l(t-p_l - \frac{\min[p_h - p_l, S]}{2}). \quad (3)$$

We assume two firms. Firm H produces high standard product with production cost c_h for a unit, while firm L produces low standard, with production cost c_l for a unit. We assume $c_l < c_h < t$. Profit of H is

$$\pi_H = Q_h(p_h - c_h), \tag{4}$$

and profit of L is

$$\pi_L = Q_l(p_l - c_l). \tag{5}$$

We consider a price-driven competition.

We denote damage caused to the environment by the low standard product by dQ_l. We refer to $d > 0$ as *damage* parameter. The total social welfare is thus

$$SW = \pi_H + \pi_L + CS - dQ_l = Q_h(t - c_h) + Q_l[t - \frac{\min[p_h - p_l, S]}{2} - c_l - d]. \tag{6}$$

Next, consider next regulation policy, where both firms are required to produce high standard products only. Then L and H participate in a standard Bertrand competition, their profit is thus 0, and in equilibrium social welfare is

$$SW_h = (t - c_h). \tag{7}$$

The proposition next states that if damage and sensitivity of society are sufficiently low, social welfare is higher when no restriction on standard is imposed by the regulator.

Proposition 1. Let $t > \frac{2S+2c_h+c_l}{3}$. If $\frac{S+6d}{5} < c_h - c_l < 2S$ or $\max[2S, \frac{S}{2} + d] < c_h - c_l$, then $SW > SW_h$.

By proposition 1, if production cost of high standard product is high, namely, $c_h - c_l$ is high, regulatory restriction reduces social welfare. This is not surprising, such as in this case regulation forces customers to buy extremely expensive products. In contrast, if production cost of high standard product is low, still some customer will prefer low standard (for low price). Then restriction on low standard enhances social welfare.

Corollary 1. Let $t > \frac{2S+2c_h+c_l}{3}$. If $c_h - c_l$ is sufficiently low, then $SW < SW_h$.

The proof is immediate by proposition 1.

In the case of no regulation restriction, as society is more sensitive, profit of H increases. Indeed, higher sensitivity leads to higher demand of high standard products. Surprisingly, it may be the case that also L is better off when S increases. An explanation is the following: as S increases, the demand for high standard increases. Thus, H raises its price. But since H and L produce a substitute product, also the price for low standard increases. For some values of t and S, the effect of price increase is strong, and L's profit increases in S.

Proposition 2. π_H weakly increases in S. If $t > \frac{2S+2c_h+c_l}{3}$ and $S > c_h - c_l$, or $t > \frac{2S+2c_h+c_l}{3}$ and $S < \frac{c_h-c_l}{2}$, then π_L weakly increases in S. Otherwise, it weakly decreases in S.

As an illustration to the proposition 2, figure 2.1 shows area, where π_L increases in S, for $c_h = 0.75$ and $c_l = 0.5$. The area where it happens is coloured.

2.2 Technology improvement available

Consider next a case where new technology is available. This technology reduces cost of production of the high standard product to $c_h^{'}$ for unit, $c_h^{'} < c_h$. Firm H chooses to adopt or not the new technology. Firm L chooses to stay to produce low standard, or to adopt new technology and to produce high standard. If the regulator prohibits production of low standard products, both L and H produce with the high standard, while each firm chooses to adopt or not the new technology. Following their decision, the firms compete over prices.

Assuming that adopting new technology is costly, both firms will not choose it (recall that we consider Bertrand competition, namely, if both firms produce a high standard product with the new technology, in equilibrium their profit is zero). Thus, in equilibrium we consider the following cases only.

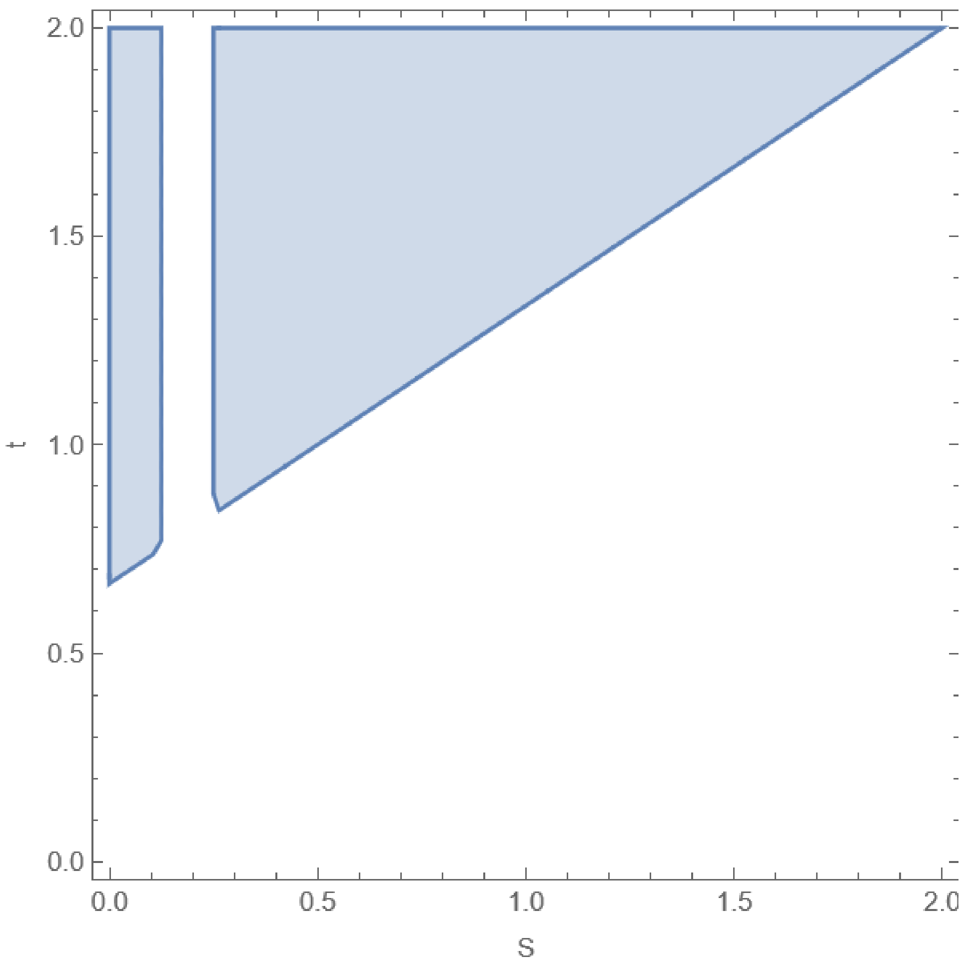

Figure 2.1: π_L increases in S.

Case 1. As in section 2.1, H produces with the high standard with an old technology, while L produces with the low standard. No restrictions are imposed by the regulator. H and L profits are, as in section 2.1, π_H and π_L, respectively.

Case 2. Again as in section 2.1, due to regulatory restriction both firms produce with high standard, with old technology. Their profit in this case is zero.

Case 3. Only high standard product is produced due to regulator's requirement. One of the firms $i \in \{H, L\}$ adopts the new technology. In this case, i fixes a price of c_h, while the production cost is $c_h^{'}$ per unit. The second firm sells zero quantity of the product. The profit of i is $\pi_n = c_h - c_h^{'}$, and the profit of the second firm is 0. We refer also to π_n as a *willingness to pay for the new technology with regulatory restriction*.

Case 4. There is no regulatory restriction, H produces with the high standard with the *new* technology, and its profit is

$$\pi_H^n = Q_h(p_h - c_h^{'}).$$

Then, $\pi_H^n - \pi_H$ is *H's willingness to pay for the new technology without regulation*. L produces the low standard product.

Case 5. There is no regulatory restriction, but L voluntarily decides to produce with the high standard with the new technology. Its profit is then $\pi_n = c_h - c_h^{'}$, and $\pi_n - \pi_L$ is *L's willingness to pay for the new technology without regulation*.

The next proposition provides conditions, given high t, where H's willingness to pay for the new technology is higher when there is no regulatory restriction on the standard.

Proposition 3. Let $t > \frac{2S+2c_h+c_l}{3}$. If $2c_l - c_h - c_h^{'} > 5S$ and $2S > c_h - c_l$, then $\pi_n < \pi_H^n - \pi_H$. If $c_h^{'} - c_l < 2S < c_h - c_l$, then $\pi_n < \pi_H^n - \pi_H$ if $(2S - c_h^{'} + c_l)^2 > 9S(c_h - c_h^{'})$. If $2S < c_h^{'} - c_l$, then $\pi_H^n - \pi_H = 0$.

If L produces with the low standard and H with the high one, then in the price-driven competition still product price may be higher than production cost. Then H's profit, and, consequently, the willingness to pay for the new technology, may be higher compared to the case where both firms are forced to produce with the high standard.

$2S > c_h - c_l$ is a condition that H produces positive quantity with both technologies, under $c_h^{'} - c_l < 2S < c_h - c_l$ it produces positive quantity with the new technology only, while for $2S < c_h^{'} - c_l$ it does not produce with both technologies.

Note that $2c_l - c_h - c_h^{'} > 5S$ and $2S > c_h - c_l$ region may not be empty only for low values of $c_h^{'}$ and for high values of c_l. In this case new technology provides a dramatic reduce in production cost, which may encourage H to adopt the new technology even without regulatory restriction.

Figure 2.2 illustrates that the region, where the proposition 3 holds, is not empty. In this example $c_l = 0.8$, $c_h^{'} = 0.1$, H's willingness to pay for the new technology is higher without regulatory restriction in the coloured region.

Without regulatory restriction, still L can choose voluntarily to adopt the new technology and to produce the high standard product. Trivially, if $c_h^{'}$ is close to c_h, namely, the new technology improvement is slight, L prefers to remain producing the low standard product. But even if technology improvement is significant (low $c_h^{'}$), L may prefer not to adopt it, if sensitivity of society is high. This is in line with proposition 2, which states that π_L may increase in S.

Proposition 4. There is S^* such that for $S > S^*$, as long as $t > \frac{2S+2c_h+c_l}{3}$ holds, $\pi_L > \pi_n$.

3 Discussion and concluding remarks

We demonstrate that the incentives provided by regulatory restrictions on eco-innovation are ambivalent. In some cases, voluntary adoption of clean technology may offer stronger incentives for firms to invest in eco-friendly innovations.

Eco-labels play a crucial role in guiding consumers towards voluntarily choosing clean products. However, for eco-labels to be effective, they must be reliable. This paper does

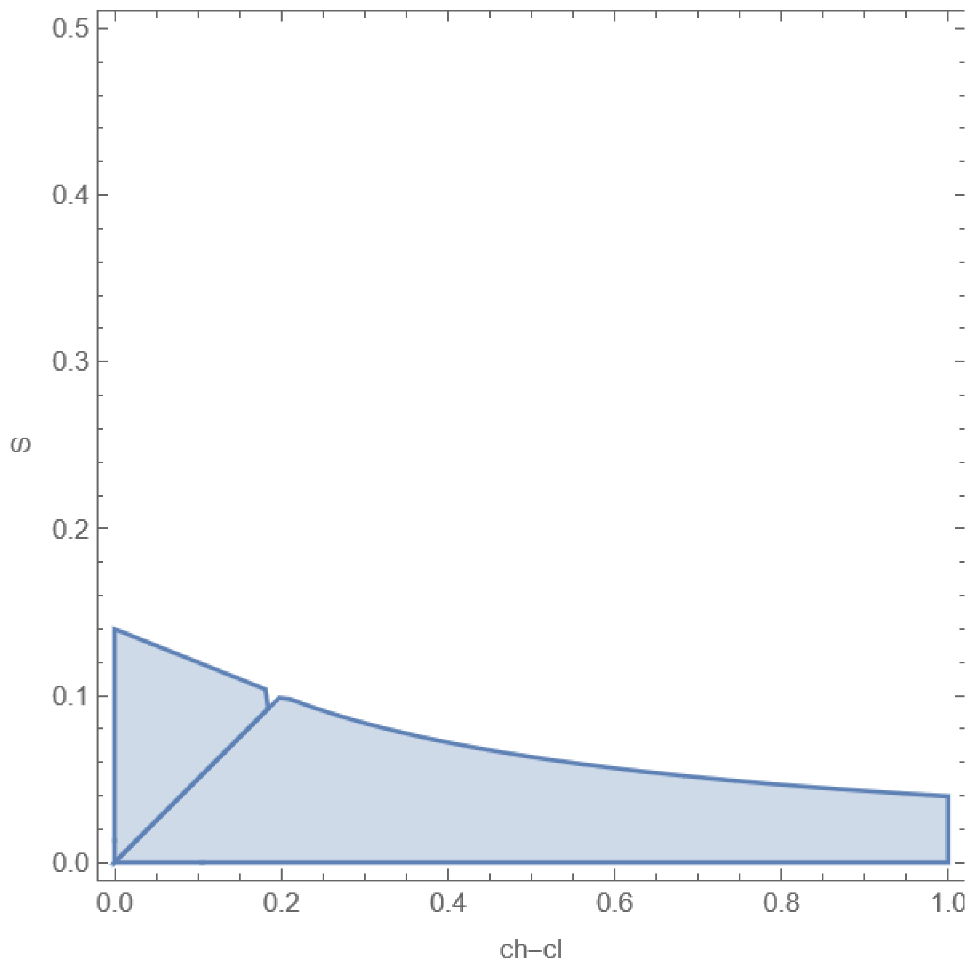

Figure 2.2: H's willingness to pay for the new technology is higher without regulatory restriction

not focus on analyzing the phenomena of 'greenwashing' or comparing trusted labels to marketing strategies. Instead, our objective is to explore how trusted eco-labels can stimulate technological changes among producers who aim to maximize their financial gains.

It is important to note that our model assumes the presence of only two firms. In the absence of regulatory restrictions and new technology, these firms engage in monopolistic competition, with each occupying a specific niche (either high or low). While a more general model involving $n > 2$ firms could be considered, the equilibrium outcome under Bertrand competition suggests that only one firm will adopt the new technology. If regulatory restrictions are imposed, the outcome aligns with Case 3 of our model. Without restrictions, if many firms produce the low-standard product, they compete on price, setting $p_l = c_l$ and earning zero profit. Consequently, the price of the high-standard product also decreases, regardless of production costs. This reduction diminishes the willingness to pay for the new technology. It can be demonstrated that if a positive quantity of the high-standard product is produced at both c_h and $c_h^{'}$ costs, then the willingness to pay for the technology is higher when restrictions are in place. A more detailed analysis of these dynamics is left for future research.

References

Acemoglu, D., P. Aghion, L. Barrage, and D. Hemous (2019). Climate change, directed innovation, and energy transition: The long-run consequences of the shale gas revolution.

Acemoglu, D., U. Akcigit, D. Hanley, and W. Kerr (2016). Transition to clean technology. *Journal of Political Economy 124*(1), 52–104.

Birg, L. and J. S. Voßwinkel (2018). Minimum quality standards and compulsory labeling when environmental quality is not observable. *Resource and Energy Economics 53*, 62–78.

Disdier, A.-C. and S. Marette (2012). Taxes, minimum-quality standards and/or product labeling to improve environmental quality and welfare: Experiments can provide answers. *Journal of Regulatory Economics 41*(3), 337–357.

Ecchia, G. and L. Lambertini (1997). Minimum quality standards and collusion. *The Journal of Industrial Economics 45*(1), 101–113.

Feldmann, C.; Hamm, U. (2015). Consumers' perceptions and preferences for local food: A review. food quality and preference. *Journal of Cleaner Production*, pp. 152–164.

Prieto-Sandoval, Vanessa; Alfaro, J. A. M.-V. A. O. (2016). Eco-labels as a multidimensional research topic: Trends and opportunities. *Journal of Cleaner Production 135*(1), 806–818.

Ritsuko., O. (2010). Cdopting sustainable innovation: What makes consumers sign up to green electricity. *Business Strategy and Environment*, pp. 1–17.

Sammer, K.; Wüstenhagen, R. (2006). The influence of eco-labelling on consumer behaviour—results of a discrete choice analysis for washing machines. *Wiley InterScience*, pp.185–199.

Thompson, D.W.; Anderson, R. H. E. K.-L. (2010). Green segmentation and environmental certification: Insights from forest products. *Business Strategy and Environment*, pp.319–334.

UNOPS (2009). A guide to environmental labels for procurement practitioners of the united nations system.

Yokessa, M. and S. Marette (2019). A review of eco-labels and their economic impact. *International Review of Environmental and Resource Economics 13*(1-2), 119–163.

Appendix I: Proofs

Proof of proposition 1. H and L maximise π_H and π_L, respectively. By (4), (5), (2) and (1), they are maximised for

$$p_h = \min[t, \frac{2S + 2c_h + c_l}{3}], \tag{8}$$

Consider a case $t > \frac{2S+2c_h+c_l}{3}$. Then

$$p_l = \frac{S + c_h + 2c_l}{3}, \tag{9}$$

$$Q_h = \begin{cases} \frac{2S-c_h+c_l}{3S} & , 2S > c_h - c_l \\ 0 & , 2S \leq c_h - c_l \end{cases}, \tag{10}$$

$$Q_l = \begin{cases} \frac{S+c_h-c_l}{3S} & , 2S > c_h - c_l \\ 1 & , 2S \leq c_h - c_l \end{cases}, \tag{11}$$

$$\pi_H = \begin{cases} \frac{(2S-c_h+c_l)^2}{9S} & , 2S > c_h - c_l \\ 0 & , 2S \leq c_h - c_l \end{cases}, \tag{12}$$

and

$$\pi_L = \begin{cases} \frac{(S+c_h-c_l)^2}{9S} & , 2S > c_h - c_l \\ \frac{S+c_h-c_l}{3} & , 2S \leq c_h - c_l \end{cases}, \tag{13}$$

By (6) and (7),

$$SW > SW_h \Leftrightarrow \frac{S + 6d}{5} < c_h - c_l < 2S \text{ or } \max[2S, \frac{S}{2} + d] < c_h - c_l.$$

□

Proof of proposition 2. Let $t > \frac{2S+2c_h+c_l}{3}$. In this case the result follows directly by (12) and (13). If $t < \frac{2S+2c_h+c_l}{3}$, by (8), $p_h = t$, $Q_h = \max[\frac{2S-t+c_l}{2S}, 0]$, $p_l = \frac{t+c_l}{2}$,and $Q_l = \min[\frac{t-c_l}{2S}, 1]$, then

$$\pi_H = \max[\frac{(2S - t + c_l)(t - c_h)}{2S}, 0], \tag{14}$$

which weakly increases in S, and

$$\pi_L = \min[\frac{(t - c_l)^2}{4S}, \frac{t - c_l}{2}], \tag{15}$$

which weakly decreases in S. □

Proof of proposition 3. For $t > \frac{2S+2c_h+c_l}{3} > \frac{2S+2c_h^{'}+c_l}{3}$, π_H^n is derived similar to (12). The result is straightforward (recall that we assume $t > c_l$). □

Proof of proposition 4. Let $2S > c_h - c_L$. Then by (13), $\pi_L > \pi_n = c_h - c_h^{'}$ for

$$S > \frac{(7c_h + 2c_l - 9c_h^{'}) + \sqrt{(-7c_h - 2c_l + 9c_h^{'})^2 - 4(c_h^2 + c_l^2 - 2c_h c_l)}}{2}.$$

□

Appendix II: Types of policies and regulations

The population's demand for a clean environment forces governments to respond to this demand through various methods and instruments that regulate and stimulate environmental protection. Command-and-control instruments can be roughly divided into fully regulated policies and laws, and instruments of soft policy seeking the deregulation.

Fully regulated policies could be defined as legal restrictions, requiring the fulfillment of certain standards, enshrined in law, and, accordingly, controlled by the state. Failure to comply with the requirement entails legal liability. There are both negative and positive aspects to strict government regulation.

State mandatory labelling influences consumer choice, but does not necessarily reflect producers' (manufacturer) decision to use technological innovation to reduce harm. This paper analyses if this legislation can bring 'new opportunities' for technology innovation development.

Eco-labels emerged as a global phenomenon. Currently, there are over 455 eco-labels in 199 countries and 25 industry sectors.

The International Standards Organisation (ISO) has classified the existing environmental labels into three typologies – Type I, II and III - and has specified the preferential principles and procedures for each one of them (UNOPS, 2009). Type I: independent and reliable labels that consider the life-cycle impact of products and services. This type of label is awarded by a certified third-party program, and based on criteria developed by independent experts, often supported by the government. Certification is granted for a specific time period after which the product/service needs to be re-certified. These labels are voluntary, for example Blue Angel (Germany). Type II: self-proclaimed labels by manufacturers, importers, retailers, or distributors, which have environmental characteristics of a product or service, e.g 'dolphin safe' labels. This type of label is focused on a particular standard of a product, e.g. compostable and not independently certified, thus can raise questions about the validity of certification. Type III: Voluntary declarations of the sustainability of a product or service's entire life cycle. This type of label provides a more detailed quantitative information of products.

Additionally, a different category called "Type I – like" is presented in the literature, which represents environmental labels focused on just one environmental or social aspect; these labels have been launched by independent organisations (see Prieto-Sandoval, 2016).

Type I-like or single issue labels can be based on a pass/fail criterion, for example setting a maximum level of energy consumption for electric appliances (ex., the Energy Star label).

Eco-label products can be found in many areas, such as food products (Feldmann, 2015), energy (Ritsuko., 2010), electrical equipment (Sammer, 2006), furniture and wood products (Thompson, 2010), clothing, cosmetics, etc.