Timing of Command-and-Control policy, asymmetric technology, and green trade unions.

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Abstract

This document delves into the Command-and-Control framework, specifically examining the timing of environmental policymaking within the context of regulating oligopolistic firms to reduce emissions. The regulator faces a crucial decision of implementing technological standards before (ex-ante timing) or after (ex-post timing) firms make production decisions. Geographical considerations also play a role, with regions adopting asymmetric anti-pollution technology standards. An innovative aspect is the inclusion of green trade unions, advocating for environmental conservation during negotiations with firms. The document conducts a comparative analysis of two games employing ex-ante and ex-post approaches, evaluating outcomes across various dimensions. The study emphasizes the significant impact of regulatory timing on environmental and economic outcomes, showcasing the advantages of a proactive (ex-ante) approach in fostering less-polluting technologies, higher production levels, increased profits, elevated social welfare, and reduced environmental damage. These insights contribute to the discourse on environmental policymaking, providing valuable considerations for policymakers, industry stakeholders, and researchers.

Keywords: Command-and-Control, timing of policy, environmental technology, emissions, oligopoly.

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1. Introduction

The temporal dimension of decision-making occupies a pivotal position in economic literature, especially in the realm of policy decisions. A multitude of studies has delved into the timing of decisions from the regulator's perspective, aiming to evaluate the efficacy of policies with a particular focus on the dichotomy between ex-ante (before externalities) and ex-post (after externalities) decision-making approaches. Previous contributions from scholars such as Shavell (1984), Kolstad et al. (1990), Hiriart et al. (2004), Requate (2005), and Asproudis et al. (2019) and more, have provided valuable insights into the nuances of policy timing.

The crux of these studies lies in understanding the regulator's commitment to a policy or technology concerning firms' production levels or/and environmental protection. This question becomes particularly relevant in a Command-and-Control approach, where the regulator wields the authority to establish minimum environmental standards, technical specifications, or specific technologies mandatory for firms operating in a given market. For instance, the European Union's introduction of Euro standards (e.g., Euro 6) for the automotive industry exemplifies such regulatory initiatives, dictating the standards that automotive companies must meet to sell new cars within the EU.

Within the Command-and-Control framework, our examination focuses on the timing of environmental policymaking, where the regulator determines technological standards for oligopolistic firms to curtail emissions. These standards encompass various aspects, ranging from end-of-pipe technology to the number of filters required for limiting greenhouse gas releases. The regulator faces a pivotal decision: whether to stipulate the technology firms should adopt before their production decisions (ex-ante timing) or after (ex-post timing). Additionally, geographical considerations come into play, with regulators specifying varying levels of asymmetric anti-pollution technology based on the firms' production regions. A pertinent example of this distinction is observed in different regions, with the EU adopting an ex-ante policy timing and the USA favoring an ex-post approach, as highlighted by Vogel (2003).

In a significant departure from conventional studies, we introduce an often-overlooked player in the environmental policy landscape: trade unions with a specific focus on environmental protection, often referred to as green trade unions. These unions, while engaging in negotiations with firms and industries on wage levels, simultaneously advocate for environmental conservation. Existing literature (e.g., Asproudis and Gil Molto, 2015;

Asproudis et al., 2022) has explored the influence of green trade unions on firms' anti-pollution technology. However, the impact of these unions on the regulator's decision-making regarding technology levels remains an uncharted territory. This becomes increasingly relevant in the context of green trade unions supporting the just transition approach, a focal point in discussions such as COP 28, addressing the shift from a fossil fuel economy to a renewable energy economy.

Transitioning from the theoretical framework, we embark on a comparative analysis of two distinct games employing the ex-ante and ex-post approaches. Each game unfolds in three stages, utilizing backward induction to unveil the Subgame Perfect Nash Equilibrium (SPNE). This strategic approach allows us to compare outcomes comprehensively, evaluating the superiority of one model over the other across various dimensions, including welfare, environmental protection, technological advancement, production levels, firms' profits, and market prices.

In the first game, where the ex-ante approach is employed, the regulator assumes a proactive role in the initial stage by introducing and committing to the technology level for each firm. Progressing to the second stage, the trade union becomes a pivotal actor, determining wages with varying levels assigned to each firm. This intricate interplay between the regulator, trade union, and firms sets the stage for the subsequent competition in the third stage, modelled after the Cournot competition dynamics.

Conversely, the second game unfolds through the ex-post approach. Here, the regulator enters the scene in the third stage, setting the technology level after firms have made their decisions regarding production levels. This structured comparison allows us to discern the advantages and drawbacks of each approach in a comprehensive manner. It provides insights into the adaptability and responsiveness of the regulatory framework to market dynamics, offering a real-world perspective on policy effectiveness.

Specifically, our study emphasizes the significant impact of regulatory timing on environmental and economic outcomes in the context of technological adoption by firms and trade unions. When the regulator intervenes proactively (ex-ante), adopting anti-pollution technology beforehand, we observe less polluting technologies, higher production levels, increased profits for firms, elevated social welfare, and reduced environmental damage. This proactive approach also results in higher product prices, reflecting a commitment to environmentally conscious practices and contributing to overall sustainability goals. This comprehensive exploration and comparative analysis contribute to the evolving discourse on environmental policymaking and its temporal dynamics. The findings offer valuable insights for policymakers, industry stakeholders, and researchers, emphasizing the need for a nuanced understanding of policy timing's multifaceted implications.

2. The model

We consider two firms indicated by $i, j = 1,2$ with $i \neq j$, producing a differentiated product that is sold in a single market. Both firms are unionised under a single trade union The inverse demand function is $p = a - q_i - bq_j$, where $a > 0$ is the market size parameter, and $q_{i,}\, q_j$ are the firms' outputs and *b* is the level of the product differentiation where for *b=0* it is a monopoly, and for *b=1* the product is homogeneous. Production exhibits constant returns to scale and it is described by $q_i = L_i$, where L_i represents the number of workers employed by firm i. The production process generates emissions, y_i, according to $y_i = k_i q_i$, where k_i is a technology allowing the reduction of the emissions rate per unit of output from 1 to $k_i \in (0,1]$ at a cost $\gamma(1 - k_i)^2$, where $\gamma > 0$ is a scale parameter.[2] This cost represents diminishing returns to investment in abatement technology.[3] The closer to one the value of technology k_i is, the lower the technological cost and the more polluting the technology will be. Therefore, a firm's total cost, consisting of labour and abatement technology cost, is given by $C_i = w_i L_i + \gamma(1 - k_i)^2$, where w_i denotes the wage of firm i. The corresponding profits are $\pi_i = (a - q_i - bq_j)q_i - w_i\, q_i - \gamma(1 - k_i)^2$.

The trade union cares about environmental quality and therefore it is a green trade union (see for example Asproudis and Gil Molto (2014), Asproudis et al. (2022). Therefore, trade union i's perceived damage from pollution is denoted by $(DF_i + DF_j) = (ey_i + ey_j)$, where $e > 0$ is a scale parameter.[4] Furthermore, a trade union cares about the well-being of its members. This is expressed by the over-the-outside-option aggregate earnings from being employed by the respective firm. If w_0 denotes the reservation wage these earnings are denoted by $(w_i - w_0)L_i$. In summary, the utility of trade union i can be expressed by $U_i = (w_i - w_0)L_i - (DF_i + DF_j)$ and for simplification reasons we assume reservation wage equal to 0.

[2] Hence, contrary to Puller (2006), an emissions reduction can be driven both by an improvement in abatement technology and a reduction in output.
[3] This type of the technology could include the filters for the reduction of CO_2 or 'scrubbers' for the reduction of SO_2 emissions. For more details see Chao and Wilson (1993).
[4] Our model restrictions also require that $a > e$.

The regulator will decide for the level of the technological standards or the environmental antipollution technology (k_i, k_j) that firms must adopt based on the maximisation of the Social Welfare $SW = CS + PS + U$ where CS is the consumer surplus, PS is the producer surplus and U is the Utility of the trade union. Since the DF is part of the trade union's utility then we do not need to add this again in the SW.[5]

3. Comparisons of the results and conclusions

We compare the results from the two previous models (Ex-ante and Ex-post) to explore when each model is superior in terms of welfare, environmental protection, technological advancement, production levels, firms' profits, and market prices. The results are presented in the next table.

	Ex-Ante (EA)	*Ex-Post (EP)*	
Technology	$\frac{5ae-36g}{5e^2-36g}$	$\frac{-ae+e^2+12g}{12g}$	$k^{EA} < k^{EP}$
Production	$\frac{6(-a+e)g}{5e^2-36g}$	$\frac{a-e}{6}$	$q^{EA} > q^{EP}$
Wages	$\frac{5ae^2-18(a+e)g}{5e^2-36g}$	$\frac{-ae^2+e^3+6ag+6eg}{12g}$	$w^{EA} < w^{EP}$
Utility	$\frac{216(a-e)^2g^2}{(5e^2-36g)^2}$	$\frac{1}{6}(a-e)^2$	$U^{EA} > U^{EP}$
Price	$\frac{5ae^2-12(2a+e)g}{5e^2-36g}$	$\frac{1}{3}(2a+e)$	$p^{EA} > p^{EP}$
Profits	$-\frac{(a-e)^2(25e^2-36g)g}{(5e^2-36g)^2}$	$\frac{(a-e)^2(e^2+4g)}{144g}$	$\Pi^{EA} > \Pi^{EP}$
Social Welfare	$-\frac{10(a-e)^2g}{5e^2-36g}$	$-\frac{(a-e)^2(e^2-12g)(e^4+16e^2g+120g^2)}{5184g^3}$	$SW^{EA} > SW^{EP}$
Environmental Damage	$\frac{12e(-a+e)(5ae-36g)g}{(5e^2-36g)^2}$	$-\frac{e(-a+e)(-ae+e^2+12g)}{36g}$	$DF^{EA} \geq DF^{EP}$

[5] Under the absence of green trade union then the equation is $SW = CS+PS+U-DF$.

Our findings underscore the pivotal role of regulatory timing in influencing environmental outcomes and economic parameters within the context of technological adoption by firms and trade unions. Specifically, our analysis reveals that when the regulator takes a proactive stance, intervening before firms (and trade unions) make decisions, the resultant technology tends to be less polluting compared to scenarios where regulatory decisions are made ex-post.

In the ex-ante model, where the regulator commits to a predetermined anti-pollution technology in advance, several positive outcomes emerge. Notably, production levels are higher than those observed under the ex-post model. This higher production translates into increased profits for firms, contributing to a more robust economic landscape. Moreover, the overall social welfare is augmented, reflecting a positive impact on the broader community. Simultaneously, environmental damage is curtailed, signifying a reduction in the ecological footprint associated with production practices.

Additionally, the commitment of the regulator to a specific anti-pollution technology in the ex-ante model fosters an environment where the price of the product is elevated compared to the ex-post model. While this may signify higher costs for consumers, it reflects the incorporation of environmentally conscious technologies and practices, aligning with sustainability goals.

In summary, our study underscores the benefits of regulatory proactivity, emphasizing that when the regulator takes a lead role in shaping technological choices, the outcomes are not only environmentally favorable but also contribute positively to economic and social dimensions. The Ex-ante model emerges as a proactive approach that not only fosters economic growth but also minimizes environmental impact and enhances overall societal well-being.

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