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Abstract

It is frequently observed that the implementation of green policies is delayed compared to the initial announcement. Considering a setting with a representative monopolist extracting a non-renewable resource, we demonstrate that announcing a green policy, but then delaying its implementation, is associated with a larger cumulative extraction at any point in time than announcing a late implementation of this policy at the outset.

JEL-Code: D920, H230, K320, Q320, Q380.

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1 Introduction

The Kyoto Protocol is widely recognized as a milestone of international climate change policy. By agreeing to reduce the carbon dioxid emissions substantially, many countries are pursuing the goal of dampening the greenhouse effect. This effect is driven by cumulative fossil carbon extraction. The Kyoto Protocol was adopted in 1997, went into force in 2005 and specifies greenhouse gas emission reduction targets for 37 countries. The so-called "first commitment period" covers the years 2008-2012. Since many countries are about to fail their specified targets, there have been initiatives to negotiate a successor of the Kyoto Protocol since the 2007 United Nations Climate Change Conference (UNCCC) in Bali. Effectively, this evolution is tantamount to postponing the original goals to a future point in time. Indeed, at the 2011 UNCCC in Durban an "Ad Hoc Working Group" was appointed to develop a proposal for a new protocol by the 2015 UNCCC which is then supposed to be implemented from 2020 on. These protracted negotiations also show features of delaying the expected implementation of stricter policies to the future.

In addition to this international problem, there are several cases on a national level in which announced climate policy measures have been cancelled or delayed later on. Among these is Australia's plan to introduce an emission trading scheme. A National Emissions Trading Taskforce, established in January 2004, proposed the implementation of a cap-and-trade system by 2010 (National Emissions Trading Taskforce, 2006), which was eventually delayed in April 2010 until after 2012, and finally has been replaced by the introduction of a carbon tax as of July 2012 (Clean Energy Bill 2011). In the United States, the American Clean Energy and Security Act – also a proposal for an emissions trading scheme to start in 2012 (H.R. 2454 (2009)) – was adopted by the House of Representatives in 2009, but further steps have been delayed by the Senate since then. South Korea and Japan also have set out plans for emission trading schemes to be implemented in 2013, but implementation in both countries will probably be delayed due to industry opposition.

In this paper we argue that announcing, or creating the expectation of, the adoption of measures in the future, but then delaying their implementation, has a twofold negative effect on climate. On the one hand, owners of fossil resources tend to accelerate their extraction in anticipation of a stricter climate policy in the future, which is known as the Green Paradox (Sinn, 2008). This happens because a policy-made reduction of the marginal profits in the distant future induces more extraction in the near future. On the other hand, if the policy is not implemented at the announced date, but delayed to some later date, resource owners are able to increase their total profits by once again shifting extraction quantities forward. During this interim period with less strict climate policy, resource owners raise their extraction once more. Due to the delay, their marginal profits turn out to be higher than they had expected before. The resulting cumulative extraction path is higher than if no policy at all had been announced and implemented. It is also higher than if the date of the eventually implemented policy is announced upfront rather than being the result of an implementation delay. While there is already a substantive literature dealing with announcement effects in environmental policy, our contribution lies in analyzing the consequences of delaying the implementation.

A number of papers discuss the effects of climate policy announcements relative to immediate action, see the survey by van der Werf and Di Maria (2012). The main supply-side channel states that resource owners extract non-renewable resources quicker as a response to announced stricter environmental policies. This is exemplified by Sinn (2008) based on the model of Hotelling (1931). Similar results have beeen derived in different frameworks by Long and Sinn (1985), Sinclair (1992), Di Maria et al. (2008), Hoel (2010), Hoel and Jensen (2010), and Eichner and Pethig (2011). Focusing on consumers, Smulders et al. (2010a, 2010b) show that announcing climate policy well in advance comes along with an unintended effect from the demand side. Households anticipate a price increase at the implementation date of a stricter policy and accumulate capital more quickly, where a higher capital stock is associated with more fossil fuel consumption. In contrast to this literature, Kennedy (2002) argues that overly hasty emission reduction policies increase the compliance costs by being more distortive than if more time is available for the adjustment.

The remainder of the paper is organized as follows. Section 2 introduces the model. After deriving the main results in Section 3, the final Section 4 discusses the findings.

2 The model

We consider a monopolist extracting a non-renewable resource. The initial stock of the resource is $x(0) = x_0 > 0$. Time is continuous and runs from $t = 0$ to infinity. The instantaneous extraction at date t is $q(t)$. For simplicity, the instantaneous profit function without taxation is time-invariant and denoted by $\pi_0(q)$. The analysis would undergo only slight changes if π_0 is interpreted as a baseline profit function at some low and constant tax rates. We impose $\lim_{q\to 0} \pi_0'(0) = \infty$, $\pi_0'' < 0$, and the existence of a finite Cournot quantity $\widehat{q}$, satisfying $\pi_0'(\widehat{q}) = 0$. The first condition may be replaced by $\lim_{q\to 0} \pi_0'(0) = b > 0$, implying a full extraction of the resource in finite time.

At date $t = T_1$, either a profit or a value tax at rate τ, or a unit tax $\theta(t; T_1)$ is introduced. The latter may also be interpreted as a cost to satisfy a new environmental standard or as a price of a permit to extract the resource. Marginal profit changes to either $\pi_1'(q) = (1 - \tau)\pi_0'(q)$ or $\pi_1'(q; t; T_1) = \pi_0'(q) - \theta(t; T_1)$. In order to neutralize the impact of discounting, the unit tax is designed so as to increase at the interest rate $r > 0$, which we assume to be time-invariant: $\theta(t; T_1) = \overline{\theta} \exp^{r(t-T_1)}$. In fact, the literature has repeatedly pointed out that the Green Paradox results depend on whether the growth rate of the unit tax exceeds or falls short of the interest rate (eg. Sinclair, 1992; Sinn, 2008). We take a partial equilibrium approach and ignore repercussions of lower profits and redistributed tax proceeds on demand. In the basic model, the policy switch is announced at date $t = 0$. The law of motion governing the evolution of the stock of the resource is

$$\dot{x} = -q. \tag{1}$$

Let $I(t)$ denote an indicator function with

$$I(t) = \begin{cases} 1 & if \quad t \in (0, T_1) \\ 0 & \quad else. \end{cases} \tag{2}$$

The monopolist maximizes the present value of its profits,

$$\Pi = \int_0^{\infty} \left[I(t)\pi_0(q(t)) + (1 - I(t))\,\pi_1(q(t)) \right] \exp^{-rt} dt. \tag{3}$$

The current-valued Hamiltonian is

$$H = I(t)\pi_0(q) + (1 - I(t))\,\pi_1(q) - \mu q, \tag{4}$$

where μ represents the costate variable. The optimal solution satifies the conditions

$$\frac{\partial H}{\partial q} = I(t)\pi_0'(q) + (1 - I(t))\,\pi_1'(q) - \mu = 0 \tag{5}$$

and

$$-\frac{\partial H}{\partial x} = 0 = \dot{\mu} - r\mu. \tag{6}$$

Equation (5) states that at each point in time the value of the costate variable is equal to the instantaneous marginal profit. Condition (6) implies that the costate variable grows at the constant rate r. Therefore, the solution describing the trajectory of the costate variable can be written as

$$\mu(t) = \mu(0) \exp^{rt}, \tag{7}$$

where $\mu(0)$ is a positive constant, its value being determined by (5), (6) and the boundary conditions $x(0) = x_0$ and $\lim_{t\to\infty} x(t) \geq 0$, where the latter will obviously be satisfied with equality.

The necessary optimality conditions imply that marginal profit increases at rate r. Since extraction will always fall short of the static Cournot quantity and since the marginal profit is diminishing in output, extraction decreases over time. When the policy switches at T_1, there is a discontinuous fall in extraction. This occurs because the change in marginal profit is governed by r and does not jump on an optimal extraction path given perfect anticipation of the tax path. Since the tax decreases all marginal profit levels, the extraction quantity is cut accordingly at the moment at which the policy is implemented.

3 The consequences of delaying green policies

In a first step, we demonstrate that cumulative extraction at any point in time $t > 0$ will be higher than in the zero tax baseline scenario if the regime switch is announced at $t = 0$ for date T_1, and implemented accordingly. Thus, confirming the Green Paradox, announcing green policies accelerates extraction. We proceed by comparing the policy of a switch at T_1 to delaying its implementation until T_2 once the originally scheduled switching date T_1 is reached. It turns out that this policy of delaying again increases cumulative extraction at any given point in time after announcing the new policy. This result is summarized in the following proposition.

Proposition 1 *(i) Announcing at $t = 0$ a green policy with a profit tax τ or a unit tax $\theta(t; T_1)$ to start at $T_1 > 0$ increases cumulative extraction at any point in time $t \in (0, \infty)$.*
(ii) Announcing at $t = 0$ the implementation of the green policy at T_1, but delaying it until $T_2 > T_1$ at date T_1 further increases cumulative extraction at any point in time $t > T_1$.

Proof. Recall that the costate variable satisfies (7) where $\mu(t) > 0$ always holds due to (5).

Let $q_i(\mu) \in (0, \widehat{q})$ be uniquely defined by $\pi_i'(q_i) = \mu$, $i \in \{0, 1\}$. From equation (5) it is obvious that $q_1(\mu) < q_0(\mu)$ for a given μ and a given green policy applying for π_1 only.

The resource constraint implies

$$x(t) = \int_t^\infty \left[I_0(s) q_0(\mu(s)) + (1 - I_0(s))\, q_1(\mu(s))\right] ds \tag{8}$$

at any point in time.Consider first the comparison between announcing and implementing a green policy at T_1 to no green policy at all, being equivalent to $T_1 = \infty$. We denote by $\mu(t; T_1)$ the value of the costate variable at date t in anticipation of a policy change at T_1, with $\mu(t; \infty)$ representing the corresponding value if no green tax policy is announced. Instantaneous extraction $q(t; T_1)$ and the corresponding levels of the resource stock $x(t; T_1)$ are defined accordingly. Note that $\mu(0; \infty) > \mu(0; T_1)$ is a consequence of having an identical initial stock of the resource and distinct future tax paths. Since the costate variable grows at rate r, it follows that $\mu(t; T_1) < \mu(t; \infty)$ at any point in time t. Due to (5), this implies $q(t; T_1) > q(t; \infty)$ for any $t \in [0, T_1)$, ensuring $x(t; T_1) < x(t; \infty)$ for any $t \in (0, T_1]$.

Observe that $\lim_{t\to\infty} x(t) = 0$, and $x(t) > 0$ at any finite t. Since moreover $x(T_1; T_1) < x(T_1; \infty)$ and both marginal profit levels increase at rate r, the relation $q(t; T_1) < q(t; \infty)$ holds for any $t > T_1$. Suppose that instead $q(t; T_1) \geq q(t; \infty)$ for some fixed $\widehat{T} > T_1$. This would require that the costate variables satisfy $\mu\left(\widehat{T}; \infty\right) \geq \mu\left(\widehat{T}; T_1\right) / (1 - \tau)$ in case of a profit tax, or $\mu\left(\widehat{T}; \infty\right) \geq \mu\left(\widehat{T}; T_1\right) + \theta(t; T_1)$ in case of a unit tax. Since in either case the LHS and the RHS of the respective inequality grow at rate r, this would imply $q(t; T_1) \geq q(t; \infty)$ for all $t > T_1$, which contradicts $\lim_{t\to\infty} x(t) = 0$ in combination with $x(T_1; T_1) < x(T_1; \infty)$. This suffices to guarantee $x(t; T_1) < x(t; \infty)$ for any $t \in (0, \infty)$.

Delaying the implementation to T_2 once T_1 is reached induces the monopolist to reoptimize the extraction path, giving rise to a new optimal path of the costate variable $\mu(t; T_1, T_2)$. Since a given extraction quantity q now yields a higher marginal profit in the interval (T_1, T_2), there is a jump in the costate variable at the date at which the delay is announced, that is $\mu(t; T_1, T_2) > \mu(t; T_1)$ for any $t > T_1$. Due to (5), this yields $q(t; T_1, T_2) < q(t; T_1)$ for any $t > T_2$. Since $\lim_{t\to\infty} x(t) = 0$ and $x(t) > 0$ at any finite t, it follows that $x(t; T_1) > x(t; T_1, T_2)$ at any $t \geq T_2$.

Moreover, as the pre-delay marginal profit path as well as the new one increase at rate r, re-optimizing yields $q(t; T_1, T_2) > q(t; T_1)$ for any $t \in (T_1, T_2)$. Suppose that instead $q(t; T_1) \geq q(t; T_1, T_2)$ for some fixed $\widehat{T} \in (T_1, T_2)$. This would require that the costate variables satisfy $\mu\left(\widehat{T}; T_1, T_2\right) \leq \mu\left(\widehat{T}; T_1\right) / (1 - \tau)$ in case of a profit tax, or $\mu\left(\widehat{T}; T_1, T_2\right) \leq \mu\left(\widehat{T}; T_1\right) + \theta(t; T_1)$ in case of a unit tax. Since in either case the LHS and the RHS of the respective inequality grow at rate r, this would imply $q(t; T_1) \geq q(t; T_1, T_2)$ for all $t \in (T_1, T_2)$, which contradicts $x(T_1; T_1) = x(T_1; T_1, T_2)$ in combination with $x(T_2; T_1) > x(T_2; T_1, T_2)$. Therefore, cumulative extraction at any point in time $t > T_1$ fulfills $x(t; T_1, T_2) < x(t; T_1)$. □

The proposition can be interpreted as follows. On the optimal path, the intertemporal arbitrage condition of the monopolist implies that instantaneous marginal profit grows at the interest rate. This holds regardless of the realization of anticipated tax changes. If the marginal profit curve shifts downward due to the introduction of a tax, a discontinuous fall in extraction occurs at the switching date. Delaying the implementation of a tighter policy increases some future marginal profit levels and raises the value of the costate variable. Consequently, extraction will increase during the period with the low-tax policy and decrease during the period with the high-tax policy. Therefore, announcing the policy increases extraction in analogy to the Green Paradox logic, and delaying gives additional incentives for early extraction until the actual implementation date.

Proposition 2 states that the annoucement-cum-delaying policy also fares worse than announcing the late implementation date immediately.

Proposition 2 *Announcing at $t = 0$ the implementation of the green policy at T_1, but delaying it until $T_2 > T_1$ at date T_1 increases aggregate extraction at any point in time $t \in (0, \infty)$ compared to announcing the same policy at $t = 0$ to start at T_2 and implementing it accordingly.*

Proof. We compare correctly anticipating T_2 as the switching date to first expecting T_1, which is then postponed to T_2 once T_1 is reached. Since $\mu(0; T_1) < \mu(0; T_2)$ and since the costate variable grows at rate r, it follows that $\mu(t; T_1) < \mu(t; T_2)$ at any point in time. Due to equation (5), this yields $q(t; T_2) < q(t; T_1)$ for any $t \in [0, T_1)$, implying $x(t, T_1) < x(t, T_2)$ for any $t \in (0, T_1]$.

When the policy is delayed at T_1, a jump in the costate variable occurs. Since the remaining tax path is identical under both policies and $\pi_1'' < 0$, the lower remaining stock translates into a higher value of the costate variable, $\mu(t; T_1, T_2) > \mu(t; T_2)$ for any $t > T_1$. Therefore, $q(t; T_1, T_2) < q(t; T_2)$ for any $t > T_1$. Recalling that $\lim_{t \to \infty} x(t) = 0$ and $x(T_1; T_1, T_2) < x(T_1; T_2)$ it follows that $x(t; T_1, T_2) < x(t; T_2)$ at any $t \geq T_1$. $\square$

Announcing an earlier rather than later implementation of a given green policy induces a higher extraction until the announced early implementation date. The policy is delayed when this date is reached, and it comes to reoptimization of the extraction path. But now the monopolist faces the same remaining policy path as in the scenario in which the later date was announced right at the outset. Since everything is equal except for the stock of the resource, at each point in time more is extracted in the case of a larger stock. As the two paths converge only as time goes to infinity, cumulative extraction is always higher when a more ambitious green policy is announced for an earlier date, but then delayed.

4 Discussion

The policy implications of our analysis are obvious. If the aim of climate policy is to decelerate the speed of resource extraction, the only way to achieve this is by implementing a green policy, for instance a carbon tax, that becomes laxer over time. If such a policy is not feasible or if it cannot be implemented immediately due to political constraints, announcing a policy for some later point in time leads to more extraction until then. This could be seen as the price of not being able to implement the policy immediately. However, whatever policy is announced for the future, delaying this policy shortly before it was supposed to be implemented is detrimental in terms of the goal to dampen the greenhouse effect. Delaying the implementation gives resource owners unexpectedly more time to extract and sell before the policy is actually implemented. Therefore, it increases the speed of extraction.

Notice that the result is independent of extraction cost levels. Even if we had the realistic scenario of a cost function which increases in the level of cumulative extraction, the mechanisms driving our results would remain intact. Also, the results carry over to modifications in which an economic exhaustion is reached in finite time. In this case, delaying a previously announced policy may in addition have the effect that a larger share of the initial resource stock would be extracted and less would remain in the ground once economic exhaustion is reached. Finally, the qualitative results will generally also hold for alternative market structures of the resource extraction industry. Indeed, the impacts of policy annnouncements of implementation and delay of a green policy on the optimization problem of the firm are quite similar in any case and will occur regardless of the question whether or not it is able to influece the market price. Hence, though our model introduces several simplifying assumptions, the results turn out to be robust for many alternative specifications.

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