Deissenberg, Christophe; Dawid, Herbert; Sevcik, Pavel

Working Paper

Cheap Talk, Gullibility, and Welfare in an Environmental Taxation Game

Nota di Lavoro, Fondazione Eni Enrico Mattei, No. 137.2004

Provided in Cooperation with:
Fondazione Eni Enrico Mattei (FEEM)

Suggested Citation: Deissenberg, Christophe; Dawid, Herbert; Sevcik, Pavel (2004) : Cheap Talk, Gullibility, and Welfare in an Environmental Taxation Game, Nota di Lavoro, Fondazione Eni Enrico Mattei, No. 137.2004, Fondazione Eni Enrico Mattei (FEEM), Milano

This Version is available at:
http://hdl.handle.net/10419/118009

Terms of use:
Documents in EconStor may be saved and copied for your personal and scholarly purposes.
You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.
If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.
Cheap Talk, Gullibility, and Welfare in an Environmental Taxation Game
Herbert Dawid, Christophe Deissenberg and Pavel Ševčík
NOTA DI LAVORO 137.2004

NOVEMBER 2004
ETA – Economic Theory and Applications

Herbert Dawid, Department of Business Administration and Economics, University of Bielefeld
Christophe Deissenberg and Pavel Ševčík, GREQAM and University of Aix-Marseille II

This paper can be downloaded without charge at:
The Fondazione Eni Enrico Mattei Note di Lavoro Series Index: http://www.feem.it/Feem/Pub/Publications/WPapers/default.htm

The opinions expressed in this paper do not necessarily reflect the position of Fondazione Eni Enrico Mattei
Corso Magenta, 63, 20123 Milano (I), web site: www.feem.it, e-mail: working.papers@feem.it
Cheap Talk, Gullibility, and Welfare in an Environmental Taxation Game

Summary
We consider a simple dynamic model of environmental taxation that exhibits time inconsistency. There are two categories of firms, Believers, who take the tax announcements made by the Regulator to face value, and Non-Believers, who perfectly anticipate the Regulator's decisions, albeit at a cost. The proportion of Believers and Non-Believers changes over time depending on the relative profits of both groups. We show that the Regulator can use misleading tax announcements to steer the economy to an equilibrium that is Pareto superior to the solutions usually suggested in the literature. Depending upon the initial proportion of Believers, the Regulator may prefer a fast or a low speed of reaction of the firms to differences in Believers/Non-Believers profits.

Keywords: Environmental policy, Emissions taxes, Time inconsistency, Heterogeneous agents, Bounded rationality, Learning, Multiple equilibria, Stackelberg games

JEL Classification: H23, H3, Q5, C69, C79, D62

Address for correspondence:

Christophe Deissenberg
University of Aix-Marseille II
58, Bd Charles Livon
13284 Marseille Cedex 07
France
E-mail: deissenb@univ-aix.fr
1 Introduction

The use of taxes as a Regulatory instrument in environmental economics is a classic topic. In a nutshell, the need for regulation usually arises because producing causes detrimental emissions. Due to the lack of a proper market, the firms do not internalize the impact of these emissions on the utility of other agents. Thus, they take their decisions on the basis of prices that do not reflect the true social costs of their production. Taxes can be used to modify the prices confronting the firms so that the socially desirable decisions are taken.

The problem has been exhaustively investigated in static settings where there is no room for strategic interaction between the Regulator and the firms. Consider, however, the following situation: (a) The emission taxes have a dual effect, they incite the firms to reduce production and to undertake investments in abatement technology. This is typically the case when the emissions are increasing in the output and decreasing in the abatement technology; (b) Emission reduction is socially desirable, the reduction of production is not; and (c) The investments are irreversible. In that case, the Regulator must find an optimal compromise between implementing high taxes to motivate high investments, and keeping the taxes low to encourage production. The fact that the investments are irreversible introduces a strategic element in the problem. If the firms are naive and believe his announcements, the Regulator can insure high production and important investments by first declaring high taxes and reducing them once the corresponding investments have been realized. More sophisticated firms, however, recognize that the initially high taxes will not be implemented, and are reluctant to invest in the first place. In other words, one is confronted with a typical time inconsistency problem, which has been extensively treated in the monetary policy literature following Kydland and Prescott (1977) and Barro and Gordon (1983)). In environmental economics, the time inconsistency problem has received yet only limited attention, although it frequently occurs. See among others Gersbach and Glazer (1999) for a number of examples and for an interesting model, Abrego and Perroni (1999)), Batabyal (1996a)), Batabyal (1996b)), Dijkstra (2002)), Marsiliani and Renström (2000)), Petrakis and Xepapadeas (2003)).

The time inconsistency is directly related to the fact that the situation described above defines a Stackelberg game between the Regulator (the leader) and the firms (the followers). As noted in the seminal work of Simaan and Cruz (1973a,b), inconsistency arises because the Stackelberg equilibrium is not defined by mutual best responses. It implies that the follower uses a best response in reaction the leader's action, but not that the leader's action is itself a best response to the follower's. This opens the door to a re-optimization by the leader once the follower has played. Thus, a Regulator who announces that he will implement the Stackelberg solution is not credible.

An usual conclusion is that, in the absence of additional mechanisms, the economy is doomed to converge towards the less desirable Nash
other agents. Thus, they take their decisions on the basis of prices that do not reflect the true social costs of their production. Taxes can be used to modify the prices confronting the firms so that the socially desirable decisions are taken.

The problem has been exhaustively investigated in static settings where there is no room for strategic interaction between the Regulator and the firms. Consider, however, the following situation: (a) The emission taxes have a dual effect, they incite the firms to reduce production and to undertake investments in abatement technology. This is typically the case when the emissions are increasing in the output and decreasing in the abatement technology; (b) Emission reduction is socially desirable, the reduction of production is not; and (c) The investments are irreversible. In that case, the Regulator must find an optimal compromise between implementing high taxes to motivate high investments, and keeping the taxes low to encourage production. The fact that the investments are irreversible introduces a strategic element in the problem. If the firms are naive and believe his announcements, the Regulator can insure high production and important investments by first declaring high taxes and reducing them once the corresponding investments have been realized. More sophisticated firms, however, recognize that the initially high taxes will not be implemented, and are reluctant to invest in the first place. In other words, one is confronted with a typical time inconsistency problem, which has been extensively treated in the monetary policy literature following Kydland and Prescott (1977) and Barro and Gordon (1983). In environmental economics, the time inconsistency problem has received yet only limited attention, although it frequently occurs. See among others Gersbach and Glazer (1999) for a number of examples and for an interesting model, Abrego and Perroni (1999), Batabyal (1996a), Batabyal (1996b), Dijkstra (2002), Marsiliani and Renström (2000), Petrakis and Xepapadeas (2003)).

The time inconsistency is directly related to the fact that the situation described above defines a Stackelberg game between the Regulator (the leader) and the firms (the followers). As noted in the seminal work of Simaan and Cruz (1973a,b), inconsistency arises because the Stackelberg equilibrium is not defined by mutual best responses. It implies that the follower uses a best response in reaction the leader’s action, but not that the leader’s action is itself a best response to the follower’s. This opens the door to a re-optimization by the leader once the follower has played. Thus, a Regulator who announces that he will implement the Stackelberg solution is not credible. An usual conclusion is that, in the absence of additional mechanisms, the economy is doomed to converge towards the less desirable Nash
A number of options to insure credible solutions have been considered in the literature – credible binding commitments by the Stackelberg leader, reputation building, use of trigger strategies by the followers, etc. See McCallum (1997) for a review in a monetary policy context. Schematically, these solutions aim at assuring the time consistency of Stackelberg solution with either the Regulator or the firms as a leader. Usually, these solutions are not efficient and can be Pareto-improved.

In this paper, we suggest a new solution to the time inconsistency problem in environmental policy. We show that non-binding tax announcements can increase the payoff not only of the Regulator, but also of all firms, if these include any number of naive Believers who take the announcements at face value. Moreover, if firms tend to adopt the behavior of the most successful ones, a stable equilibrium may exist where a positive fraction of firms are Believers. This equilibrium Pareto-dominates the one where all firms anticipate perfectly the Regulator’s action. To attain the superior equilibrium, the Regulator builds reputation and leadership by making announcements and implementing taxes in a way that generates good results for the Believers, rather than by pre-committing to his announcements.

This Pareto-superior equilibrium does not always exist. Depending upon the model parameters (most crucially: upon the speed with which the firms that follow different strategies react to differences in their respective profits, i.e., upon the flexibility of the firms) it may be rational for the Regulator to steer the Pareto-inferior fully rational equilibrium. This paper, thus, stresses the importance of the flexibility in explaining the policies followed by a Regulator, the welfare level realized, and the persistence or decay of private confidence in the Regulator’s announcements.

The potential usefulness of employing misleading announcements to Pareto-improve upon standard game-theoretic equilibrium solutions was suggested for the case of general linear-quadratic dynamic games in Vallée et al. (1999)) and developed by the same authors in subsequent papers. An early application to environmental economics is Vallée (1998)). The Believers/Non-Believers dichotomy was introduced in Deissenberg and Alvarez Gonzalez (2002)), who study the credibility problem in monetary economics in a discrete-time framework with reinforcement learning. A similar monetary policy problem has been investigated in Dawid and Deissenberg (2004)) in a continuous-time setting akin to the one used in the present work.

The paper is organized as follows. In Section 2, we present the model of environmental taxation, introduce the imitation-type dynamics that determine the evolution of the number of Believers in the economy, and derive
the optimal reaction functions of the firms. In Section 3, we discuss the solution of the static problem one obtains by assuming a constant proportion of Believers. Section 4 is devoted to the analysis of the dynamic problem and to the presentation of the main results. Section 5 concludes.

2 The Model

We consider an economy consisting of a Regulator $R$ and of a continuum of atomistic, profit-maximizing firms $i$ with identical production technology. Time $\tau$ is continuous. To keep notation simple, we do not index the variables with either $i$ or $\tau$, unless useful for a better understanding.

In a nutshell, the situation we consider is the following. The Regulator can tax the firms in order to incite them to reduce their emissions. Taxes, however, have a negative impact on the employment. Thus, $R$ has to choose them in order to achieve an optimal compromise between emissions reduction and employment. The following sequence of events occurs in every $\tau$:

- $R$ makes a non-binding announcement $t^a \geq 0$ about the tax level he will implement. The tax level is defined as the amount each firm has to pay per unit of its emissions.
- Given $t^a$, the firms form expectations $t^e$ about the actual level of the environmental tax. As will be described in more detail later, there are two different ways for an individual firm to form its expectations. Each firm $i$ decides about its level of emission reduction $v_i$ based on its expectation $t^e_i$ and makes the necessary investments.
- $R$ chooses the actual level of tax $t \geq 0$.
- Each firm $i$ produces a quantity $x_i$ generating emissions $x_i - v_i$.
- The individual firms revise the way they form their expectations (that is, revise their beliefs) depending on the profits they have realized.

The Firms

Each firm produces the same homogenous good using a linear production technology: The production of $x$ units of output requires $x$ units of labor and generates $x$ units of environmentally damaging emissions. The production costs are given by:
\[ c(x) = wx + c_x x^2, \]  \hspace{1cm} (1)

where \( x \) is the output, \( w > 0 \) the fixed wage rate, and \( c_x > 0 \) a parameter. For simplicity’s sake, the demand is assumed infinitely elastic at the given price \( \tilde{p} > w \). Let \( p := \tilde{p} - w > 0 \).

At each point of time, each firm can spend an additional amount of money \( \gamma \) in order to reduce its current emissions. The investment

\[ \gamma(v) = c_v v^2, \]  \hspace{1cm} (2)

with \( c_v > 0 \) a given parameter, is needed in order to reduce the firm’s current emissions by \( v \in [0, x] \). The investment in one period has no impact on the emissions in future periods. Rather than expenditures in emission-reducing capital, \( \gamma \) can therefore be interpreted as the additional costs resulting of a temporary switch to a cleaner resource – say, of a switch from coal to natural gas.

Depending on the way they form their expectations \( t^e \), we consider two types of firms, Believers \( B \) and Non-Believers \( NB \). The fraction of Believers in the population is denoted by \( \pi \in [0, 1] \). Believers consider the Regulator’s announcement to be truthful and set \( t^e = t^a \). Non-Believers disregard the announcement and anticipate perfectly the actual tax level, \( t^e = t \). Making perfect anticipations at any point of time, however, is costly. Thus, Non-Believers occur costs of \( \delta > 0 \) per unit of time.

The firms are profit-maximizers. As will become apparent in the following, one can assume without loss of substance that they are myopic, that is, maximize in every \( \tau \) their current profit.

**The Regulator** \( R \)

The Regulator’s goal is to maximize over an infinite horizon the cumulated discounted value of an objective function with the employment, the emissions, and the tax revenue as arguments. In order to realize this objective, it has two instruments at his disposal, the announced instantaneous tax level \( t^a \), and the actually realized level \( t \).
The objective function is given by:

\[
\Phi(t^a, t) = \int_0^\infty e^{-\rho \tau} \phi(t^a, t) d\tau \tag{3}
\]

where \(x^b, x^{nb}, v^b, v^{nb}\) denote the optimal production respectively investment chosen by the Believers \(B\) and the Non-Believers \(NB\), and where \(k\) and \(\kappa\) are strictly positive weights placed by \(R\) on the average employment respectively on the average emissions (remember that output and employment are in a one-to-one relationship in this economy). The strictly positive parameter \(\rho\) is a social discount factor.

**Belief Dynamics**

The firms’ beliefs (\(B\) or \(NB\)) change according to a imitation-type dynamics, see Dawid (1999), Hofbauer and Sigmund (1998)). The firms meet randomly two-by-two, each pairing being equiprobable. At each encounter the firm with the lower current profit adopts the belief of the other firm with a probability proportional to the current difference between the individual profits. This gives rise to the dynamics:

\[
\dot{\pi} = \beta \pi (1 - \pi) (g^b - g^{nb}), \tag{4}
\]

where \(g^b\) and \(g^{nb}\) denote the profits of a Believer and of a Non-Believer:

\[
g^b = px^b - c_x(x^b)^2 - t(x^b - v^b) - c_v(v^b)^2, \]

\[
g^{nb} = px^{nb} - c_x(x^{nb})^2 - t(x^{nb} - v^{nb}) - c_v(v^{nb})^2 - \delta.
\]

Notice that \(\pi(1 - \pi)\) reaches its maximum for \(\pi = \frac{1}{2}\) (the value of \(\pi\) for which the probability of encounter between firms with different profits is maximized), and tends towards 0 for \(\pi \to 0\) and \(\pi \to 1\) (for extreme values of \(\pi\), almost all firms have the same profits). The parameter \(\beta \geq 0\), that depends on the adoption probability of the other’s strategy may be interpreted as a measure of the willingness to change strategies, that is, of the flexibility of the firms.

Equation (4) implies that by choosing the value of \((t^a, t)\) at time \(\tau\), the Regulator not only influences its instantaneous objective but also the future
proportion of Bs in the economy. This, in turn, has an impact on the values of its objective function. Hence, although there are no explicit dynamics for the economic variables \( v \) and \( x \), the \( R \) faces a non-trivial inter-temporal optimization problem.

**Optimal Decisions of the Firms**

Since the firms are atomistic, each single producer is too small to influence the dynamics of \( \pi \). Thus, the single firm does not take into account any inter-temporal effect and, independently of its true planning horizon, *de facto* maximizes its current profit in every \( \tau \). Each firm chooses its investment \( v \) after it has learned \( t^a \) but *before* \( t \) has been made public. However, it fixes its production level \( x \) *after* \( v \) and \( t \) are known. The firms being price takers, the optimal production decision is:

\[
x = \frac{p - t}{2c_x}. \tag{5}
\]

The thus defined optimal \( x \) does not depend upon \( t^a \), neither directly nor indirectly. As a consequence, both Bs and NBs choose the same production level (5) as a function of the realized tax \( t \) alone, \( x^b = x^{nb} = x \).

The profit of a firm given that an investment \( v \) has been realized is:

\[
g(v; t) = \frac{(p - t)^2}{4c_x} + tv. \]

When the firms determine their investment \( v \), the actual tax rate is not known. Therefore, they solve:

\[
\max_v [g(v; t^e) - c_v v^2],
\]

with \( t^e = t \) if the firm is a NB and \( t^e = t^a \) if the firm is a B. The interior solution to this problem is:

\[
v^b = \frac{t^a}{2c_v}, \quad v^{nb} = \frac{t}{2c_v}. \tag{6}
\]

The net emissions \( x - v \) of any firm will remain non-negative after the investment, i.e., \( v \in [0, x] \) will hold, if:

\[
p \geq \frac{c_v + c_x}{c_v} \max[t, t^a]. \tag{7}
\]
Given above expressions (5) for \( x \) and (6) for \( v \), it is straightforward to see that the belief dynamics can be written as:

\[
\dot{\pi} = \beta \pi (1 - \pi) \left( -\frac{(t^a - t)^2}{4c_v} + \delta \right).
\]  (8)

The two effects that govern the evolution of \( \pi \) become now apparent. Large deviations of the realized tax level \( t \) from \( t^a \) induce a decrease in the stock of believers, whereas the stock of believers tends to grow if the cost \( \delta \) necessary to form rational expectations is high.

Using (5) and (6), the instantaneous objective function \( \phi \) of the Regulator becomes:

\[
\phi(t^a, t) = (k - \kappa + t) \frac{p - t}{2c_x} + \frac{\kappa - t}{2c_v} (\pi t^a + (1 - \pi) t).
\]  (9)

3 The static problem

In the model, there is only one source of dynamics, the beliefs updating (4). Before investigating the dynamic problem, it is instructive to cursorily consider the solution \( \$ \) of the static case in which \( R \) maximizes the integrand in (3) for a given value of \( \pi \).

From (9), one recognizes easily that at the optimum \( t^a \) will either take its highest possible value or be zero, depending on whether \( \kappa - t^s \) is positive or negative. The case \( \kappa - t^s < 0 \) corresponds to the uninteresting situation where the regulator values tax income more than emissions reduction and thus tries to increase the volume of emissions. We therefore restrict our analysis to the environmentally friendly case \( t^s < \kappa \). Note that (7) provides a natural upper bound \( \bar{t}^a \) for \( t \), namely:

\[
\bar{t}^a = \frac{pc_v}{c_v + c_x}.
\]  (10)

Assuming that the optimal takes the upper value \( \bar{t}^a \) just defined (the choice of another bound is inconsequential for the qualitative results), the optimal tax \( t^s \) is:

\[
t^s = \frac{1}{2} (\kappa + \bar{p}^a - \frac{c_v k}{c_v + c_x - c_x \pi}).
\]  (11)

Note that \( t^s \) is decreasing in \( \pi \). (As \( \pi \) increases, the announcement \( t^a \) becomes a more powerful instrument, making a recourse to \( t \) less necessary). The requirement \( \kappa > t^s \) is fulfilled for all \( \pi \) iff:
\[ c_v(k + \kappa - p) + c_x\kappa > 0. \]  \hspace{1cm} (12)

In the reminder of this paper, we assume that (12) holds.

Turning to the firms profits, one recognizes the difference \( g^{nb} - g^b \) between the \( NB \)'s and \( B \)'s profits is increasing in \( |t^a - t^a\| : \)

\[ g^{nb} - g^b = \frac{(t^a - t^a\|^2}{4c_v} - \delta. \]  \hspace{1cm} (13)

For \( \delta = 0 \), the profit of the \( NB \)'s is always higher that the profit of the \( B \)'s whenever \( t^a \neq t \), reflecting the fact the latter make a systematic error about the true value of \( t \). The profit of the \( B \)'s, however, can exceed the one of the \( NB \)'s if the learning cost \( \delta \) is high enough. Since \( t^a\| \) is constant and \( t^a\| \) decreasing in \( \pi \), and since \( t^a\| < t^a\| \), the difference \( t^a\| - t^a\| \) increases in \( \pi \). Therefore, the difference between the profits of the \( NB \)'s and \( B \)'s, (13), is increasing in \( \pi \).

Further analytical insights are exceedingly cumbersome to present due to the complexity of the functions involved. We therefore illustrate a remarkable, generic feature of the solution with the help of Figure 1. Not only the Regulator’s utility \( \phi \) increases with \( \pi \), so do also the profits of the \( B \)’s and \( NB \)’s. For \( \pi = 0 \), the outcome is the Nash solution of a game between the \( NB \)'s and the Regulator. This outcome is not efficient, leaving room for Pareto-improvement. As \( \pi \) increases, the \( B \)’s enjoy the benefits of a decreasing \( t \), while their investment remains fixed at \( v(t^a)\). Likewise, the \( NB \)’s benefit from the decrease in taxation. The lowering of the taxation is made rational by the existence of the Believers, who are led by the \( R \)’s announcements to invest more than they would otherwise, and to subsequently emit less. Accordingly, the marginal tax income goes down as \( \pi \) increases and therefore \( R \) is induced to reduce taxation if the proportion of believers goes up.

The only motive that could lead \( R \) to reduce the spread between \( t \) and \( t^a \), and in particular to choose \( t^a < t^a\| \), lies in the impact of the tax announcements on the beliefs dynamics. Ceteris paribus, \( R \) prefers a high proportion of \( B \)’s to a low one, since it has one more instrument (that is, \( t^a\)\) to influence the \( B \)’s than to control the \( NB \)’s. A high spread \( t^a - t \), however, implies that the profits of the \( B \)’s will be low compared to those of the \( NB \)’s. This, by (4), reduces the value of \( \dot{\pi} \) and leads over time to a lower proportion of \( B \)’s.

\[ ^1 \text{The parameter values underlying the figure are } c_v = 5, \ c_x = 3, \ \delta = 0, \ p = 6, \ k = 4, \ \kappa = 3. \]  The figure is qualitatively robust with respect to changes in these values.
diminishing the instantaneous utility of R. Therefore, in the dynamic problem, R will have to find an optimal compromise between choosing a high value of $t^a$, which allows a low value of $t$ and insures the Regulator a high instantaneous utility, and choosing a lower one, leading to a more favorable proportion of Bs in the future.

Figure 1: Profits of the believers (solid line), of the non-believers (dashed line), and Regulator’s utility (bold-line) as a function of $\pi$.

4 Dynamic Analysis

4.1 Characterization of the optimal paths

As pointed out earlier, the Regulator faces a dynamic optimization problem because of the effect of his current action on the future stock of believers. This problem is given by:

$$\max_{0 \leq \tau \leq \tau(\tau)} \Phi(t^a, t) \text{ subject to } (8).$$

The Hamiltonian of the problem is given by:

$$H(t^a, t, \pi, \lambda) = (k - \kappa + t) \frac{p - t}{2c_x} + \frac{\kappa - t}{2c_v} (\pi t^a + (1 - \pi)t)$$

$$+ \lambda \beta \pi (1 - \pi) \left( -\frac{1}{4c_v} (t^a - t)^2 + \delta \right),$$
where $\lambda$ denotes the co-state variable. The Hamiltonian is concave in $(t, t^a)$ iff:

$$2\lambda \beta (1 - \pi) (c_v + c_x) - \pi c_x > 0.$$  \hspace{1cm} (14)

The optimal controls $^*$ are then given by:

$$t^*(\pi, \lambda) = \frac{\lambda \beta (1 - \pi) (c_v (\hat{\rho} - k + \kappa) + c_x \kappa) - c_x \kappa \pi}{2\lambda \beta (1 - \pi) (c_v + c_x) - c_x \pi}$$ \hspace{1cm} (15)

$$t^{a*}(\pi, \lambda) = \frac{1}{2\lambda \beta (1 - \pi) (c_v + c_x) - c_x \pi} \left[ c_x \kappa (1 - \pi) + \lambda \beta (1 - \pi) (c_v (\hat{\rho} - k + \kappa) + c_x \kappa) - c_v (\hat{\rho} - k - \kappa) \right]$$ \hspace{1cm} (16)

Otherwise, there are no interior optimal controls. In what follows we assume that (14) is satisfied along the optimal path. It can be easily checked that this is the case at the equilibrium discussed below.

The difference between the optimal announced and realized tax levels is given by:

$$t^{a*} - t^* = \frac{\kappa - t^*}{\lambda \beta (1 - \pi)}.$$ \hspace{1cm} (17)

Hence the optimal announced tax exceeds the realized one if and only if $t^* < \kappa$. As in the static case, we restrict the analysis to the environmentally friendly case $t^* < \kappa$ and assume that (12) holds.

According to Pontriagins’ Maximum Principle, an optimal solution $(\pi(\tau), \lambda(\tau))$ has to satisfy the state dynamics (8) plus:

$$\dot{\lambda} = \rho \lambda - \frac{\partial H(t^{a*}(\pi, \lambda), t^*(\pi, \lambda), \pi, \lambda)}{\partial \pi},$$ \hspace{1cm} (18)

$$\lim_{\tau \to \infty} e^{-\rho \tau} \lambda(\tau) = 0.$$ \hspace{1cm} (19)

In our case the co-state dynamics are given by:

$$\dot{\lambda} = \rho \lambda - \frac{\kappa - t}{2c_v} (t^a - t) - \lambda \beta (1 - 2\pi) \left( -\frac{1}{4c_v} (t^a - t)^2 + \delta \right).$$ \hspace{1cm} (20)

In order to analyze the long run behavior of the system we now provide a characterization of the steady states for different values of the public flexibility parameter $\beta$. Due to the structure of the state dynamics there are always trivial steady states for $\pi = 0$ and $\pi = 1$. For $\pi = 0$ the announcement is irrelevant. Its optimal value is therefore indeterminate. The optimal tax level is $t = \kappa$. For $\pi = 1$, the concavity condition (14) is violated.
and the optimal controls are like in the static case. In the following, we restrict our attention to $\pi < 1$. In Proposition 1, we first show under which conditions there exists an interior steady state where Believers coexist with Non-Believers. Furthermore, we discuss the stability of the steady states.

**Proposition 1 Steady states and their stability:**

(i) For $0 < \beta \leq \frac{\rho}{2\delta}$ there exists no interior steady state. The steady state at $\pi = 0$ is stable.

(ii) For $\beta > \frac{\rho}{2\delta}$ there exists a unique stable interior steady state $\pi^+$ with:

$$\pi^+ = 1 - \frac{\rho}{2\beta\delta}. \quad (21)$$

The steady state at $\pi = 0$ is unstable.

**Proof:** We prove the existence and the stability of the interior steady state. The claims about the boundary steady state at $\pi = 0$ follow directly.

Equation (8) implies that, in order for $\dot{\pi} = 0$, to hold one must have:

$$(t^a - t^*)^2 = 4c_v\delta. \quad (22)$$

That is, taking into account (17):

$$t^* = \kappa - 2\lambda^+\beta(1 - \pi^+)\sqrt{c_v\delta}. \quad (23)$$

Equation (22) implies that $\dot{\lambda} = 0$ is satisfied iff:

$$\rho\lambda - \frac{\kappa - t^*}{2c_v}(t^a - t^*) = 0. \quad (24)$$

Using (17) for $t^a - t^*$ in (24) we obtain the condition:

$$t^* = \kappa - \sqrt{2\rho\beta(1 - \pi^+)c_v}. \quad (25)$$

Combining (23) and (25) shows that

$$2\lambda^+\beta(1 - \pi^+)\sqrt{c_v\delta} = \sqrt{2\rho\beta(1 - \pi^+)c_v}$$

must hold at an interior steady state. This condition is equivalent to (21). For $\beta \leq \frac{\rho}{2\delta}$, (21) becomes smaller or equal zero. Therefore, an interior steady state is only possible for $\beta > \frac{\rho}{2\delta}$. 

13
Using (21, 15, 23), one obtains for the value of the co-state at the steady state:

\[
\lambda^+ = \frac{\delta \beta (c_x (2\sqrt{c_v \delta} + \kappa) + c_v (k + \kappa - p)) - \rho c_x \sqrt{c_v \delta}}{2 \rho \beta \sqrt{c_v \delta} (c_v + c_x)}.
\]  

(26)

To determine the stability of the interior steady state we investigate the Jacobian matrix \(J\) of the canonical system (8, 20) at the steady state. The eigenvalues of \(J\) are given by:

\[
e_{1,2} = \frac{tr(J) \pm \sqrt{tr(J)^2 - 4 \text{det}(J)}}{2}.
\]

Therefore, the steady state is saddle point stable if and only if the determinant of \(J\) is negative. Inserting (15, 16) into the canonical system (8, 20), taking the derivatives with respect to \((\pi, \lambda)\) and then inserting (21, 26) gives the matrix \(J\). Tedious calculations show that its determinant is given by:

\[
\text{det}(J) = C \left( -\sqrt{\delta \beta} (c_v (k + \kappa - p) + c_x \kappa) - c_x \sqrt{c_v \delta} (2 \beta \delta - \rho) \right),
\]

where \(C\) is a positive constant. The first of the two terms in the bracket is negative due to the assumption (12), the second is negative whenever \(\beta > \frac{\rho}{23}\). Hence, \(\text{det}(J) < 0\) whenever an interior steady state exists, implying that the interior steady state is always stable. For \(\beta = \frac{\rho}{23}\) this stable steady state collides with the unstable one at \(\pi = 0\). The steady state at \(\pi = 0\) therefore becomes stable for \(\beta \leq \frac{\rho}{23}\). \(\square\)

Since there is always only one stable steady state and since cycles are impossible in a control problem with a one-dimensional state, we can conclude from Proposition 1 that the stable steady state is always a global attractor. Convergence to the unique steady state is always monotone. The long run fraction of believers in the population is independent from the original level of trust. From (21) one recognizes that it decreases with \(\rho\). An impatient Regulator will not attempt to build up a large proportion of \(Bs\) since the time and efforts needed now for an additional increase of \(\pi\) weighs heavily compared to the future benefits. By contrast, \(\pi^+\) is increasing in \(\beta\) and \(\delta\). A high flexibility \(\beta\) of the firms means that the cumulated loss of potential utility occurred by the Regulator \(en\ route\) to \(\pi^+\) will be small and easily compensated by the gains in the vicinity of and at \(\pi^+\). Reinforcing this, the Regulator does not have to make \(Bs\) much better off than \(NBs\) in order to insure a fast reaction. As a result, for \(\beta\) large, the equilibrium \(\pi^+\) is characterized by a large proportion of \(Bs\) and provide high profits respectively.
utility to all players. A high learning cost \( \delta \) means that the Regulator can make the Bs better off than the NBs at low or no cost, implying again a high value of \( \pi \) at the steady state.

Note that it is never optimal for the Regulator to follow a policy that would ultimately insure that all firms are Believers, \( \pi^+ = 1 \). There are two concurrent reasons for that. On the one hand, as \( \pi \) increases, the Regulator has to deviate more and more from the statically optimal solution \( q_s(\pi) \), \( t_s(\pi) \) to make believing more profitable than non-believing. On the other hand, the beliefs dynamics slow down. Thus, the discounted benefits from increasing \( \pi \) decrease.

For \( \rho = 0.8 \), \( c_v = 5 \), \( c_x = 3 \), \( \delta = 0.15 \), \( p = 6 \), \( k = 4 \), \( \kappa = 3 \) e.g., the profits and utility at the steady state \( \pi^+ = 0.733333 \) are \( g^b = g^{nb} = 1.43785 \), \( \phi = 2.33043 \). This steady state Pareto-dominates the fully rational equilibrium with \( \pi = 0 \), where \( g^{nb} = 1.32708 \), \( \phi = 2.30844 \). It also dominates the equilibrium attained when the belief dynamics (8) holds but the Regulator maximizes in each period his instantaneous utility \( \phi \) instead of \( \Phi \). At this last equilibrium, \( \pi = 0.21036 \), \( g^b = g^{nb} = 1.375 \), \( \phi = 2.23689 \). Note that the last two equilibria cannot be compared, since the latter provides a higher profit to the firms but a lower utility to the Regulator.

This ranking of equilibria is robust with respect to parameter variations. A clear message emerges. As we contended at the beginning of this paper the suggested solution Pareto-improves on the static Nash equilibrium. This solution implies both a beliefs dynamics among the firms and a farsighted Regulator. A farsighted Regulator without beliefs dynamics is pointless. Beliefs dynamics with a myopic Regulator lead to a more modest Pareto-improvement. But it is the combination of beliefs dynamics and farsightedness that Pareto-dominates all other solutions.

### 4.2 The Influence of Public Flexibility

An interesting question is whether the Regulator would prefer a population that reacts quickly to profit differences, shifting from Believing to Non-Believing or vice versa in a short time, or if it would prefer a less reactive population. In other words, would the Regulator prefer a high or a low value of \( \beta \)?

From Proposition 1 we know that the long run fraction of Believers is given by:

\[
\pi^+ = \max \left[ 0, 1 - \frac{\rho}{\rho + \beta} \right].
\]

A minimum level \( \beta > \frac{\rho}{2\delta} \) of flexibility is necessary for the system to converge
towards an interior steady state with a positive fraction of $B$s. For $\beta$ greater than $\frac{\rho}{2\delta}$, the fraction of $B$s at the steady state increases with $\beta$, converging towards $\pi = 1$ as $\beta$ goes to infinity. One might think that, since the Regulator always prefers a high proportion of $B$s at equilibrium, he would also prefer a high value of $\beta$. Stated in a more formal manner, one might expect that the value function of the Regulator, $V^R(\pi_0)$, increases with $\beta$ regardless of $\pi_0$. This, however, is not the case. The dependence of $V^R(\pi_0)$ on $\beta$ is non-monotone and depends crucially on $\pi_0$. An analytical characterization of $V^R(\pi_0)$ being impossible, we use a numerical example to illustrate that point. The results are very robust with respect to parameter variations.

Figure 2 shows the steady state value $\pi^+ = \pi^+(\beta)$ of $\pi$ for $\beta \in [1, 30]$. Figure 3 compares $V^R(0.2)$ and $V^R(0.8)$ for the same values of $\beta$. The other parameter values are as before $\rho = 0.8$, $c_v = 5$, $c_x = 3$, $\delta = 0.15$, $p = 6$, $k = 4$, $\kappa = 3$ in both cases.

Figure 2: The proportion believers at the steady state for $\beta \in [1, 30]$.

Figure 3 reveals that one always has $V^R(0.8) > V^R(0.2)$, reflecting the

---

2The numerical calculations underlying this figure were carried out using a powerful proprietary computer program for the treatment of optimal control problems graciously provided by Lars Grüne, whose support is most gratefully acknowledged. See Grüne and Semmler (2002)).
Figure 3: The value function of the Regulator for $\pi = 0.2$ (dotted line) and $\pi = 0.8$ (solid line) for $\beta \in [1,30]$.

A general result is that $V^R(\pi_0)$ is increasing in $\pi_0$ for any $\beta$. Both value functions are not monotone in $\beta$ but U-shaped. Combining Figure 2 and Figure 3 shows that the minimum of $V^R(\pi_0)$ is always attained for the value of $\beta$ at which the steady state value $\pi^+(\beta)$ coincides with the initial fraction of Believers $\pi_0$. This result is quite intuitive. If $\pi^+(\beta) < \pi_0$, it is optimal for the Regulator to reduce $\pi$ over time. The Regulator does it by announcing a tax $t^a$ much greater than the tax $t$ he will implement, making the Bs worse off than the NBs, but also increasing his own instantaneous benefits $\phi$. Thus, $R$ prefers that the convergence towards the steady state be as slow as possible. That is, $V^R$ is decreasing in $\beta$. On the other hand, if $\pi^+ > \pi_0$, it is optimal for $R$ to increase $\pi$ over time. To do so, he must follow a policy that makes the Bs better off than the NBs, but this is costly in terms of his instantaneous objective function $\phi$. It is therefore better for $R$ if the firms react fast to the profit difference. The value function $V^R$ increases with $\beta$. Summarizing, the Regulator prefers (depending on $\pi_0$) to be confronted with either very flexible or very inflexible firms. In-between values of $\beta$ provide him smaller discounted benefit streams.

Whether a low or a high flexibility is preferable for $R$ depends on the
initial fraction $\pi_0$ of Believers. Our numerical analysis suggests that a Regulator facing a small $\pi_0$ prefer large values of $\beta$, whereas he prefers a low value of $\beta$ when $\pi_0$ is large. This result may follow from the specific functional form used in the model rather than reflect any fundamental property of the solution.

If $\beta = 0$, the proportion of $B$s remains fixed over time at $\pi_0$ – any initial value of $\pi_0 \in (0, 1)$ corresponds to a stable equilibrium. The Pareto-improving character of the inner equilibrium then disappears. Given $\beta = 0$, condition (14) is violated. The Regulator can announce any tax level without having to fear negative long term consequences. Thus, it is in his interest to exploit the gullibility of the $B$s to the maximum. To obtain a meaningful, Pareto-improving solution, some flexibility is necessary that assures that the firms are not kept captive of beliefs that penalize them. Only then will the Regulator be led to take into account the $B$s interest.

5 Conclusions

The starting point of this paper is a situation frequently encountered in environmental economics (and similarly in other economic contexts as well): If all firms are perfectly rational Non-Believers who make perfect predictions of the Regulator’s actions and discard the Regulators announcements as cheap talk, standard optimizing behavior leads to a Pareto-inferior outcome, although there are no conflicts of interest between the different firms and although the objectives of the firms and of the Regulator largely concur. We show that, in a static world, the existence of a positive fraction of Believers who take the Regulator’s announcement at face value Pareto-improves the economic outcome. This property crucially hinges on the fact that the firms are atomistic and thus do not anticipate the collective impact of their individual decisions.

The static model is extended by assuming that the proportion of Believers and Non-Believers changes over time depending on the difference in the profits made by the two types of firms. The Regulator is assumed to recognize his ability to influence the evolution of the proportion of Believers by his choice of announced and realized taxes, and to be interested not only in his instantaneous but also in his future utility. It is shown that a rational Regulator will never steer the economy towards a Pareto-optimal equilibrium. However, his optimal policy may lead to a stable steady state with a strictly positive proportion of Believers that is Pareto-superior to the equilibrium where all agents perfectly anticipate his actions. Prereq-
uisites therefore are a sufficiently patient Regulator and firms that occur sufficiently high costs for building perfect anticipations of the government actions and/or are suitably flexible, i.e., switch adequately fast between Believing and Non-Believing. The conjunction of beliefs dynamics for the firms and of a farsighted Regulator allows for a larger Pareto-improvement than either only beliefs dynamics or only farsightedness. Depending upon the initial proportion of Believers, the Regulator is better off if the firms are very flexible or very inflexible. Intermediate values of the flexibility parameter are never optimal for the Regulator.

References


Dijkstra, B. Time Consistency and Investment Incentives in Environmental Policy. Discussion paper 02/12, School of Economics, University of Nottingham, U.K., 2002.


NOTE DI LAVORO PUBLISHED IN 2003

PRIV 2.2003 Ibolya SCHINDELE: Theory of Privatization in Eastern Europe: Literature Review
PRIV 3.2003 Wietze LISE, Claudia KEMFERT and Richard J. TOL: Strategic Action in the Liberalised German Electricity Market
KNOW 5.2003 Reyer GERLAGH: Induced Technological Change under Technological Competition
ETA 6.2003 Efram CASTELNUOVO: Squeezing the Interest Rate Smoothing Weight with a Hybrid Expectations Model
SIEV 7.2003 Anna ALBERINI, Alberto LONGO, Stefania TONIN, Francesco TROMBETTA and Margherita TURVANI: The Role of Liability, Regulation and Economic Incentives in Brownfield Remediation and Redevelopment: Evidence from Surveys of Developers
PRIV 8.2003 Elissaios PAPYRAKIS and Reyer GERLAGH: Natural Resources: A Blessing or a Curse?
CLIM 9.2003 A. CAPARRÓS, J.-C. PEREAU and T. TAZDAÏT: North-South Climate Change Negotiations: a Sequential Game with Asymmetric Information
KNOW 10.2003 Giorgio BRUNELLO and Daniele CHECCHI: School Quality and Family Background in Italy
CLIM 11.2003 Efrem CASTELNUOVO and Marzio GALEOTTI: Learning By Doing vs Learning By Researching in a Model of Climate Change Policy Analysis
KNOW 12.2003 Carole MAIGNAN, Gianmarco OTTAVIANO and Dino PINELLI (eds.): Economic Growth, Innovation, Cultural Diversity: What are we all talking about? A critical survey of the state-of-the-art
KNOW 15.2003 Tuzin BAYCAN LEVENT, Enso MASUREL and Peter NIJKAMP (lx): Diversity in Entrepreneurship: Ethnic and Female Roles in Urban Economic Life
KNOW 16.2003 Alexandra BITUSIKOVA (lx): Post-Communist City on its Way from Grey to Colourful: The Case Study from Slovakia
KNOW 17.2003 Billy E. VAUGHN and Katarina MLEKOV (lx): A Stage Model of Developing an Inclusive Community
KNOW 18.2003 Selma van LONDEN and Arie de RUIJTER (lx): Managing Diversity in a Glocalizing World
PRIV 20.2003 Giacomo CALZOLARI and Alessandro PAVAN (lx): Monopoly with Resale
PRIV 22.2003 Marco LiCalzi and Alessandro PAVAN (lx): Tilting the Supply Schedule to Enhance Competition in Uniform-Price Auctions
PRIV 23.2003 David ETTINGER (lx): Bidding among Friends and Enemies
PRIV 24.2003 Hannu VARTIAINEN (lx): Auction Design without Commitment
PRIV 26.2003 Christine A. PARLOUR and Uday RAJAN (lx): Rationing in IPOs
PRIV 27.2003 Kjell G. NYBORG and Ilja A. STREBULAEV (lx): Multiple Unit Auctions and Short Squeezes
PRIV 28.2003 Anders LUNANDER and Jan-Eric NILSSON (lx): Taking the Lab to the Field: Experimental Tests of Alternative Mechanisms to Procure Multiple Contracts
PRIV 30.2003 Etnel MAASLAND and Sander ONDERSTAL (lx): Auctions with Financial Externatilities
ETA 31.2003 Michael FINUS and Bianca RUNDHAGEN: A Non-cooperative Foundation of Core-Stability in Positive Externality NTU-Coalition Games
KNOW 32.2003 Michele MORETTO: Competition and Irreversible Investments under Uncertainty
PRIV 33.2003 Philippe QUIRION: Relative Quotas: Correct Answer to Uncertainty or Case of Regulatory Capture?
KNOW 34.2003 Giuseppe MEDA, Claudio PIGA and Donald SIEGEL: On the Relationship between R&D and Productivity: A Treatment Effect Analysis
ETA 35.2003 Alessandra DEL BOCA, Marzio GALEOTTI and Paola ROTA: Non-convexities in the Adjustment of Different Capital Inputs: A Firm-level Investigation
GG  36.2003  Matthieu GLACHANT: Voluntary Agreements under Endogenous Legislative Threats
PRIV  37.2003  Narjess BOUBAKRI, Jean-Claude COSSET and Omran GUEDHAMI: Postprivatization Corporate Governance: the Role of Ownership Structure and Investor Protection
CLIM  38.2003  Rolf GOLOMBEK and Michael HOEL: Climate Policy under Technology Spillovers
KNOW  39.2003  Slim BEN YOUSSEF: Transboundary Pollution, R&D Spillovers and International Trade
CTN  40.2003  Carlo CARRARO and Carmen MARCHORI: Endogenous Strategic Issue Linkage in International Negotiations
KNOW  42.2003  Tino GOESCHL and Timothy SWANSON: On Biology and Technology: The Economics of Managing Biotechnologies
CLIM  44.2003  Katrin MILLOCK and Céline NAUGES: The French Tax on Air Pollution: Some Preliminary Results on its Effectiveness
PRIV  45.2003  Bernardo BORTOLOTTI and Paolo PINOTTI: The Political Economy of Privatization
ETA  47.2003  Jens HORBACH: Employment and Innovations in the Environmental Sector: Determinants and Econometrical Results for Germany
CLIM  48.2003  Lori SNYDER, Nolan MILLER and Robert STAVINS: The Effects of Environmental Regulation on Technology Diffusion: The Case of Chlorine Manufacturing
CTN  50.2003  László A. KÓCZY and Luc LAUWERS: The Minimal Dominant Set is a Non-Empty Core-Extension
CTN  51.2003  Matthew O. JACKSON (lx): Allocation Rules for Network Games
CTN  52.2003  Ana MAULEON and Vincent VANNETELBOSCH (lx): Farsightedness and Cautiousness in Coalition Formation
CTN  54.2003  Matthew HAAG and Roger LAGUNOFF (lx): On the Size and Structure of Group Cooperation
CTN  55.2003  Taiji FURUSAWA and Hideo KONISHI (lx): Free Trade Networks
CTN  56.2003  Halis Murat YILDIZ (lx): National Versus International Mergers and Trade Liberalization
CTN  57.2003  Santiago RUBIO and Alistair ULPH (lx): An Infinite-Horizon Model of Dynamic Membership of International Environmental Agreements
KNOW  58.2003  Carole MAIGNAN, Dino PINELLI and Gianmarco I.P. OTTAVIANO: ICT, Clusters and Regional Cohesion: A Summary of Theoretical and Empirical Research
KNOW  59.2003  Giorgio BELLETTINI and Gianmarco I.P. OTTAVIANO: Special Interests and Technological Change
ETA  60.2003  Ronnie SCHOB: The Double Dividend Hypothesis of Environmental Taxes: A Survey
SIEV  63.2003  Alberto PETRUCCELLI: Taxing Land Rent in an Open Economy
CLIM  64.2003  Joseph E. ALDY, Scott BARRETT and Robert N. STAVINS: Thirteen Plus One: A Comparison of Global Climate Policy Architectures
SIEV  65.2003  Edi DEFRANCESCO: The Beginning of Organic Fish Farming in Italy
SIEV  66.2003  Klaus CONRAD: Price Competition and Product Differentiation when Consumers Care for the Environment
CLIM  68.2003  ZhongXiang ZHANG: Open Trade with the U.S. Without Compromising Canada’s Ability to Comply with its Kyoto Target
KNOW  69.2003  David FRANTZ (lxi): Lorenzo Market between Diversity and Mutation
KNOW  70.2003  Ercole SORI (lxi): Mapping Diversity in Social History
KNOW  71.2003  Lilijana DERU SIMIC (lxi): What is Specific about Art/Cultural Projects?
KNOW  72.2003  Natalya V. TARANOVA (lxi): The Role of the City in Fostering Intergroup Communication in a Multicultural Environment: Saint-Petersburg’s Case
KNOW  73.2003  Kristine CRANE (lxi): The City as a Arena for the Expression of Multiple Identities in the Age of Globalisation and Migration
KNOW  74.2003  Kazuma MATOBA (lxi): Glocal Dialogue- Transformation through Transcultural Communication
KNOW  75.2003  Catarina REIS OLIVEIRA (lxi): Immigrants’ Entrepreneurial Opportunities: The Case of the Chinese in Portugal
KNOW  76.2003  Sandra WALLMAN (lxi): The Diversity of Diversity - towards a typology of urban systems
KNOW  77.2003  Richard PEARCE (lxi): A Biologist’s View of Individual Cultural Identity for the Study of Cities
KNOW  78.2003  Vincent MERK (lxi): Communication Across Cultures: from Cultural Awareness to Reconciliation of the Dilemmas
KNOW  79.2003  Giorgio BELLETTINI, Carlotta BERTI CERONI and Gianmarco I.P. OTTAVIANO: Child Labor and Resistance to Change
ETA  80.2003  Michele MORETTO, Paolo M. PANTEGHINI and Carlo SCARPA: Investment Size and Firm’s Value under Profit Sharing Regulation
NOTE DI LAVORO PUBLISHED IN 2004

IEM 1.2004 Anil MARKANDYA, Suzette PEDROSO and Alexander GOLUB: Empirical Analysis of National Income and So2 Emissions in Selected European Countries

ETA 2.2004 Masahisa FUTITA and Shlomo WEBER: Strategic Immigration Policies and Welfare in Heterogeneous Countries

PRA 3.2004 Adolfo DI CARLUCCHIO, Giovanni FERRI, Cecilia FRALE and Ottavio RICCHI: Do Privatizations Boost Household Shareholding? Evidence from Italy

ETA 4.2004 Victor GINSBURGH and Shlomo WEBER: Languages Disenfranchisement in the European Union


PRA 7.2004 Sandro BRUSCO, Giuseppe LOPOMO and S. VISWANATHAN (Ixv): Merger Mechanisms

PRA 8.2004 Wolfgang AUSSENEG, Pegaret PICHLER and Alex STOMPER (Ixv): IPO Pricing with Bookbuilding, and a When-Issued Market

PRA 9.2004 Pegaret PICHLER and Alex STOMPER (Ixv): Primary Market Design: Direct Mechanisms and Markets


PRA 11.2004 Bjarni BRENDSTRUP and Harry J. PAARSCH (Ixv): Nonparametric Identification and Estimation of Multi-Unit, Sequential, Oral, Ascending-Price Auctions With Asymmetric Bidders

PRA 12.2004 Ohad KADAN (Ixv): Equilibrium in the Two Player, k-Double Auction with Affiliated Private Values

PRA 13.2004 Maarten C.W. JANSEN (Ixv): Auctions as Coordination Devices

PRA 14.2004 Gadi FIBICH, Arieh GAVIOUS and Aner SELA (Ixv): All-Pay Auctions with Weakly Risk-Averse Buyers

PRA 15.2004 Orly SADE, Charles SCHNITZLEIN and Jaime F. ZENDER (Ixv): Competition and Cooperation in Divisible Good Auctions: An Experimental Examination

PRA 16.2004 Marta STRYSZOWSKA (Ixv): Late and Multiple Bidding in Competing Second Price Internet Auctions

CCMP 17.2004 Slim Ben YOUSSEF: R&D in Cleaner Technology and International Trade

NRM 18.2004 Angelo ANTOCI, Simone BORGHESI and Paolo RUSSU (Ixvi): Biodiversity and Economic Growth: Stabilization Versus Preservation of the Ecological Dynamics

SIEV 19.2004 Anna ALBERINI, Paolo ROSATO, Alberto LONGO and Valentina ZANATTA: Information and Willingness to Pay in a Contingent Valuation Study: The Value of S. Erasmo in the Lagoon of Venice


NRM 21.2004 Jacqueline M. HAMILTON (Ixv): Climate and the Destination Choice of German Tourists


NRM 23.2004 Pius ODUNGA and Henk FOLMER (Ixviii): Profiling Tourists for Balanced Utilization of Tourism-Based Resources in Kenya


NRM 26.2004 Juan Luis EUGENIO-MARTÍN, Noelia MARTÍN MORALES and Riccardo SCARPA (Ixvii): Tourism and Economic Growth in Latin American Countries: A Panel Data Approach

NRM 27.2004 Raúl Hernández MARTÍN (Ixvii): Impact of Tourism Consumption on GDP. The Role of Imports


NRM 29.2004 Marian WEBER (Ixvii): Assessing the Effectiveness of Tradable Landuse Rights for Biodiversity Conservation: an Application to Canada's Boreal Mixedwood Forest

NRM 30.2004 Trond BJØRNDAL, Phoebe KOUNDOURI and Sean PASCOE (Ixvii): Output Substitution in Multi-Species Trawl Fisheries: Implications for Quota Setting


ETA 39.2004 Alberto CAVALIERE: Price Competition with Information Disparities in a Vertically Differentiated Duopoly

PRA 40.2004 Andrea BIGANO and Stef PROOST: The Opening of the European Electricity Market and Environmental Policy: Does the Degree of Competition Matter?

CCMP 41.2004 Micheal FINUS (Ixv): International Cooperation to Resolve International Pollution Problems

KTHC 42.2004 Francesco CRESPI: Notes on the Determinants of Innovation: A Multi-Perspective Analysis
on the Islands of the Venice Lagoon: A Spatially-Distributed Hedonic-Hierarchical Approach

Resources Management: A DSS Tool and a Pilot Study Application

for Security of Energy Supply

and Public Policy Implications

Evidence from a Three-Country Contingent Valuation Study

Using Ecosystem Indicators: An Ecological Economics Perspective

the Implications of Climate Change: Sea Level Rise

on the Security of Supply?

Natural Resources Dynamics: Another Look

The Cooperative Theory of Two Sided Matching Problems: A Re-examination of Some

The Political Economy of Privatization: Why Do Governments Want Reforms?

The Question of Generation Adequacy in Liberalised Electricity Markets

Pay for Reductions in Pesticide Risk Exposure

from a Survey of Milan, Italy, Residents

Proportional Representation

the Canonical Form

the Implications of Climate Change: Sea Level Rise

Defining Rules in Cost Spanning Tree Problems Through theCanonical Form

from a Survey of Milan, Italy, Residents

A Meta-Analysis of the Willingness to

Willingness to Pay for Agricultural Environmental Safety: Evidence

in Transition Economies

Privatisation Methods and Economic Growth in Transition Economies

Why Do Governments Want Reforms?

Privatization and Restructuring in Concentrated Markets

Evidence from a Three-Country Contingent Valuation Study

Scientific Advice to Public Policy-Making

The Economics of Warm Glow: A Note on Consumer’s Behavior

Economy-Wide Estimates of

Economy-Wide Estimates of

Economy-Wide Estimates of

Economy-Wide Estimates of

Market-Based Options

shortcomings of traditional Meteorological Climate Agreements and Technology Policy

Natural Resources, Investment and Long-Term Income

Climate Agreements and Technology Policy

Interactions between Climate and Trade Policies: A Survey

Agricultural Land and Natural Resources, Privatisation and

Privatisation through Sale Method

Asset Accumulation, Fertility Choice and Nondegenerate Dynamics in a Small Open

Potential Maximization

Potential Maximization

Potential Maximization

Potential Maximization

Potential Maximization

Potential Maximization

Potential Maximization

Potential Maximization

Potential Maximization

Privatisation

Privatisation

Privatisation

Privatisation

Privatisation

Privatisation

Privatisation

Privatisation
Paul MENSINK: Instant Efficient Pollution Abatement Under Non-Linear Taxation and Asymmetric Information: The Differential Tax Revisited

Mauro FABIANO, Gabriella CAMARSA, Rosanna DURSI, Roberta IVALDI, Valentina MARIN and Francesca PALMISANI: Integrated Environmental Study for Beach Management: A Methodological Approach

Irena GROSFELD and Iraj HASHI: The Emergence of Large Shareholders in Mass Privatized Firms: Evidence from Poland and the Czech Republic

Mauro BERRITTELLA, Andrea BIGANO, Roberto ROSON and Richard S.J. TOL: A General Equilibrium Analysis of Climate Change Impacts on Tourism

Reyer GERLAGH: A Climate-Change Policy Induced Shift from Innovations in Energy Production to Energy Savings

Elissaios PAPYRAKIS and Reyer GERLAGH: Natural Resources, Innovation, and Growth

Bernardo BORTOLOTTI and Mara FACCI: Reluctant Privatization

Riccardo SCARPA and Mara THIENE: Destination Choice Models for Rock Climbing in the Northeast Alps: A Latent-Class Approach Based on Intensity of Participation


Santiago J. RUBIO: On Capturing Oil Rents with a National Excise Tax Revisited

Ascensión ANDINA DÍAZ: Political Competition when Media Create Candidates’ Charisma

Anna ALBERINI: Robustness of VSL Values from Contingent Valuation Surveys

Gernot KLEPPER and Sonja PETERSON: Marginal Abatement Cost Curves in General Equilibrium: The Influence of World Energy Prices

Herbert DAWID, Christophe DEISSENBERG and Pavel ŠEVČÍK: Cheap Talk, Gullibility, and Welfare in an Environmental Taxation Game
(lix) This paper was presented at the ENGIME Workshop on “Mapping Diversity”, Leuven, May 16-17, 2002
(lx) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications”, organised by the Fondazione Eni Enrico Mattei, Milan, September 26-28, 2002
(lxi) This paper was presented at the Eighth Meeting of the Coalition Theory Network organised by the GREQAM, Aix-en-Provence, France, January 24-25, 2003
(lxii) This paper was presented at the ENGIME Workshop on “Communication across Cultures in Multicultural Cities”, The Hague, November 7-8, 2002
(lxiii) This paper was presented at the ENGIME Workshop on “Social dynamics and conflicts in multicultural cities”, Milan, March 20-21, 2003
(lxiv) This paper was presented at the International Conference on “Theoretical Topics in Ecological Economics”, organised by the Abdus Salam International Centre for Theoretical Physics - ICTP, the Beijer International Institute of Ecological Economics, and Fondazione Eni Enrico Mattei – FEEM Trieste, February 10-21, 2003
(lxv) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications” organised by Fondazione Eni Enrico Mattei and sponsored by the EU, Milan, September 25-27, 2003
(lxvi) This paper has been presented at the 4th BioEcon Workshop on “Economic Analysis of Policies for Biodiversity Conservation” organised on behalf of the BIOECON Network by Fondazione Eni Enrico Mattei, Venice International University (VIU) and University College London (UCL), Venice, August 28-29, 2003
(lxvii) This paper has been presented at the international conference on “Tourism and Sustainable Economic Development – Macro and Micro Economic Issues” jointly organised by CRENoS (Università di Cagliari e Sassari, Italy) and Fondazione Eni Enrico Mattei, and supported by the World Bank, Sardinia, September 19-20, 2003
(lxviii) This paper was presented at the ENGIME Workshop on “Governance and Policies in Multicultural Cities”, Rome, June 5-6, 2003
(lxix) This paper was presented at the Fourth EEP Plenary Workshop and EEP Conference “The Future of Climate Policy”, Cagliari, Italy, 27-28 March 2003
(lxx) This paper was presented at the 9th Coalition Theory Workshop on “Collective Decisions and Institutional Design” organised by the Universitat Autònoma de Barcelona and held in Barcelona, Spain, January 30-31, 2004
### 2003 SERIES

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Editor</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLIM</td>
<td>Climate Change Modelling and Policy</td>
<td>Marzio Galeotti</td>
</tr>
<tr>
<td>GG</td>
<td>Global Governance</td>
<td>Carlo Carraro</td>
</tr>
<tr>
<td>SIEV</td>
<td>Sustainability Indicators and Environmental Valuation</td>
<td>Anna Alberini</td>
</tr>
<tr>
<td>NRM</td>
<td>Natural Resources Management</td>
<td>Carlo Giupponi</td>
</tr>
<tr>
<td>KNOW</td>
<td>Knowledge, Technology, Human Capital</td>
<td>Gianmarco Ottaviano</td>
</tr>
<tr>
<td>IEM</td>
<td>International Energy Markets</td>
<td>Anil Markandya</td>
</tr>
<tr>
<td>CSRM</td>
<td>Corporate Social Responsibility and Management</td>
<td>Sabina Ratti</td>
</tr>
<tr>
<td>PRIV</td>
<td>Privatisation, Regulation, Antitrust</td>
<td>Bernardo Bortolotti</td>
</tr>
<tr>
<td>ETA</td>
<td>Economic Theory and Applications</td>
<td>Carlo Carraro</td>
</tr>
<tr>
<td>CTN</td>
<td>Coalition Theory Network</td>
<td>Carlo Carraro</td>
</tr>
</tbody>
</table>

### 2004 SERIES

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Editor</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCMP</td>
<td>Climate Change Modelling and Policy</td>
<td>Marzio Galeotti</td>
</tr>
<tr>
<td>GG</td>
<td>Global Governance</td>
<td>Carlo Carraro</td>
</tr>
<tr>
<td>SIEV</td>
<td>Sustainability Indicators and Environmental Valuation</td>
<td>Anna Alberini</td>
</tr>
<tr>
<td>NRM</td>
<td>Natural Resources Management</td>
<td>Carlo Giupponi</td>
</tr>
<tr>
<td>KTHC</td>
<td>Knowledge, Technology, Human Capital</td>
<td>Gianmarco Ottaviano</td>
</tr>
<tr>
<td>IEM</td>
<td>International Energy Markets</td>
<td>Anil Markandya</td>
</tr>
<tr>
<td>CSRM</td>
<td>Corporate Social Responsibility and Management</td>
<td>Sabina Ratti</td>
</tr>
<tr>
<td>PRIV</td>
<td>Privatisation, Regulation, Antitrust</td>
<td>Bernardo Bortolotti</td>
</tr>
<tr>
<td>ETA</td>
<td>Economic Theory and Applications</td>
<td>Carlo Carraro</td>
</tr>
<tr>
<td>CTN</td>
<td>Coalition Theory Network</td>
<td>Carlo Carraro</td>
</tr>
</tbody>
</table>