

A NOTE ON SPECULATION, EMISSIONS TRADING AND  
ENVIRONMENTAL PROTECTION

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# A Note on Speculation, Emissions Trading and Environmental Protection.

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## Abstract

The exchange of emission permits involves remarkably low transaction costs. Speculation is, therefore, very likely to take place. This paper represents a first step towards filling a gap in the received literature, by analyzing the consequences of speculation on environmental quality under emissions trading. We build a two period model with  $n$  firms and a representative speculator, and compare a benchmark case with no speculation with one where speculation takes place under environmental policy uncertainty among the two periods. We find that, when a stricter environmental policy is expected in the second period, the first period permits price is higher under speculation, and environmental quality better. Speculation might therefore be helpful when an emissions trading scheme is characterized by a "soft" start. Further, and surprisingly, a decrease in future expected policy strictness might lead to an increase in first period environmental quality.

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This is the case when uncertainty concerning policy or speculators' risk aversion are sufficiently high.

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**JEL classification:** D62, D84, Q58.

## 1 Introduction

The use of emissions trading as an environmental policy tool is increasing worldwide. The growing relevance of market based intervention has been accompanied by clear signs of a changing attitude towards the environment; businesses start to go voluntarily "green" to please more environmentally concerned consumers; a "Green Dow Jones" index (the so-called Dow Jones Sustainability Index) is available since 2001<sup>1</sup>; an increasing amount of empirical evidence shows that the stock market value of corporations increases when environmental friendly investments are made<sup>2</sup>. All the mentioned facts seem to suggest that "pure market profits" decisions may contribute to obtaining sooner and/or better results than those government had in mind or could implement in practice.

This is particularly relevant when dealing with emissions trading. Other agents than regulated firms, such as speculators, could in fact take part to the market and influence *via* changes in permits price, regulated firms' abatement and investment choices. The working of such agents is suggested,

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<sup>1</sup>See [4].

<sup>2</sup>See, for example, [10].

for example, by the analysis of the US  $SO_2$  tradable permits system, (see Schmalensee et al. [8]). It is, therefore worthwhile to focus attention on the role speculation might have in determining the performance of emissions trading systems.

To the best of our knowledge, the only paper dealing with the issue is the one by Colla et al. [3]. The authors build on the paper by Baldursson and von der Fehr [2]<sup>3</sup>, and extend it to analyze the role of speculators when firms are risk averse, so that they might have an interest in selling (part of their) permits to speculators in order to reduce the uncertainty they face. Speculators hold inventories of permits on behalf of firms and are compensated by positive expected returns. The authors also show that social welfare might be improved by the presence of speculators.

In [3] uncertainty is simply modeled as a demand shock, but other sources of uncertainty might be relevant in emissions trading; we focus on uncertainty concerning future environmental policy strictness and permits price, and investigate whether and under what circumstances financial speculation may (or may not) strengthen environmental protection.

Environmental policy uncertainty is relevant both theoretically and in practice. Under the first respect, the received literature shows how uncertainty concerning future environmental policy can influence firms' pollution choices. For example, Farzin and Kort [6] and Baker and Shittu [1], among others, underline how uncertainties about the timing and stringency of environmental regulation can affect the abatement investment and R&D ac-

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<sup>3</sup>In [2] the relative performance of tradable permits and taxes under risk aversion is analysed, but no role is explicitly played by speculation.

tivity by regulated firms, although the sign of the relationship is not always straightforward. Regulatory uncertainty in emissions trading is also briefly discussed in Stavins [9]. "Real life" observation seems to confirm the relevance of such uncertainty, as the recent and limited experience of the EU emission trading market<sup>4</sup> shows. The evidence concerning permits price and volume exchanged seems clear enough: the program displayed a "soft" start or, in other words, not having an official aggregate cap, it allowed for too many permits to be distributed<sup>5</sup>. Further, many National Allocation Plans were made stricter *in itinere*, and this generated uncertainty for regulated sources concerning the amount of permits issued by the environmental authorities.

The aim of our paper is to investigate under what circumstances an emissions trading system (ETS) could indeed benefit from the presence of speculation. Even if speculation is modeled in a "naive" way, we capture the essence of it by assuming that the market features economic agents (speculators) that buy or sell permits in order to exploit price changes. A remarkable, although not unexpected, result of our analysis is that speculation may improve ETS's environmental performance when ETS themselves are in their early stages. As the experience with the EU system shows, the first stages of any newly introduced instrument suffer from implementation problems, mainly related to the acceptance by strong affected sectors. The need to boost implementability implies loose environmental target in early stages

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<sup>4</sup>We refer to the first compliance period of the EU emissions trading Directive (2003/87/CE), going from 2005 to 2007.

<sup>5</sup>Concerning the difficulties in creating scarcity in the EU ETS see, among others, the Stern Review on the Economics of Climate Change [11], p.329.

and stricter environmental quality requirements as the system spreads and becomes increasingly accepted. As a consequence, any market force capable of "moving" future environmental improvements to the present would be of much help. Speculation is indeed a candidate under this respect. As we show in the first part of the paper, the presence of speculation might anticipate to the present some benefits of a future stricter environmental regulation, as the presence of speculators expecting a permits' price increase might lead to the overachievement of the emission reduction target set by the environmental regulator in the present, without jeopardizing further improvements in the future.

A second, less intuitive, contribution of our paper is related to the way expected future environmental strictness might influence current environmental quality. More specifically, we show that, when a stricter future environmental policy is expected, then it is not always the case that a further increase in future expected strictness leads to a better current environmental quality. This happens because the incentive of speculators in trading permits is not only affected by expected changes in price, but also by the degree of uncertainty they face, that in our setting is represented by the variance of future permits' price.

Contrary to Colla et al. [3], we assume that firms hold no permits inventories. The reason for this is twofold: on one hand, we want to underline the substantial difference in the behavior of firms and speculators; on the other hand, we want to trace back unequivocally results' causes. Along this line of reasoning, we assume that firms aim at minimizing compliance costs, while speculators aim at exploiting expected price changes.

The relevance of our results is mainly theoretical. Indeed, we provide a simple but powerful framework to consider the consequences of policy uncertainty on the environmental performance of ETSs when speculators are allowed to exchange permits in the market. Nonetheless, our conclusions might also have a policy content, as they suggest that speculation in carbon and other environmental markets may be fruitfully exploited.

The paper is organized as follows. In the second section we build a very simple theoretical model linking firms environmental decisions with financial speculation, while in the third and the fourth sections we compare the (benchmark) levels of permits price and environmental quality under non speculation with those arising under speculation. Section five performs some policy relevant comparative statics. The last section concludes.

## 2 The model

We assume that there are  $n$  ( $i = 1, \dots, n$ ) risk neutral firms generating pollution; emissions are subject to regulation *via* emissions trading. Each firm chooses abatement over a two periods time horizon,  $a_{i,T}$  ( $T = t, t + 1$ ). An environmental regulator announces an aggregate emission standard in each of the two periods and distributes permits accordingly. While the first period aggregate cap is certain (call it  $\bar{E}_t$ ) the second period cap is uncertain in period  $t$ ; more specifically, the expectation over the strictness of the environmental cap in period  $t + 1$  ( $\bar{E}_{t+1}$ ) is determined as follows: with probability  $\pi$  environmental policy does not change, while with probability  $1 - \pi$  environmental policy is stricter (looser) by a factor  $\eta < 1 (> 1)$ . Once the standard

has been set and permits have been distributed, firms exchange them on a perfectly competitive market in order to minimize compliance costs in each period, given by the sum of abatement costs minus revenues from selling permits (or plus costs from buying permits).

The market also features many identical speculators, that we treat as one representative speculator, aiming at maximizing the utility of expected profits. Resuming our clear cut differentiation among firms and speculators, we assume that firms aim at minimizing compliance costs while speculators aim at exploiting price changes over time. This very fact has an additional advantage, namely to simplify our analysis, which we do not expect to be much affected. As the only source of uncertainty is related to future environmental policy, when firms do not hold inventories, then their risk aversion does not matter for the analysis and our results are valid *independently* of firms' risk attitude.

Given our assumptions, firms choose the level of abatement in each period  $T$ ,  $a_{i,T}$ , (and, therefore, the level of actual emissions) in accordance with the solution of the following problem:

$$\min_{a_{i,T}} c_i(a_{i,T}) + p_T(e_{i,T}^B - a_{i,T} - \bar{e}_{i,T})$$

where  $c_i(a_{i,T})$  are abatement costs, assumed to be increasing in abatement and convex;  $p_T$  is the price of permits in time  $T$ ;  $\bar{e}_{i,T}$  is the amount of permits originally distributed to firm  $i$  in period  $T$ ; finally,  $e_{i,T}^B$  are unregulated, that is, business as usual emission in time  $T$  (assumed to be identical across periods for simplicity). To obtain explicit solutions we assume that

$$c_i(a_{i,T}) = \frac{1}{2}\beta_i (a_{i,T})^2,$$

where  $\beta_i$  is a positive parameter. The firm's FOCs are, therefore, given by

$$\beta_i a_{i,T} - p_T = 0.$$

As a consequence, abatement in time  $T$  by firm  $i$  is given by:

$$a_{i,T} = \frac{p_T}{\beta_i} \quad (1)$$

Concerning speculators' behavior, as already anticipated we assume there is one "representative speculator". Its profits are given by:

$$\pi_s = e_s(p_{t+1} - p_t)$$

where  $e_s$  is the amount of permits bought (sold) by the speculator. As the future price of permits is unknown, the speculator will maximize expected utility from profits, where the shape of the benefits function will describe the attitude of the speculator towards risk. We assume, to keep matters simple, that the speculator has a mean-variance expected utility function:

$$U(\pi_s) = \bar{\pi}_s - \frac{1}{2}\rho var(\pi_s) \quad (2)$$

where  $\rho$  is the constant (absolute) risk aversion parameter,  $\bar{\pi}_s$  are expected profits and  $var(\pi_s) = e_s^2 var(p_{t+1})$ . It is easily shown that the maximization of (2) implies the following (necessary and sufficient) FOCs:

$$(E(p_{t+1}) - p_t) - \rho e_s var(p_{t+1}) = 0$$

where  $E(p_{t+1})$  is expected time  $t + 1$  permits price and  $var(p_{t+1})$  is the corresponding variance. The resulting number of permits bought (sold) by the representative speculators will be:

$$e_s^* = \alpha(E(p_{t+1}) - p_t) \quad (3)$$

where  $\alpha = \frac{1}{\rho var(p_{t+1})}$ .

### 3 No speculation

In the absence of speculation, the optimal level of abatement by firm  $i$  in time  $T$  is given by condition (1). The equilibrium on the permits market requires that total emissions equal total allowed emissions:

$$\sum_i \left( e_{i,T}^B - \frac{p_T}{\beta_i} \right) = \sum_i \bar{e}_{i,T}$$

that is,

$$p_T^{ns} = \frac{E_T^B - \bar{E}_T}{C} \quad (4)$$

where  $E_T^B = \sum_i e_{i,T}^B$ ,  $C = \sum_i \frac{1}{\beta_i}$  and  $\bar{E}_T = \sum_i \bar{e}_{i,T}$ . We label all equilibrium variables in the absence of speculation with an  $ns$  superscript.

Substituting back in (1) we get

$$a_{i,T}^{ns} = \frac{1}{\beta_i} \frac{E_T^B - \bar{E}_T}{C}$$

and

$$\sum_i a_{i,T}^{ns} = \sum_i \frac{1}{\beta_i} \frac{E_T^B - \bar{E}_T}{C} = E_T^B - \bar{E}_T$$

that is, the environmental standard is reached in each period  $T$ .

### 4 Equilibrium with speculation

As said, speculators aim at exploiting expected changes in permits' price. In our two periods setting, speculation can only take place among the first and the second period. In the second period the representative speculator just clears his position. The equilibrium price of permits in  $t + 1$  is given by the

following condition<sup>6</sup>:

$$\sum_i \left( e_{i,t}^B - \frac{p_{t+1}}{\beta_i} \right) = \sum_i \bar{e}_{i,t+1} + e_s;$$

solving with respect to the permits price we get:

$$p_{t+1} = \frac{E_t^B - \bar{E}_{t+1} - e_s}{C} \quad (5)$$

where the notation is the same as in the case with no speculation, while a superscript  $s$  characterizes equilibrium values in the speculation case. As, however, environmental policy in  $t + 1$  is uncertain, the speculator can only form expectations about the level of  $\bar{E}_{t+1}$ . Following our assumptions, expected allowances in  $t + 1$  can be simply shown to be:

$$E(\bar{E}_{t+1}) = (\pi + \eta(1 - \pi)) \bar{E}_t$$

and the corresponding variance is:

$$\text{var}(\bar{E}_{t+1}) = \bar{E}_t^2 (1 - \pi)\pi(1 - \eta)^2$$

The variance of permits price in  $t + 1$  is therefore:

$$\text{var}(p_{t+1}) = \frac{\bar{E}_t^2}{C^2} (1 - \pi)\pi(1 - \eta)^2$$

After simple manipulations, we get the following expression for the expected second period price:

$$E(p_{t+1}) = \frac{E_t^B - (\pi + \eta(1 - \pi)) \bar{E}_t + \alpha p_t}{C + \alpha} \quad (6)$$

Using (6) we can derive the equilibrium condition in the first period:

$$\alpha \left( \frac{E_{t+1}^B - (\pi + \eta(1 - \pi)) \bar{E}_t + \alpha p_t}{C + \alpha} - p_t \right) + E_t^B - C p_t = \bar{E}_t$$

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<sup>6</sup>Recall the assumption that BAU emissions are the same in the two periods.

implying the following equilibrium price of allowances:

$$p_t^s = \frac{E_t^B}{C} - \frac{(\alpha(\pi + \eta(1 - \pi) + 1) + C)}{C(2\alpha + C)} \bar{E}_t \quad (7)$$

Equation (7) brings us to the following Proposition.

**Proposition 1** *When a stricter environmental policy is expected in  $t + 1$ , then:*

- *The equilibrium permits price in time  $t$  is higher under speculation with respect to the no speculation case;*
- *current (i.e. time  $t$ ) environmental quality benefits from the existence of speculators.*

*The opposite holds when a looser environmental policy is expected.*

**Proof.** Comparing prices with and without speculation, we get:

$$p_t^s - p_t^{ns} = \alpha \frac{(1 - \pi)(1 - \eta)}{C(2\alpha + C)} \bar{E}_t$$

which is positive (negative) when  $\eta \in (0, 1)$  (when  $\eta > 1$ ), that is, when a stricter (looser) environmental policy is expected in the future. The same result can be achieved with respect to total abatement. Indeed, with and without speculation and in any  $T$ :

$$\sum_{i=1}^n a_{i,T} = Cp_T$$

so that, in time  $t$

$$\sum_i a_{i,t}^s - \sum_i a_{i,t}^{ns} = C(p_t^s - p_t^{ns}).$$

The above difference is, again, positive (negative) when  $\eta \in (0, 1)$  (when  $\eta > 1$ ), that is, when a stricter (looser) environmental policy is expected in the future. ■

Focusing on the case of a stricter future expected environmental policy, the proposition shows that the expected increase in stringency leads to a higher current equilibrium price under speculation and a total abatement that exceeds the one under no speculation, which is equivalent to the environmental quality standard set by the environmental regulator in time  $t$ . The pollution reduction target is overachieved.

Using (3), (6) and (7) we get the equilibrium net demand for permits by speculators:

$$e_s^* = \frac{\alpha}{(2\alpha + C)} (1 - \pi) (1 - \eta) \bar{E}_t \quad (8)$$

Before moving to some interesting comparative statics, notice that when future environmental policy is expected to be stricter, the increase in environmental quality related to speculation does not necessarily damage future environmental quality. Suppose that indeed future environmental policy turns out to be more stringent. This implies that the number of permits in period  $t + 1$  decreases with respect to period  $t$  by the following amount:

$$\bar{E}_t - \bar{E}_{t+1} = (1 - \eta) \bar{E}_t$$

This decrease is only partially compensated by the speculators in  $t + 1$ , because

$$\bar{E}_t - \bar{E}_{t+1} - e_s^* = (1 - \eta) \frac{\alpha + C + \alpha\pi}{2\alpha + C} \bar{E}_t > 0$$

We can therefore conclude that the increase in policy's stringency can be only partially offset by the permits sold by the speculators in  $t + 1$ . This

in turn means that speculation simply anticipates a certain amount of environmental quality improvements from period  $t + 1$  to period  $t$ . As a result, speculation might be helpful when emissions trading starts with unambitious environmental quality targets for practical reasons. This seems to be the case at the beginning of any scheme when the system must be made "politically" acceptable.

## 5 A comparative statics exercise

The aim of this section is to show how the presence of speculation might affect the relationship among environmental policy and environmental quality. More specifically, we will investigate the relationship between future expected strictness and current environmental quality. From the expression of the variance of  $p_{t+1}$  we can explicitly calculate the value of  $\alpha$ , that is:

$$\alpha = \frac{1}{\rho \text{var}(p_{t+1})} = \frac{C^2}{\rho \bar{E}_t^2} \frac{1}{(1 - \pi)\pi(1 - \eta)^2}$$

As the excess abatement under speculation is proportional to the difference between permits prices with and without speculation, we can investigate the impact of changes in expected strictness on prices as well as on environmental quality by analyzing how  $p_t^s - p_t^{ns}$  depends on  $\eta$  and  $\pi$ . Taking the first derivative of  $p_t^s - p_t^{ns}$  w.r.t.  $\eta$  we get:

$$\frac{\partial(p_t^s - p_t^{ns})}{\partial \eta} = \frac{(1 - \pi) \bar{E}_t}{\left(2C + (1 - \pi) \pi (1 - \eta)^2 \rho \bar{E}_t^2\right)^2} \left( (1 - \pi) \pi (1 - \eta)^2 \rho \bar{E}_t^2 - 2C \right) \quad (9)$$

An increase in  $\eta$  has two effects on  $p_t^s - p_t^{ns}$  :

- a *direct* one, through which the difference decreases (as expected stringency in  $t + 1$  decreases) and
- an *indirect* one *via*  $\alpha$ . This second effect is related to the impact an increase in  $\eta$  has on variance and, as a consequence, on  $\alpha$  itself. Such an impact depends on future expected strictness. More specifically, when a stricter (looser) environmental cap is expected, an increase in  $\eta$  increases (decreases) time  $t$  price under speculation, as the "propensity" of speculators to buy or sell permits increases (decreases), but decreases (increases) expected  $t + 1$  permits price, as the more permits are bought (sold) today, the more permits will be sold (bought) tomorrow, bringing future equilibrium price down (up). Taking the derivative of (8) with respect to  $\alpha$  we get:

$$\frac{\partial e_s^*}{\partial \alpha} = \frac{C\bar{E}_t}{(2\alpha + C)^2} (1 - \pi)(1 - \eta)$$

which is positive (negative) when a stricter (looser) future environmental policy is expected; we can therefore conclude that the *indirect* effect on  $p_t^s - p_t^{ns}$  will always be positive (negative) if the future environmental cap is expected to be stricter (looser).

Further, it can be easily shown that

$$\frac{\partial var(p_{t+1})}{\partial \eta} = -2\frac{\bar{E}_t^2}{C^2} (1 - \pi)\pi(1 - \eta) \begin{cases} < 0 \text{ when } 0 < \eta < 1 \\ > 0 \text{ when } \eta > 1 \end{cases}$$

and that

$$\frac{\partial var(p_{t+1})}{\partial \pi} = \frac{\bar{E}_t^2}{C^2} (1 - \eta)^2 (1 - 2\pi) \begin{cases} > 0 \text{ when } \pi \in (0, \frac{1}{2}) \\ \leq 0 \text{ otherwise} \end{cases}$$

As it is reasonable, for any given  $\eta$ , the closer  $\pi$  is to  $\frac{1}{2}$ , the higher the variance. Indeed, a value of  $\pi$  close to  $\frac{1}{2}$  implies that expectations are formed with almost no knowledge of future environmental policy. The effect of  $\eta$  is a little more complex. When a stricter environmental policy is expected, then a low value of  $\eta$  implies a high variance, and increasing  $\eta$  implies a signal from the environmental policy authority suggesting that the announced change will not be as strong as previously believed. This will reduce the variance. The opposite will happen if a looser environmental policy is expected. In this case, the higher  $\eta$ , the higher future permits price variance. In this case, the announcement that environmental policy will be even more slack will increase variance. We can sum up the above considerations in the following Proposition (where  $\Delta p = p_t^s - p_t^{ns}$ ).

**Proposition 2** *The price differential increases with  $\eta$ , that is,  $\frac{\partial \Delta p}{\partial \eta} > 0$ :*

- *when uncertainty is high ( $\pi$  close to  $\frac{1}{2}$ ) and/or,*
- *when future environmental policy is expected to be much tighter or much weaker than the current one.*

The intuition is as follows: when environmental policy is expected to be much stricter in  $t + 1$  given  $\pi$ , increasing  $\eta$  implies less stringent expected policy, a lower variance and therefore a higher  $\alpha$ . Then the *indirect* effect will drive  $p_t^s - p_t^{ns}$  up, possibly dominating the *direct* effect, through which the difference decreases (as expected stringency in  $t + 1$  decreases); this is the case if risk aversion or future expected strictness are sufficiently "strong". All the mechanics are reversed when environmental policy is expected to be looser in  $t + 1$  (given  $\pi$ ).

A graphical intuition of proposition 2 is given in Figure 1 (for a stricter future environmental policy) and in Figure 2 (for a weaker future environmental policy). The two figures show the relationship between  $\frac{\partial \Delta p}{\partial \eta}$  and  $\pi$ , for different values of  $\eta$ . Figure 1 shows that when future environmental policy is expected to be much stricter ( $\eta = \frac{1}{4}$ ), then  $\Delta p$  increases with  $\eta$ , unless  $\pi$  is very low. Indeed, in the latter case parameter  $\alpha$  is very high: the speculator reacts therefore to any change in expected strictness by lowering the number of bought permits so much as to dominate any other possible consequence of the increase in  $\eta$ . The price differential decreases accordingly. If the expected increase in strictness is relatively not very tight ( $\eta = \frac{3}{4}$ ), then  $\Delta p$  is always decreasing with  $\eta$ . Finally, for an intermediate value of the expected increase in strictness ( $\eta = \frac{11}{16}$ )  $\Delta p$  is decreasing with  $\eta$  when uncertainty is not relevant (extreme values of  $\pi$ ), while it is increasing in  $\eta$  when uncertainty is relatively high (values of  $\pi$  closer to one half). As Figure 2 shows, the relationship between  $\Delta p$  and  $\eta$  moves in the opposite direction when environmental policy is expected to be weaker: in this case when future environmental policy is expected to be much weaker ( $\eta = 2$ ), then  $\Delta p$  increases with  $\eta$  for any  $\pi$ , unless  $\pi$  itself is very low. In the latter case parameter  $\alpha$  is so high as to generate a huge increase in speculators' short position as a consequence of a decrease in expected strictness; this effect dominates any other possible consequence of the increase in  $\eta$ . If the expected decrease in strictness is relatively not strong ( $\eta = \frac{5}{4}$ ), then  $\Delta p$  is always decreasing with  $\eta$ . Finally, for an intermediate value of the expected decrease in strictness ( $\eta = \frac{11}{8}$ )  $\Delta p$  is decreasing with  $\eta$  when uncertainty is not relevant (extreme values of  $\pi$ ), while it is increasing in  $\eta$  when uncertainty is relatively high

(values of  $\pi$  closer to one half).

The above result might have relevant policy implications. Suppose a very tight future environmental policy is expected. In this case, a signal from the environmental authority that, for example, some exemptions might be granted could lead speculators, facing a lower variance and, therefore, a lower risk, to increase their speculative demand for permits. This will increase the relevance of speculation in shifting future environmental improvements to the present.

Turning to comparative statics with respect to  $\pi$  we get:

$$\frac{\partial (p_t^s - p_t^{ns})}{\partial \pi} =$$

$$= - (1 - \eta) \frac{Z}{(2B + (1 - \pi) \pi (1 - \eta)^2 \rho Z^2)^2} (2B + (1 - \pi)^2 (1 - \eta)^2 \rho Z^2) < 0$$

This leads us to the following straightforward result.

**Proposition 3** *when a stricter (looser) environmental policy is expected, then an increase of the probability that the status quo is retained will lead to a lower increase (decrease) in time  $t$  equilibrium permits price and a lower environmental quality with respect to the benchmark (no speculation) case.*

## 6 Concluding remarks

To improve current environmental quality, which is equivalent to make current environmental policy more stringent, speculation may be helpful. It helps when an emission trading system enters into force through a quite "soft" first phase. In these circumstances the overall pollution reduction

target can be far less stringent than it ought to be, and pure financial speculators might expect an increase in permits prices. As we have shown, this would lead the aggregate abatement target to be exceeded. In other words, speculation might help in pushing abatement towards a level *truly* consistent with the dimension of the environmental problem at hand, boosting present environmental quality, without necessarily damaging it in the future. Further, we have shown that counterintuitive policy implications might arise. More specifically, if the objective is to increase current environmental quality, which is the case when emissions trading starts with unambitious targets, then it could be a good idea to send to regulated firms and speculators signals supporting the expectation of a decrease in future strictness.

Given these theoretical results, a crucial point is therefore to judge how reasonable it is to assume prices rise expectations on the part of speculators. This assumption appears well justified in the practical case we have in mind, which is the EU environmental policy. If the EU countries want to comply with the Kyoto Protocol, as they did show with the introduction of the ETS in 2005, environmental regulation needs to become more stringent in the near future and, therefore,  $CO_2$  price can be expected to grow.

It follows from our paper that the fruitful link among speculation and environmental quality may be exploited. This is why, when shaping emissions trading systems, the role of speculators should not be overruled.

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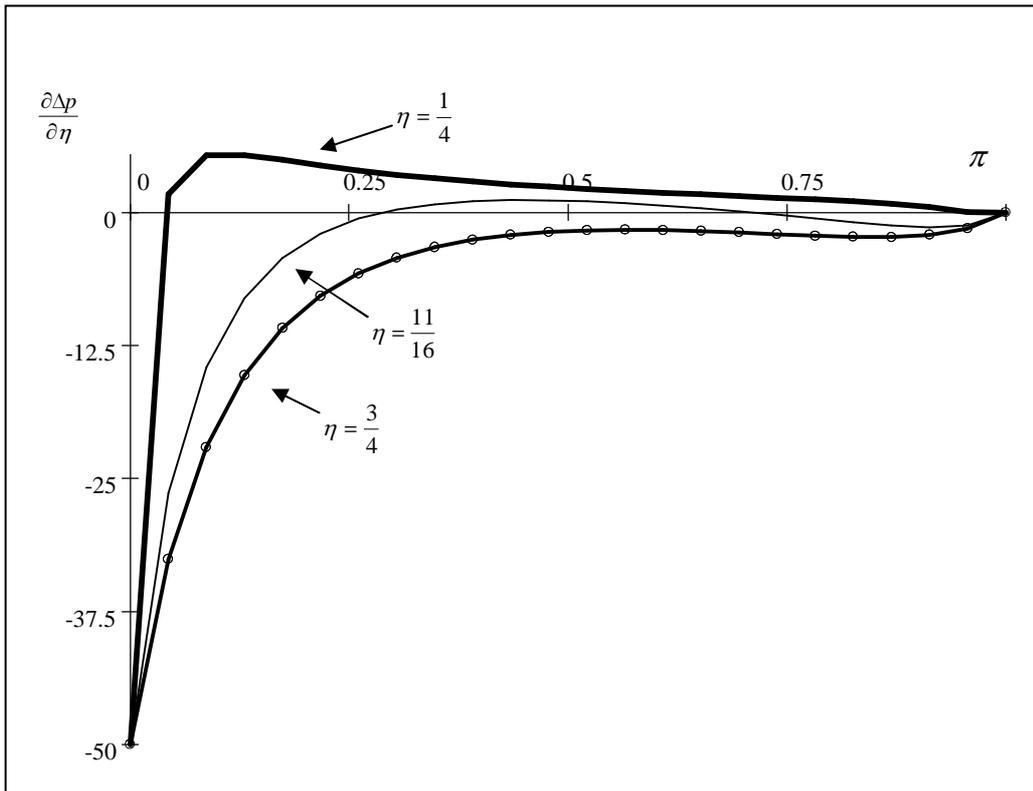


Figure 1: Stricter expected environmental policy

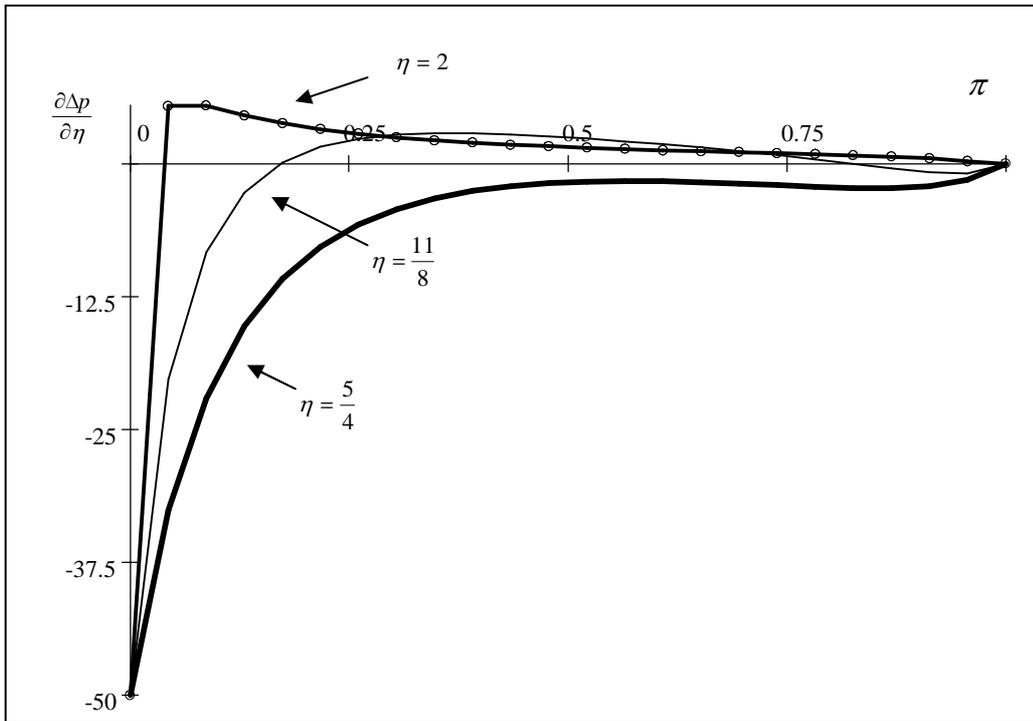


Figure 2: Weaker expected environmental policy