Portfolio management of emission permits and prudence behaviour

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Abstract

The aim of this paper is to provide an analytical explanation of the stylized fact in emission permits markets, high permits price volatility and low trade volumes, using the concept of prudence developed by Kimball (1990, 1993). We show that prudence behaviour is a sufficient condition for the firm to save permits in portfolio and that the number of permits saved decreases when interest rate increases.

1 Introduction

Since the pioneer studies of Dales [9], emission permits markets interest a growing number of energy and environmental economists. Particularly, the first theoretical discussions were revived by large-scale projects and implementations of such programs. Among these programs, we can mention American experiences (Acid Rain Program, OTC NOx Budget Program, RECLAIM Program, ...), the future European emissions trading scheme that normally should start on January 2005, and the future global greenhouse gas market (Kyoto Protocol, 1997).

At present, it is widely recognized that under the hypothesis of perfect market, a system of emission permits is a flexible instrument to attain an environmental objective at least aggregate cost. Precisely, these cost savings come from averaging and trading[1] (intrafirm and interfirm flexibility) and from banking[2] (intertemporal flexibility). Unfortunately, perfect market assumptions rarely hold up in practice. Indeed, emission permits markets can suffer from several impediments such as uncertainties, high transaction costs, market power, imperfect monitoring and enforcement.

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1 For theoretical proofs, see for example [23], [8] and [26].

2 For theoretical proofs, see for example [26], [7], [25], and [19].

In this paper, we focus our attention on uncertainty. In a transferable permits market, firms may face various kind of uncertainty like permit price uncertainty, demand uncertainty which means production and emissions uncertainty, abatement costs uncertainty, regulatory uncertainty, ... A number of researches have already analyzed the role of uncertainty in emission permits markets. In particular, first conclusions come from experimental economics. In different experimental settings, [6] and [11] show that uncertainty faced by regulated firms about their total emissions creates price instability which is higher when banking is not allowed. Moreover, price peaks are higher in high rate emission periods. From theoretical and numerical models of marketable permits, [22] studies the effect of uncertainty on trade approval and transaction costs on market performance and aggregate control costs. Although uncertainty and transaction costs suppress exchanges that otherwise would have been mutually beneficial, it is shown that a marketable permits system is still cost-effective compared to a command-and-control approach. In a model of perfectly competitive markets, [15] examine the impacts of stochastic pollution on production decisions. They show that the existence of uncertainty about the magnitude of pollution tends to reduce production activities relative to the situation of non-stochastic pollution with the same mean rate of emissions. In theoretical and experimental settings, [3] analyze the effects of permits price uncertainty and risk aversion on firms' abatement investments and trading behaviours. Results suggest that abatement efforts of risk-averse permits sellers (buyers) are lower (higher) under uncertainty than under certainty. Consequently, at equilibrium, the number of allowances traded are lower under uncertainty than in a perfectly market setting. Very recently, [2] use the concept of risk aversion to qualify trading attitude : "... when firms are sufficiently risk averse trade will be limited ; in particular, infinitely risk-averse firms would not trade at all." (p. 696).

Our contribution is closed to this last study but it differs in two points. First, we assume that uncertainty comes from emission permits price and not from amount of pollution. Second, we look how regulated firms manage their emission permits portfolio inside a compliance period. Indeed, we will see that portfolio management of emissions permits is unjustly forgotten in theoretical analysis. Nevertheless, both results are not so far from each other and seem to indicate that uncertainty has disturbing effects on trading.

2 The Portfolio Management of emissions permits under uncertainty

In practice, permits price uncertainty appears for regulated firms as one of the main problems to build compliance decisions. For example, a great number of factors can suggest that permits prices may rise. Among these factors, we can mention the possibility that fossil fuel prices increase, a growth of the permits demand because of the entry of new sources, or a drastic reduction of emissions in the future phase of the program. As oil, gas, coal, or electricity, emission permits are commodities with market values that require a proactive portfolio management by regulated firms even if they are allocated free of charge ("grandfathering"). For example, in the Acid Rain Program, the value of the emission permits portfolio of an electricity producer exceeds in a lot of cases 500 millions dollars with a market price volatility in the order of 40%. Thus, when electricity producers keep all or a part of their allowances in portfolio, they realize risky and speculative decisions about future emission permits prices.

Portfolio management has become a well-known practice for energy firms in particular because of the high volatility of energy prices. However, as inputs, emission permits distinguish from other energy commodities in the fact that these inputs are not immediately needed for production. Emission markets are designed in a such a way that it is possible to produce today without a permit because production periods do not match with the end of the compliance period. Thus after the initial allocation of permits, regulated firms must choose if they keep their allowances in portfolio or if they sell them and buy them back later. At constant prices, if a firm sells some permits and buys them back later at a lower price, it realizes a gain due to a good expectation. However, if this firm sells some permits and buys them back later at an higher price, then it supports a loss due to a bad expectation. Consequently, a firm which is long in permits may hesitate to sell permits when there is little chance to have a need for these permits in later periods.

Recent experiences of emissions trading implementations (Acid Rain Program, OTC NOx Budget Program, ...) have often shown low trade volumes and also high volatility. Concerning the Acid Rain Program, [4] notice that firms have inconsistently participated in trading. In the beginning of the program, the majority of transactions were intrafirm and gradually, trading activity developed but transaction volumes were very disparate between firms. It is important to understand these differences in firms trading activities because they may lead to permits price volatility. Permits price volatility is awkward because permits price is a signal used for long-term abatement investments ; and in a certain manner, this volatility seems to refute the traditional belief that permits prices are a valid expression of the marginal cost of abatement and that the market for pollution rights minimises the total cost of abatement.

Following, we show that portfolio management and prudent behaviour of the firm may lessen trading volumes inside a compliance period. To study this problem, we consider a two-period model[3] of a risk-averse firm maximising expected utility of its profits across periods.

3 Prudence and Disincentive to Trade

3.1 The model

Consider a compliance period divided in two exchanges periods[4].The utility function is the same for both periods ($t = 0, 1$), concave and denoted by u. To catch the portfolio management behaviour of emissions permits, we consider the simple case of a firm who knows exactly its market demand and thus its production and pollution level during these periods. Therefore, the firm knows

[3]As mentioned by [1], a two-periods model often allows to catch principal characteristics of a phenomenon, even if it is not the most elegant method in a mathematical viewpoint. Furthermore, restricting the setting to two dates eliminates the problem of time inconsistency [12].

[4]It is important to notice that our model do not take into account banking behaviours. We just show how firms manage permits inside a compliance periods and not between compliance periods.

exactly its rates of profit through periods denoted by π_0 and π_1. Furthermore, we make the assumption that this firm has already done abatement effort in such a way that it is technological not possible to reduce pollution anymore during these periods, and that its initial allocation of permits e matches with its pollution needs for the compliance period. In the first period, the firm chooses a quantity b of permits to save in its portfolio, taking into account the unit value of permits in the first period p_0 (perfectly known in 0) and the unit value of permits in the second period $\tilde{p_1}$[5], which is not known in the first period. Transaction costs are not including in our analysis and $e-b$ corresponds to the amount of permits sold in the first period.

The problem of the firm is to maximize :

$$H(b) = u_0[\pi_0 + (e-b)p_0] + Eu_1[\pi_1 + (b-e)\tilde{p_1}] \tag{1}$$

Consider now that :

$$\tilde{p_1} = p_1 + \tilde{\varepsilon} \tag{2}$$

The deterministic component p_1 corresponds to $E(\tilde{p_1})$ because the $\tilde{\varepsilon}$ is chosen as a white noise. Note that $\tilde{\varepsilon}$ is independent[6] from any other function. For instance $cov(u_1'(.), \tilde{\varepsilon}) = 0$.

We can then compare the situation where $\tilde{p_1} = p_1$ is perfectly known in the first period, to the alternative situation where a risk with a zero mean is added[7]. A zero mean risk is necessary to avoid a smoothing effect across periods, generally wished when utility functions are concave.

The first-order-condition (FOC) in the certainty case is :

$$-p_0 u_0'(\pi_0 + (e-b)p_0) + p_1 u_1'(\pi_1 + (b-e)p_1) = 0 \tag{3}$$

With uncertainty on the permits price, the corresponding FOC is :

$$-p_0 u_0'(\pi_0 + (e-b)p_0) + E[\tilde{p_1} u_1'(\pi_1 + (b-e)\tilde{p_1})] = 0 \tag{4}$$

Introducing (2), we obtain :

$$-p_0 u_0'(\pi_0 + (e-b)p_0) + p_1 E u_1'(\pi_1 + (b-e)\tilde{p_1}) + E[\tilde{\varepsilon}.u_1'(\pi_1 + (b-e)\tilde{p_1})] = 0 \tag{5}$$

3.2 Results and Interpretation

We now use the FOC to give some results about the trading behaviour of the firm. Remember that for any pair of random variables x and y, $cov(x,y) = E(xy) - E(x)E(y)$. Using independence from $\tilde{\varepsilon}$ with any other variable, (5) becomes:

$$-p_0 u_0'(\pi_0 + (e-b)p_0) + p_1 E u_1'(\pi_1 + (b-e)\tilde{p_1}) = 0 \tag{6}$$

We can then compare trading levels in both certainty and uncertainty cases. Because (3) and (6) are similar concerning first period, we have just to compare the second period component or :

[5] Random variables are denoted with a tilde.

[6] Formally independence occurs if $\forall f$, $\forall g$, $cov(f(\tilde{p_1}), g(\tilde{\varepsilon}))$ but this stronger condition is not necessary for our purpose (see [16], p. 15).

[7] As in [17], we shall assume that this risk is uninsurable in any market.

$$Eu_1'(\pi_1 + (b-e)\tilde{p_1}) \quad and \quad u_1'(\pi_1 + (b-e)p_1)$$

If the decision maker has concave utility functions for the two periods (which is a reasonable assumption), then he has a preference for profit smoothing across periods. In this case, H is a concave function in b, and there is lower trading level if :

$$Eu_1'(\pi_1 + (b-e)\tilde{p_1}) \geq u_1'(\pi_1 + (b-e)p_1) \tag{7}$$

or :

$$Eu_1'(\Theta + (b-e)\tilde{\varepsilon}) \geq u_1'(\Theta) \tag{8}$$

Following [12] (p. 237) and using diffidence theorem, it yields that (8) holds for any Θ if and only if u_1' is convex[8]. Convexity of marginal utility refers to the concept of prudence as defined by [17] (p. 68) : *"...the sign of the third derivative of the utility function governs the presence or absence of a precautionary saving motive[9]..."*

Proposition 1 *If the agent is prudent, then his willingness to save permits increases compared to the certainty case.*

Corollary 1 *Prudence is a sufficient and necessary condition for a lower amount of trading.*

A positive third derivative of utility function indicates a trading disincentive. That is, that uncertainty about future prices of permits will reduce current trading and increase current saving of allowances.

Because permits are required to produce any pollution, these can be seen as usual inputs. We explain here how a prudent firm manages its initial allocation, knowing the total amount of permits required at the end of the compliance period, which coincides in our model with resolution of uncertainty. Prudence leads to save more permits because there is an uncertainty concerning the future price of these permits, which has an influence on the amount the firm will have to pay.

A relevant issue is to know whether prudence is a realistic concept or not. Theoretically, prudence is a necessary condition for DARA hypothesis, which is commonly accepted throughout economic literature.

Furthermore, some empirical studies ([13], [14], [5] or [20]) have examined the prudence behaviour in a consumption framework[10]. The aim was to assess if more exposed people to future income risks would save more and this seems to be confirmed by studies.

[8]For a definition of the diffidence theorem see ([12], p 81-89).

[9]"just as the sign of the second derivative governs the presence or absence of risk aversion", ibid. p 68. Note that this result may also be attributed to Leland [21].

[10]The Decreasing Absolute Prudence concept (DAP), equivalent of DARA for risk aversion (see [18] and [24]), has also been recently explored in [10].

3.3 The Role of Interest Rate

Now consider that the amount sold in the permits market can be valorized at a rate ρ until the second period. Program to be maximized can be rewritten:

$$H(b) = u_0[\pi_0 + (e-b)p_0] + Eu_1[\pi_1 + (b-e)\tilde{p_1} + \rho(e-b)p_0] \tag{9}$$

Proposition 2 *The optimal level of trade is increasing with the interest rate.*

Proof 1 *Maximizing (9) yields to the FOC :*

$$-p_0u_0'[\pi_0 + (e-b)p_0] + E[(\tilde{p_1} - \rho p_0)u_1'[\pi_1 + (b-e)\tilde{p_1} + \rho(e-b)p_0]] = 0$$

Using independence property about $\tilde{\varepsilon}$, as in the previous result, simplification yields to :

$$-p_0u_0'[\pi_0 + (e-b)p_0] + (p_1 - \rho p_0)Eu_1'[\pi_1 + (b-e)\tilde{p_1} + \rho(e-b)p_0] = 0$$

Full differentiation then gives :

$$-\Big[p_0^2u_0''[\pi_0 + (e-b)p_0] + (p_1 - \rho p_0)^2Eu_1''[\pi_1 + (b-e)\tilde{p_1} + \rho(e-b)p_0]\Big]\frac{db}{d\rho} =$$

$$-bp_0Eu_1'[\pi_1+(b-e)\tilde{p_1}+\rho(e-b)p_0]+(e-b)p_0(p_1-\rho p_0)Eu_1''[\pi_1+(b-e)\tilde{p_1}+\rho(e-b)p_0]$$

Because of concavity of utility functions, the sign of $\frac{db}{d\rho}$ is the right-hand side sign, which is negative.

The intuition is the following : when the interest rate increases, the agent has a stronger incentive to sell a part of its initial allocation to make a profit using financial markets. This principle is very often met in the financial theory.

4 Concluding Remarks

Prudent behaviours of regulated firms lessen trade volumes in emissions permits markets. This result is consistent with other studies in the literature and seems to indicate that possible welfare gains exist from governmental intervention. As mentioned by [2], "The government may be able to improve the performance of a tradable quota system by judicious choice of distribution and amount of initial quotas and by trading pro-actively in the quota market." Although this policy recommendation is not new (see for example [9]), it is however not implemented into practice.

A future research into the effects of uncertainty in emissions trading may be to verify the concept of prudence in a production framework. We mean to confirm empirically whether firms save more when permits price risk increases. Trade level can then be put in perspective with the structure of the firm to assess if there a form of corporate prudence.

Another extension may be to take into account the portfolio management of emissions permits between compliance periods when banking is allowed.

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