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Relative Quotas: Correct Answer to Uncertainty or Case of Regulatory Capture?

Summary

There is a tendency among policy-makers and industry lobbyists toward "specific", "relative" or "output-based" quotas, i.e., freely distributed to firms proportionally to their output. With a stochastic analytical model, we demonstrate that relative quotas are dominated either by absolute quotas or by price instruments as regards expected social cost. Furthermore, price instruments entail a lower expected compliance cost than relative quotas. Why, then, do industry lobbyists favour quantity instruments over price instruments? A possible explanation is that if the industry anticipates that the State will underestimate output and overestimate the MAC curve slope, it has an interest in defending relative quotas. The problem is that in such a case, both the environmental damage and the social cost are higher with relative quotas than with absolute ones. The choice of relative quotas over price instruments or absolute quotas may thus be a case of regulatory capture, to use Stigler's vocabulary.

Keywords: Uncertainty, policy choice, environmental taxes, tradable permits, regulatory capture

JEL: D81, Q25, Q28

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Introduction

Since the seminal contribution of Weitzman (1974), it is widely recognised that in order to choose between taxes and quotas for creating or preserving a public good, policy makers should take into account the contrasted way these two instruments react to uncertainty on abatement cost. In particular, taxes should be favoured when the marginal abatement cost curve is steeper than the marginal environmental benefit curve, and vice-versa. Many papers have expanded the original model and some have applied it to various problems.

However there are also key differences not only *between* but also *among* each family of instrument. Furthermore, since some of these differences have to do with uncertainty, it is worth studying them in the framework of a stochastic model.

In particular, there is a tendency toward using "specific", "relative" or "output-based" quotas, i.e., freely distributed to firms proportionally to their output. Such systems are in place in the U.K. for cutting energy and CO_2 emissions and will soon be implemented in the Netherlands to tackle NO_X (Boemare and Quirion, 2002). In the latter country, long-term agreements on energy efficiency, which have been concluded with industry and other sectors since 1992, are expressed in energy consumption per physical unit of product (Albrecht et al., 2002). Furthermore, there is a wide (although not unanimous) support for such systems among industry groups. At last, the Bush initiative on climate change aims at capping the CO_2 intensity, i.e., emissions per unit of GDP. Admittedly, there is no direct link between such a national "intensity" target and "relative" quotas for individual sectors, since the former is expressed in terms of GDP whereas the latter is based on physical units. However, this proposal has stemmed a renewed interest for relative quotas.

Some recent papers have cast light on (in)efficiency of relative quotas or of a performance standard (their non-tradable equivalent) as compared to traditional, "absolute", quotas, but all these analyses have been conducted in a deterministic framework. Koutstaal et al. (2002, section 3.3) affirm that "the Weitzman theorem, which states that under uncertainty the preference for either price control through taxes or quantity control with tradable emission permits depends on the relative steepness of the marginal cost and benefit curves, is not affected directly if instead of absolute caps, trading with relative caps is analysed", but as we demonstrate in the present paper, this statement is not correct.

Our model is basically an extension of Weitzman's (1974). We distinguish two sources of uncertainty on costs: business-as-usual emissions, assumed proportional to output, and the slope of the marginal abatement cost curve.

To keep our analytical model tractable, we abstract from the mechanisms identified by the above-mentioned, deterministic, literature. This is not to understate their importance but to disentangle these well-established mechanisms from the stochastic effects we identify in the present paper.

Without uncertainty, relative quotas are equivalent to a tax whose revenues are rebated as a proportion to output[1], but this equivalence vanishes in a stochastic framework. The introduction of uncertainty in the comparison of the fashionable "relative" quotas with the more classical "absolute" ones thus opens at the same time the possibility of comparing them with various kinds of taxes. This comprehensive treatment is welcome since, as we will see, some earmarked taxes perform better than relative quotas with respect to a number of criteria.

We thus compare four instruments: absolute and relative quotas and two kinds of price instruments, that differ from one another with respect to the financial transfer to the State they may entail. We compare them as regards the expected social cost (the sum of the abatement cost and the environmental damage from unabated emissions). We then enter into political economy considerations to explain the positions of industry lobbyists and environmental groups as regards instrument choice.

Our main results are as follows. In a nutshell, relative quotas are a halfway solution between the absolute quantity instrument and the price instrument: they are more flexible than the former but less than the latter, following a change in the abatement cost schedule. As a consequence, they are dominated either by the absolute quantity instrument or by the price instruments as regards the expected social cost.

Relative quotas dominate absolute ones as regard expected compliance cost, which may explain why industry lobbyists favour the former over the latter. But given the superiority of price instruments over relative (and all the more absolute) quotas as regards this criterion, why do industry lobbyists favour quantity instruments over price instruments? Several explanations may compete but one stems from our model: if the industry anticipates that the

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[1] Such a system exists in Sweden for NO_X emissions and is described and assessed in Sterner and Höglund (2000).

State will underestimate output and overestimate the MAC curve slope, it has an interest in defending relative quotas over every other instrument. The problem is that in such a case, both the environmental damage and the social cost are higher with relative quotas than with absolute ones. The choice of relative quotas over price instruments or absolute quotas may thus be a case of regulatory capture, to use Stigler's (1971) vocabulary.

1. Lessons from deterministic models

The existing literature on the welfare impact of absolute vs. relative quotas and output-rebated taxes has focused on the scarcity rent created by absolute (auctioned or grandfathered) quotas[2]. Under auctioning, this rent is socialised and may be used to cut pre-existing, distortionary, taxes, whereas grandfathering is equivalent to distributing this rent for free to polluters. If public funds are levied by distortionary taxes, grandfathering is thus costlier than auctioning. Relative quotas, on the contrary, do not create any scarcity rent. Thus, they do not suffer from the above-mentioned drawback of grandfathering. The other side of the coin is that the price of output is not raised by the value of the external damage they create, so output is too large, except under some cases of imperfect competition. As a consequence, for a given aggregate abatement, abatement per unit of output is too high. In applied models, the welfare impact of output-based quotas is generally in-between that of auctioned and grandfathered ones, or close to grandfathering.

To keep our analytical model tractable, we abstract from these mechanisms by assuming that there is no opportunity cost of public funds and that the impact of environmental policy instruments on output has negligible consequences on welfare. This is not to understate the importance of the above results, but to disentangle these well known, deterministic, mechanisms from the stochastic mechanisms we identify in the present paper.

2. Key assumptions and model description

The key difference between relative and absolute quotas is that with the former, the firm receives more (less) allowances if its output if higher (lower) than expected. The rationale for

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[2] Cf. Albrecht et al. (2002), Boom and Nentjes (2002), Burtraw et al. (2001), Ebert (1998), Edwards and Hutton (2001), Fischer (2001), Goulder et al. (1999a and b), Koutstaal et al. (2002), Quirion (2002).

this instrument is that a higher output entails more emissions, other things being equal, "so that" more quotas should be distributed to prevent too high a compliance cost. Industry lobbyists have consistently put this argument forward, in particular during the negotiation of the European greenhouse gas allowance-trading directive (COM(2001)581).

To compare in a formal framework relative and absolute quotas, we thus have to model the uncertainty on baseline (i.e., business as usual) emissions, that we assume proportional to output, hence to the quantity of allowances distributed in the case of relative quotas. This assumption will be loosened in section 5.

Because we are interested in the level of baseline emissions, we cannot rely on local approximations of marginal cost and benefit curves, as Weitzman do. We have to distinguish two kinds of cost uncertainty: on the slope of the marginal abatement cost curve and on the level of baseline emissions. As a consequence, it is more convenient to reason in term of emissions instead of abatement, as in Weitzman's paper. We thus end up with the following marginal private benefit of emissions:

$$MPB = \frac{c_2}{f}\left(1+\alpha-e\right) \tag{1}$$

which is analogous to Weitzman's marginal cost curve. f is a random variable reflecting the uncertainty on the slope, normalised so that $E\left[f\right]=1$, α is a random variable reflecting the uncertainty on baseline emissions, normalised so that $E\left[\alpha\right]=0$, c_2/f is the slope of the curve and $e\in\left[0,1+\alpha\right]$ is the emission level. Note that without loss of generality, expected baseline emissions are normalised to 1. In addition, we have $c_2>0$, $f>0$ and $\alpha<1$.

$$MED = b_1 + b_2 e \tag{2}$$

(2) is the marginal environmental damage, analogous to Weitzman's marginal benefit curve. We have $b_1\in\left[0,Min\left[c_2,c_2/f\right]\right)$, to avoid a corner solution either ex ante or ex post, and $b_2>0$. We do not model the uncertainty of the environmental damage side since it is well known that this uncertainty matters only when correlated with abatement cost (Weitzman, 1974, Stavins, 1996, Shrestha, 2001).

As in Weitzman (1974), we assume that firms know the true value of both random variables f and α when they abate emissions, but that the State only knows their expected value.

However it is neither necessary nor always realistic to assume that firms know these values when they negotiate the environmental policy. We turn back to this issue in section 8.

As stressed by Weitzman, without uncertainty on the reaction function of the firm (*MPB* here) all instruments yield the same optimal outcome. Indeed, the State may either choose an emission quota $\hat{e}$, which will entail a price of emissions $p(\hat{e})$, or a tax of rate $\tilde{p}=p(\hat{e})$, which will entail an emission level $e(\tilde{p})= \hat{e}$. If, however, the *MPB* curve differs from what the State expects, the outcome will differ among instruments and from the ex post optimum. On Figure 1 below, either the initial emission level (left panel) or the slope of *MPB* (right panel) are higher than expected. As a consequence, in both cases, as indicated by dashed lines, absolute quotas yield too low an emission level and tax too high an emission level, as compared to the ex post optimum, defined by the intersection of the ex post (dashed) *MPB* curve and the *MEC* curve. Relative quotas behave like the tax on the left panel, since the quantity of quotas allocated is, by assumption, proportional to baseline emissions. On the opposite, they perform like absolute quotas on the right panel, because the quantity of quotas allocated is unmodified by the slope of the *MPB* curve.

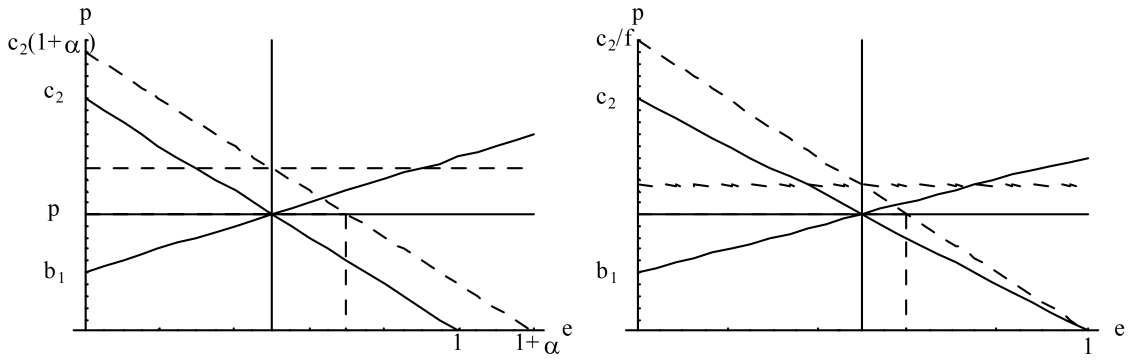

Figure 1. Outcome of a price instrument and of absolute and relative quotas.

b_1=0.1, b_2=0.2, c_2=0.4. Left panel: α =0.1, f=1; right panel: α =0, f=0.8

3. Two pairs of instruments

With absolute quotas (*Qa*), the State defines the emission quota $\hat{e}$ at the intersection of the ex ante MPB curve and the MEC curve. We thus have:

$$\hat{e} = \frac{c_2 - b_1}{b_2 + c_2} \tag{3}$$

yielding a price: $p\left(\hat{e}\right)=\dfrac{c_2\left(b_1+b_2+\left(b_2+c_2\right)\alpha\right)}{\left(b_2+c_2\right)f}$.

With relative quotas (*Qr*), the State distributes a quantity of allowances that varies with output hence with baseline emissions:

$$e_{qr}\equiv\hat{e}+\alpha=\frac{c_2-b_1}{b_2+c_2}+\alpha \tag{4}$$

yielding a price: $p\left(e_{qr}\right)=\dfrac{\left(b_1+b_2\right)c_2}{\left(b_2+c_2\right)f}$.

With a price instrument, the States fixes a tax rate:

$$\tilde{p}=\frac{\left(b_1+b_2\right)c_2}{b_2+c_2} \tag{5}$$

leading to an emission level:

$$e\left(\tilde{p}\right)=\frac{\left(b_2+c_2\right)\left(\alpha+1\right)-\left(b_1+b_2\right)f}{b_2+c_2} \tag{6}$$

If quotas are distributed for free, which is the most usual way to proceed (Boemare and Quirion, 2002), the equivalent price instrument is a "price-subsidy" scheme (Pezzey, 1992) under which each existing firm pays a tax for emissions over a reference level and receives a subsidy if its emissions drop under this level. To maintain the symmetry between price and quantity instruments, we assume that the tax and the subsidy rates are equal.

If this reference level is fixed so as to equalise the ex ante amount of tax and subsidies, we get a price equivalent of absolute quotas, that we label *Pa*; if it is adjusted ex post so as to maintain the amount of tax equal to the amount of subsidies, we get a price equivalent of relative quotas, labelled *Pr*.

The total social cost of each instrument is defined as the sum of total compliance cost and total environmental damage minus the public budget balance:

$$TSC_{Qa}\equiv TCC_{Qa}+TED_{Qa}=\int_{\hat{e}}^{1+\alpha}MPB+MED\,de\,; \tag{7}$$

$$TSC_{Qr}\equiv TCC_{Qr}+TED_{Qr}=\int_{e_{qr}}^{1+\alpha}MPB+MED\,de\,; \tag{8}$$

$$TSC_{Pa} \equiv TCC_{Pa} + TED_{Pa} - PB_{Pa} = \left(\int_{e(\tilde{p})}^{1+\alpha} MPB\, de + \tilde{p}\left(e\left(\tilde{p}\right) - r\right) \right) + \int_{e(\tilde{p})}^{1+\alpha} MED\, de - \tilde{p}\left(e\left(\tilde{p}\right) - r\right) \quad (9)$$

where $r = \hat{e} = \dfrac{c_2 - b_1}{b_2 + c_2}$ is the reference level;

$$TSC_{\mathrm{Pr}} \equiv TC_{\mathrm{Pr}} + TEC_{\mathrm{Pr}} = \int_{e(\tilde{p})}^{1+\alpha} MPB + MED\, de\,. \quad (10)$$

A first obvious result is that $TSC_{\mathrm{Pr}} = TSC_{\mathrm{P}a} \equiv TSC_{p}$, which is due to our assumption that lump-sum transfers are costless. We can then compare the expected social cost of relative quotas to that of absolute quotas and of the price instruments.

4. Is there a room for relative quotas?

From (1) to (4), (8) and (9), relative quotas should be favoured over absolute ones (according to the expected social cost criterion) if and only if[3]:

$$Qr \succ Qa \Leftrightarrow E\left[TSC_{Qa}\right] > E\left[TSC_{Qr}\right] \Leftrightarrow E\left[\frac{1}{f}\right]\frac{c_2\sigma^2}{2} - \frac{b_2\sigma^2}{2} > 0$$

where σ^2 is the variance of α. Although the expected value of the inverse function cannot be computed without making further assumptions, we get, by Jensen inequality and the convexity of the inverse function:

$$E\left[\frac{1}{f}\right] > \frac{1}{E[f]} = 1, \forall f > 0\,.$$

If the variance of the slope of the *MPB* curve tends to zero, relative quotas should be preferred if and only if the *MPB* curve is steeper than the *MEC* curve. This is the well-known condition of superiority of prices over quantities in Weitzman's basic model. A higher variance of f reinforces the case of relative over absolute quotas. Thus there is indeed a room for relative over absolute quotas.

Let us turn to the choice between relative quotas and price instruments. From (1), (2), (4), (5), (6), (8) and (10), relative quotas should be favoured over price instruments (again according to the expected social cost criterion) if and only if:

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[3] All demonstrations are available from the author upon request as a Mathematica Notebook.

$$Qr \succ P \Leftrightarrow E\left[TSC_P\right] > E\left[TSC_{Qr}\right] \Leftrightarrow \frac{\left(b_1+b_2\right)^2}{2\left(b_2+c_2\right)^2}\left(b_2\delta^2 - c_2\left(E\left[\frac{1}{f}\right]-1\right)\right) - \frac{b_2\left(b_1+b_2\right)\sigma_{\alpha f}}{b_2+c_2} > 0$$

where δ^2 is the variance of *f* and $\sigma_{\alpha f}$ is the covariance between α and *f*. We can first notice that when the variance of *f* tends to zero, the difference in expected social cost collapses. In other cases, the last term shows that a positive covariance between *f* and α (i.e., a negative correlation between the steepness of the *MPB* curve and baseline emissions) favours the price instrument and vice-versa. Abstracting from this effect (we go back to it in section 7), relative quotas tends to be preferable if and only if the *MPB* curve is steeper than the *MEC* curve, more precisely, assuming no covariance:

$$Qr \succ P \Leftrightarrow \frac{c_2}{b_2} < \delta^2 \Big/ \left(E\left[\frac{1}{f}\right]-1\right)$$

To go further, we have to compute $E\left[1/f\right]$, thus to make special assumptions on the random variable *f*. Let us assume that *f* may take, with an equal probability, to values, $\overline{f}$ and 2-$\overline{f}$. We now have:

$$Qr \succ P \Leftrightarrow \frac{c_2}{b_2} < \left(2-\overline{f}\right)\overline{f}\ .$$

Applying the same assumption, we have:

$$Qr \succ Qa \Leftrightarrow \frac{c_2}{b_2} > \left(2-\overline{f}\right)\overline{f}\ .$$

Qr is thus dominated either by the price instruments or by the absolute quotas; it is never the best instrument, according to the expected social cost criterion. Either the relative quotas are too flexible, so that absolute quotas should be preferred, or they are not flexible enough and price instruments dominate them. Although this conclusion does not necessarily hold for any probability distribution, it indicates that there is, at best, very little room for relative quotas.

5. Initial emissions not strictly proportional to output

New installations tend to pollute less, for a given production level, than older ones, especially in energy intensive industries. How does this well-known stylised fact impact our results?

Let us assume that baseline emissions are linked to output in a fixed proportion, more precisely that a rise in baseline emissions α stems from a surge in output ($a.\alpha$), α >1.

With relative quotas, the State now distributes a quantity of allowances:

$$e_{qrnp} \equiv \hat{e} + a\alpha = \frac{c_2 - b_1}{b_2 + c_2} + a\alpha \tag{11}$$

yielding a price:

$$p\left(e_{qrnp}\right) = \frac{\left(b_1 + b_2\right)c_2}{\left(b_2 + c_2\right)f} - \frac{\left(a-1\right)c_2}{f}\alpha$$

The quota price is now negatively dependent on α . The expected social cost is now:

$$TSC_{Qrnp} \equiv TCC_{Qrnp} + TED_{Qrnp} = \int_{e_{qrnp}}^{1+\alpha} MPB + MED\, de\,. \tag{12}$$

From (1), (2), (4), (8), (11) and (12):

$$Qrnp \succ Qr \Leftrightarrow E\left[TSC_{Qr}\right] > E\left[TSC_{Qrnp}\right] \Leftrightarrow E\left[\frac{1}{f}\right]\frac{\left(a-1\right)^2 c_2\sigma^2}{2} + \frac{\left(a^2-1\right)b_2\sigma^2}{2} < 0$$

which if never true for a>1. Since the outcome of other instruments is not modified by the non-proportionality between baseline emissions and output, this non-proportionality further reduces the room for relative quotas over both price instruments and absolute quotas. Intuitively, when α >0, ex post emissions are already too high with *Qr*, and this drawback is still reinforced when emissions are less than proportional to output.

6. Prices vs. (absolute) quantities reconsidered

From (1), (2), (3), (5), (6), (7) and (9), absolute quotas should be favoured over price instruments (according to the expected social cost criterion) if and only if:

$$Qa \succ P \Leftrightarrow E\left[TSC_P\right] > E\left[TSC_{Qa}\right] \Leftrightarrow$$

$$\frac{1}{2}\left(\frac{\left(b_1+b_2\right)^2}{\left(b_2+c_2\right)^2}\left(b_2\delta^2 - c_2\left(E\left[\frac{1}{f}\right]-1\right)\right) + \left(b_2 - c_2E\left[\frac{1}{f}\right]\right)\sigma^2 - \frac{b_2\left(b_1+b_2\right)\sigma_{\alpha f}}{b_2+c_2}\right) > 0$$

We can first notice that when the variance of f tends to zero, the first and the last terms collapse and the remaining difference in expected social cost is equivalent to that between *Qa* and *Qr* (see above, section 4). In other cases, the last term shows that a positive covariance between f and α (i.e., a negative correlation between the steepness of the MPB curve and baseline emissions) favours the price instrument and vice-versa. Abstracting again from this effect until section 7, as in Weitzman's model, prices tends to be preferable if the MPB curve is steeper than the MEC curve, and vice-versa. However, Weitzman's criterion is modified by expressions involving the random variable *f*. In the second parenthesis, since $E\left[1/f\right]$>1, the advantage of prices is reinforced as compared to the basic Weitzman's criterion. To look at the expression in the first parenthesis, we have to compare $E\left[1/f\right]-1$ to δ^2, thus to make special assumptions on the random variable *f*. Making the same assumptions as in section 4 above, we have:

$$E\left[1/f\right]-1>\delta^2 \Leftrightarrow \frac{\left(\bar{f}-1\right)^4}{\left(2-\bar{f}\right)\bar{f}}>0$$

which is always true since $\bar{f}\in\left(0,2\right)$. As a consequence, as compared to Weitzman's basic model, prices should more often be chosen over quantitative instruments, at least without a negative covariance between *f* and α.

7. Correlation between initial emissions and *MPB* curve slope

As we have seen, a positive correlation between *f* and α (i.e., a negative correlation between the steepness of the *MPB* curve and baseline emissions) favours the price instrument over both relative and absolute quotas, and has no impact on the choice between the latter two instruments. What correlation should we expect, if any?

If a higher output requires new investment in productive capacity, the correlation between the steepness of the *MPB* curve and baseline emissions is clearly negative: it is always cheaper to install a cleaner production process at once than first to install a new production process and then to implement cleaning technologies. If, on the other hand, a higher output just requires a longer utilisation of machines, the "fixed cost" component of abatement measures (scrubbers, heat exchangers…) will generate more abatement for a given cost, so the correlation between the steepness of the *MPB* curve and baseline emissions is negative again.

As a consequence, the above conclusion is still reinforced: prices should more often be chosen over quantitative instruments as compared to Weitzman's basic model.

8. Political economy considerations

Various stakeholders routinely get involved in the policy process to favour one instrument or the other. For example, in the European Union negotiation on greenhouse gas mitigation, most industry lobbies support relative quotas over taxes and over absolute quotas, whereas environmental groups prefer taxes or absolute quotas[4]. How can we explain these positions?

A basic premise is to assume that environmental NGOs are primarily concerned about environmental damage and firms about compliance costs. As regards expected environmental damage, relative quotas perform worse than absolute ones:

$$E\left[TED_{Qr} - TED_{Qa}\right] = \frac{b_2 \sigma^2}{2} > 0$$

This is due to the convexity of the marginal environmental damage function and Jensen's inequality. The comparison of expected environmental damage among instruments is thus consistent with the preference of environmental groups for absolute vs. relative quotas.

The expected environmental damage of relative quotas compared to price instruments is:

$$E\left[TED_{Qr} - TED_{P}\right] = \frac{b_2\left(b_1 + b_2\right)\left(2\left(b_2 + c_2\right)\sigma_{\alpha f} - \left(b_1 + b_2\right)\delta^2\right)}{2\left(b_2 + c_2\right)^2}$$

which is negative except, possibly, with a positive correlation between α and f, but we have just seen that the latter is very unlikely. According to our model, environmental groups should thus favour quotas over taxes, but existing surveys show that there is no general pattern is this respect (Dijkstra, 1999).

For firms that care mainly about expected compliance cost relative quotas yield a better outcome than absolute ones but a worse outcome than price instruments:

$$E\left[TCC_{Qr} - TCC_{Qa}\right] = -\frac{c_2 \sigma^2}{2} E\left[\frac{1}{f}\right]$$

which is negative ;

$$E\left[TCC_{Qr} - TCC_{Pa}\right] = E\left[TCC_{Qr} - TCC_{\Pr}\right] = \frac{\left(b_1 + b_2\right) c_2 \sigma^2}{2\left(b_2 + c_2\right)^2}\left(E\left[\frac{1}{f}\right] - 1\right)$$

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[4] Cf. in particular Climate Action Network Europe (2000) and European Environmental Bureau (2001).

which is positive. We can thus understand the preference of most industry lobby groups for relative quotas over absolute ones, but not their preference for quotas over price instruments.

Risk aversion cannot explain the latter preference either, as shown by figure 2 below, which displays the ex post total compliance cost for each instrument. On the left panel, we have low baseline emissions (α =–0.2) and various values for *f*. On the right panel, we have high baseline emissions (α =0.2) and various values for *f*, with the same scales. Although the worst-case total compliance cost is higher for absolute quotas and prices than for relative quotas, it is even lower for the relative price instrument, whose expected cost is also lower than that of relative quotas, as we have seen.

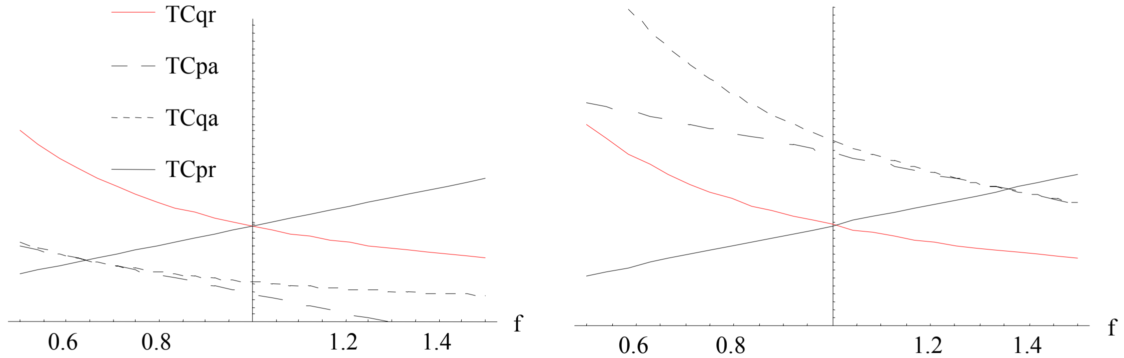

Figure 2. Ex post total compliance cost for low baseline emissions (left panel) and high baseline emissions (right panel)

b_1=0.05, b_2=0.4, c_2=0.4, α =-0.2 (left panel), α =0.2 (right panel)

Furthermore, although there are good reasons to consider that firms are risk-averse (as demonstrated by of the extent of hedging activities), they should not be concerned only by the environmental control burden but by their whole profit. Since, first, baseline emissions are positively correlated with output and, second, a higher output is generally positively correlated with a higher profit, firms should be concerned about avoiding too high a compliance cost associated with low baseline emissions. As shown by the left panel in Figure 2, relative quotas perform very poorly in this respect.

However, there is no reason to think that firms have the same expectations than the State as regards compliance costs. Although they generally have a poorer knowledge of the marginal abatement cost curve when environmental policy is being negotiated than at the subsequent implementation stage, they may very well benefit from an asymmetry of information over the State even at this initial stage. What instrument they will favour in such a situation depends on their beliefs over baseline emissions and over the slope of the *MPB* curve, as compared to policy makers' expectations. The left panel of Figure 3 below displays the values of α and f for which each instrument yields the lowest ex post total compliance cost. It turns out that relative quotas tends to be preferred for a flatter than expected *MPB* (f>1)and higher than expected baseline emissions (α >0). However, as is apparent from the right panel in Figure 3, relative quotas for these parameter values are always dominated by absolute ones.

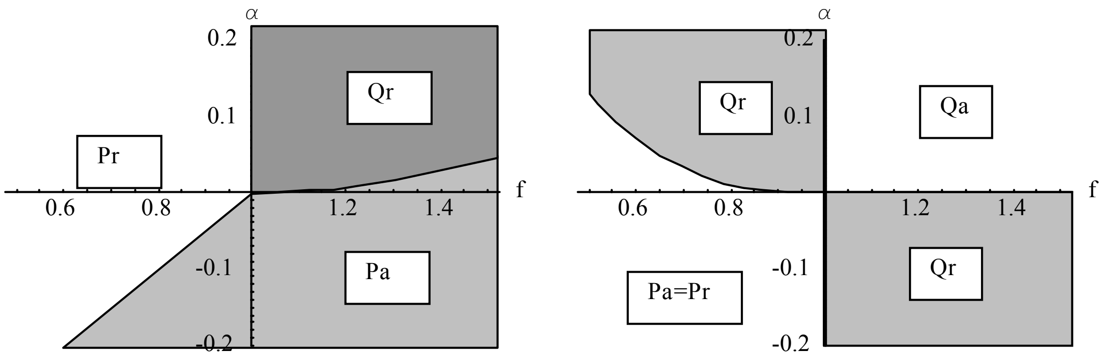

Figure 3. Instrument yielding the lowest ex post compliance cost (left panel) and social cost (right panel) for various values of random variables. b_1=0.05, b_2=0.4, c_2=0.4

As a consequence, industry lobbyists' plea for relative quota, if successful, could very well be a case of regulatory capture, to use Stigler's (1971) wording. Benevolent policy makers should not follow this self-interested advice but utilise this industry position as an indication that they should revise their expectations of baseline emissions upwards and their expectations of the slope of the MPB curve downwards.

Conclusions

In the framework of a stochastic analytical model, we have demonstrated that relative quotas are dominated either by absolute quotas or by price instruments as regards the expected social cost. Furthermore, price instruments entail a lower expected compliance cost than relative quotas. Why, then, do industry lobbyists favour quantity instruments over price instruments? A possible explanation is the following: if the industry anticipates that the State will underestimate output and overestimate the MAC curve slope, it has an interest in defending relative quotas over every other instrument. The problem is that in such a case, both the environmental damage and the social cost are higher with relative quotas than with absolute ones. The choice of relative quotas over price instruments or absolute quotas may thus be a case of regulatory capture, to use Stigler's (1971) vocabulary.

In this paper, we have assumed away the mechanisms present in deterministic models that compare relative and absolute instruments (cf. references in footnotes 1 and 2 above). However, results from this literature add up to ours to be cautious about relative quotas. In particular, Fisher (2001) and Koutstaal et al. (2002) have utilised theoretical models to show that relative quotas entail too high an output level and thus (for a given emission level) too much abatement per unit of output.

All in all, relative quotas appear to be a poor compromise between price and quantity instruments. Robert and Spence (1976) proposal of creating an allowance market with a price cap and a price floor seems a much better compromise.

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KNOW	*Knowledge, Technology, Human Capital* (Editor: Gianmarco Ottaviano)
IEM	*International Energy Markets* (Editor: Anil Markandya)
CSRM	*Corporate Social Responsibility and Management* (Editor: Sabina Ratti)
PRIV	*Privatisation, Regulation, Antitrust* (Editor: Bernardo Bortolotti)
ETA	*Economic Theory and Applications* (Editor: Carlo Carraro)
CTN	*Coalition Theory Network*