EMISSIONS TAX, EMISSIONS TRADING AND ALLOWANCE BANKING UNDER AMBIGUITY AVERSION

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Overview

This article explores the comparative efficiency of tax and cap-and-trade regimes under ambiguity when liable firms exhibit ambiguity aversion, with a special focus on allowance banking. First, this paper first extends the work of Baldursson & von der Fehr (2004) to ambiguity and investigates the impacts of ambiguity aversion on liable firms' optimal abatement decisions. Second, it contributes to the emerging literature on decision-making under ambiguity aversion by providing a novel comparative characterisation of, and numerical simulations for ambiguity prudence and pessimism. It does so by bringing together three stands of literature: decision-making under ambiguity aversion, comparison of environmental market-based instruments, and allowance banking.

In present ETSs, design issues such as ex-post allowance supply management arise due to pervasive uncertainty, e.g. on abatement demand (see e.g. Borenstein et al., 2015) or of political nature (e.g. regulatory uncertainty). This also has an impact on firms' abatement decisions. We argue that ambiguity aversion capture this better than mere risk aversion. In our model, liable firms face one source of exogenous ambiguity: either *(1)* market-level extrinsic ambiguity, channelled via the allowance price; or, *(2)* firm-level intrinsic ambiguity on baseline emissions, also engendering market-level ambiguity via the allowance price endogenously forming on the market.

Methods

In a two-period model, we consider a continuum of homogenous risk-neutral ambiguity-averse polluting firms liable under either a tax or an ETS. As in Slechten (2013) date-1 abatements have long-term effects, that is they are persistent in that they both carry over to date 2 and affect date-2 abatement cost. If environmental regulation is effective at date 2 only, date-1 abatement can be interpreted as investment in abatement technology or 'early emission reduction' in the perspective of future regulation. If environmental regulation is effective at both dates, we assume that liable firms are already in compliance at date-1 and that they have exhausted all trades opportunities, so that date-1 abatement corresponds to additional abatement in expectation of a more stringent regulation at date-2, i.e. allowance banking.

Agents display smooth ambiguity aversion (Klibanoff et al., 2005,2009) in its recursive form. This brings about nice comparative statics and tractability properties, thanks to which explicit computations of optimal date-1 abatement, otherwise hard to come by, are bypassed. In the presence of one source of ambiguity, *(1)* or *(2)*, we analyse how ambiguity aversion alters optimal date-1 abatement decisions under both instruments, where ambiguity neutrality serves as our benchmark. In this sense, our analysis differs from the Weitzman-like 'prices vs quantities' literature. We conduct numerical simulations to measure the two ambiguity aversion-induced effects, namely pessimism and ambiguity prudence (see e.g. Gierlinger & Gollier (2015)), when initial allocation or ambiguity aversion vary, which is a novelty. We finally consider and discuss natural extensions to our model.

Results

1. Under a tax regime with ambiguous baselines, intertemporal cost-efficiency obtains only when agents display Constant Absolute Ambiguity Aversion (CAAA). Otherwise, at date 1, firms over-abate (under-abate) relative to ambiguity neutrality when they exhibit Decreasing (Increasing) Absolute Ambiguity Aversion, or DAAA (IAAA). It is hence natural to define ambiguity prudence as DAAA, as in Gierlinger & Gollier (2015).

2. In an ETS with ambiguous future allowance price, intertemporal cost-efficiency does not obtain in general. As compared with the tax regime where the price is deterministic, ambiguity averse firms distort the future allowance price in a pessimistic manner by overweighting 'bad' scenarios. For pessimism to lead to date-1 over-abatement, 'bad' scenarios must coincide with those scenarios inducing high marginal date-2 profitability from date-1 abatement – hence corresponding to an anticomonotonicity criterion between date-2 profits and marginal profits across scenarios. As in Baldursson & von der Fehr (2004), this translates into a threshold condition on initial allocation: In line with a precautionary effect, only when firms are allocated too few permits, i.e. they expect to be net buyer of permits at date 2 under ambiguity neutrality in all scenarios, does anticomonotonicity holds. We note that this might be too strong a requirement. In total, ambiguity aversion induces two effects, ambiguity prudence and pessimism, which can reinforce one another or work in opposite directions. In particular, when firms are allocated to few permits, DAAA or CAAA is conducive to over-abatement at date 1 while one cannot sign the date-1 abatement adjustment for sure under IAAA.

3. In the special case where price ambiguity is binary, both the threshold condition and the effects of ambiguity aversion are clearer. When ambiguity bears on firms' baselines, we are able to derive more fine-grained results and show that under a symmetric allocation plan, anticomonotonicity always holds. In terms of comparative statics, we show that an increase in the degree of ambiguity aversion always leads to: an increase in pessimism in the sense of a monotone-likelihood deterioration; an increase in the ambiguity prudence coefficient provided that ambiguity prudence is not too high relative to ambiguity aversion. In general we find that it is difficult to sign the effect of an increase in initial allocation on optimal date-1 abatement for a given ambiguity aversion degree.
4. With numerical simulations, we find that: date-1 abatement unambiguously decreases with initial allocation; a uniquely defined threshold on initial allocation exists, below (above) which firms over-(under-)abate. From this, we infer that it suffices that anticomonotonicity holds in expectations over the set of possible scenarios for pessimism to be conducive to over-abatement. In an ETS under CAAA, for a given allocation level, the higher the degree of ambiguity aversion, the higher the variation in date-1 abatement relative to neutrality and the higher the sensitivity of date-1 abatement around the threshold. In particular, smooth ambiguity aversion describes the continuum between the two limiting cases of ambiguity neutrality and the pioneering MEU decision criterion of Gilboa & Schmeidler (1989). In a tax regime under DAAA, ambiguity aversion always leads to higher date-1 abatement but a higher degree of ambiguity aversion is not necessarily conducive to higher date-1 abatement. In an ETS under DAAA, ambiguity prudence adjusts date-1 abatement upwards for all ambiguity aversion degrees and all initial allocation levels, but does so with different intensities. In particular, when initial allocation is relatively small, a higher ambiguity aversion degree is not necessarily conducive to higher date-1 abatement. Overall, it seems that the pessimism effect is the main driver of date-1 abatement adjustment while the ambiguity prudence effect remains marginal, especially around the threshold on initial allocation.
5. We also consider some extensions to our model. When forward contracts are introduced and assumed to be fairly priced, the pessimism effect vanishes out, but the ambiguity prudence effect remains: An ETS with forwards performs like a tax. When the market comprises both ambiguity averse and neutral firms, we show that date-1 abatement decisions deviate further away from the optimum for ambiguity-averse firms while ambiguity neutral firms also reduce date-1 abatement. We show that the presence of ambiguity averse firms in the market reduces the overall traded volume. We finally discuss our results robustness to the introduction of risk aversion, more periods, more heterogeneity across firms and to two simultaneous sources of ambiguity.

Conclusion

In terms of preferability of instruments, our paper mitigates Baldursson and von der Fehr (2004)'s findings that only the ETS deteriorates in the presence of uncertainty. Under ambiguity aversion, a tax regime is also not conducive to efficiency. As standard, note that the introduction of ambiguity aversion is not necessarily conducive to over-abatement at date 1 but is rather in line with a precautionary effect so that this eventually depends on both the initial allocation level and the degree of ambiguity aversion. Ambiguity aversion induces two effects: pessimism and ambiguity prudence. We find that pessimism is the central effect while ambiguity prudence has a residual role, except in extreme situations where initial allocation is very low or very high.
Because pessimism is absent in a tax regime, one might be tempted to conclude that, despite it is not cost-efficient, tax still performs better than cap and trade. However, we find that the introduction of forwards mitigates the pessimism effect, and, when ambiguity bears on firms' abatement costs, we show that the two instruments are equivalent in terms of performance under ambiguity aversion. This also mitigates Zhao (2003)'s findings that ETS better sustains investment incentives than taxes do under cost uncertainty.

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