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Emissions trading with profit-neutral permit allocations ☆

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ABSTRACT

This paper examines the impact of an emissions trading scheme (ETS) on equilibrium emissions, output, price, market concentration, and profits in a generalized Cournot model. We develop formulae for the number of emissions permits that have to be freely allocated to firms to neutralize the profit impact of the ETS. We show that its profit impact is usually limited: in a Cournot oligopoly with constant marginal costs, total industry profits are preserved so long as freely allocated permits cover a fraction of initial emissions that does not exceed the industry's Herfindahl index.

1. Introduction

There is increasingly broad recognition that greenhouse gas emissions are contributing to changes to Earth's climate. Emissions trading schemes for CO_2 and other greenhouse gases are an important part of the policy response to this problem. The justification for the use of economic instruments, such as emissions trading and emissions taxes, arises from the observation that imposing a common price on emissions equalizes marginal abatement costs across polluting firms and minimizes the aggregate cost of pollution control (see Baumol and Oates, 1988). In most cases, this makes economic instruments more efficient than "command-and-control" intervention which specifies input or output standards or technologies. However, there is a significant disadvantage to the use of taxes or trading: inframarginal wealth transfers in the form of payments of taxes or for emissions permits impose an additional burden on industry. The extent to which this burden can be alleviated affects the magnitude of emissions reductions that are politically feasible.

Policy makers have sought to alleviate this problem by implementing trading schemes where all or some of the emissions permits are granted for free. This is often referred to as *grandfathering* since the number of permits freely allocated to a firm is typically related to its past emissions. Grandfathering relieves the financial burden of the ETS on industry, without affecting firms' incentives to reduce emissions at the margin.[1]

For most emissions trading schemes in the US, and also in the early phases of the European Union's ETS for CO_2 (EU ETS), almost all permits were freely allocated in this manner. It is clear that not selling permits (at auction, say) entails a significant loss of government revenue which could potentially be more productively employed in other

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[1] Another method of protecting average profits in an industry is to hold an auction for emissions permits but to then return the revenue back to the firms using some other formula. This was originally proposed by Hahn and Noll (1982); a small fraction of the permits in the Sulfur Allowance Program is allocated through a zero-revenue auction (see Tietenberg (2006, Chapter 6)).

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ways (for example, in the reduction of distortionary taxes).[2] Furthermore, a firm's incentive to raise prices in response to the higher marginal cost is also unaffected by the free allocation of permits. This raises the possibility that firms will make "windfall profits" from free permit allocations. For these reasons and others, the question of whether to freely allocate permits, and, if so, to what extent, is an important one.

1.1. Model setup and ETS impact on emissions

The aim of this paper is to provide a basic theoretical framework in which the profit impact and other central issues relating to an ETS can be analyzed. We assume that the industry affected by the ETS is an oligopoly in its product market. The industry's *conduct parameter* θ governs the strategic interaction within the industry, with $\theta=1$ corresponding to a Cournot oligopoly, $\theta=0$ corresponding to perfect competition, and higher values of θ implying more collusive behavior. The production process gives rise to emissions, which have to be paid for with emissions permits; firms are price-takers in the market for permits. This is a reasonable setup since we have in mind a trading scheme, like the EU ETS, where permits are traded across many industries in (potentially) many countries, so that firms are price takers in the market for permits, while individual industries have oligopolistic structures.

Before we examine the issue of permit allocations, several more basic questions need to be answered. Most importantly, does the imposition of a price on emissions have the desired effect of reducing emissions in this industry? This effect, however intuitive, is not guaranteed in an oligopoly model.[3] We show that two added conditions on the model guarantee that the ETS has the effect of reducing industry output, reducing firms' average emissions intensity—and hence also reducing total emissions: (a) firms' marginal costs are non-negatively correlated with their emissions intensities,[4] and (b) the industry faces a log-concave demand function.[5]

The imposition of a price on emissions will always encourage firms to engage in abatement, thus (weakly) lowering each firm's emissions intensity. But the ETS also changes firms' output decisions, so that the industry's *average* emissions intensity can increase if dirtier firms gain market share. We show that this possibility is excluded by conditions (a) and (b), which together have two important effects. First, firms with lower marginal costs gain market share and, since these are the bigger firms in the industry to begin with, market concentration in the industry rises. Second, since (a) guarantees that these firms are *not* more emissions intensive, the industry's average emissions intensity and total emissions both decline.

1.2. ETS impact on profits

The gain in market share of lower-cost firms means that the ETS has the effect of moving the industry closer to the joint profit-maximizing (fully collusive) outcome. This is one reason why the adverse profit impact (averaged across the whole industry) of the ETS tends to be limited. We measure the profit impact by looking at the *profit-neutral permit allocation* (PNA): the number of permits that have to be freely allocated to the industry to guarantee that aggregate industry profit is preserved at its level from before introduction of the ETS. Our framework yields bounds on this number without requiring a fully-specified parametric model. In particular, consider a Cournot oligopoly with constant marginal costs and satisfying conditions (a) and (b). We show that if x is the number of permits required to cover the industry's pre-ETS emissions (had the permits been needed), then the profit-neutral permit allocation is below Hx, where H is the Herfindahl index (see Case 4, Section 4.2). This bound becomes more (less) stringent if the industry is more (less) competitive than Cournot (equivalently, if the conduct parameter $\theta\leq(>)1$). Even in relatively concentrated industries, the Herfindahl index is often *much* lower than 0.5. For example, consider a Cournot oligopoly with a Herfindahl index of 0.4, and suppose the ETS targets a 20% reduction in emissions. In this case, the number of emissions permits required for profit-neutrality, as a fraction of the number of issued permits, is no more than 0.4/0.8 or 50%. In other words, about half the number of permits can be auctioned whilst preserving total industry profit. If instead the industry's Herfindahl index is 0.20, the required proportion of free permits falls to 25%.

Our results on profit-neutral permit allocations are obtained by developing formulae that bound the level of profit-neutral permit allocations at the firm- and industry-level. These formulae involve familiar parameters that can often be estimated with a reasonable degree of accuracy, making them amenable to empirical implementation. We illustrate this by applying them to calculate the profit-neutral permit allocation in the UK cement industry (which is included in the EU ETS). This application also shows that profit-neutral permit allocations can remain low even if we depart significantly from assumptions (a) and (b).

1.3. Related literature

Bovenberg et al. (2005) (see also Bovenberg and Goulder (2001)) build a competitive general equilibrium model in which capital is imperfectly mobile, so that investment in sectors affected by an ETS will have a lower rate of return. Capital in these sectors could be compensated with free permits, which in turn has an economy-wide efficiency cost (because, for instance, of the foregone opportunity to reduce distortionary taxes). They consider a scheme to control SO_2 emissions in the U.S. and show that the efficiency cost of compensation policies is limited, mainly because the extent of free permit allocations needed to maintain equity returns is low (no more than 50% of issued permits). Their model assumes that all sectors of the economy (including those affected by the ETS) are perfectly competitive, so the qualitative features of their analysis are related to our analysis of the perfectly competitive case (see Case 1, Section 4.2).

This paper does not consider various other interesting issues relating to emissions trading, including some that may have an impact on profit-neutral permit allocations.[6] Among our main assumptions is that firms are price takers in the market for permits. This will be violated in situations where the permit market is not significantly broader than the product market; Hahn (1984) and Liski and Montero (2006) consider market power in the emissions market, motivated by the markets for acid rain and particulates.[7] The allocation process can also lead to rent-seeking behavior among firms; for an account of this process in the case of the Acid Rain Program, see Joskow and Schmalensee (1998). It has also been argued that the incentive for technological innovation in emissions abatement is dependent on grandfathering. Some of these issues are surveyed by Cramton and Kerr (2002) who also discuss alternative methods for auctioning permits.

[2] See, e.g., Fullerton and Metcalf (2001), Bovenberg and Goulder (2001), and Bovenberg et al. (2005).

[3] The possibility of such perverse effects has also been noted in Levin's (1985) study of emissions taxation in a Cournot model. An issue closely related to this is that of the optimal level of emissions taxation; on this issue, see Ebert (1992) and Simpson (1995). Both of these issues are discussed in Requate's (2007) survey of the literature on environmental policy under imperfect competition.

[4] Emissions intensity is defined as emissions per unit of output. Note that condition (a) is consistent with notions of eco-efficiency (see Section 3 for more discussion). It is also satisfied if firms do not differ significantly in their emissions intensities.

[5] Log-concavity is a commonly-made restriction on the demand function; it is a sufficient (and, in a certain sense, necessary) condition for a Cournot oligopoly to be a game of strategic substitutes (see Section 3 for more discussion).

[6] See also Tietenberg (2006) for a careful summary of these points.

[7] Clearly, the presence of transaction costs also means that initial permit allocations have strategic consequences (Stavins, 1995), although there is some evidence of transaction costs being low in the US sulfur dioxide scheme (see Joskow et al., 1998).