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10

Updating the Allocation of Greenhouse Gas Emissions Permits in a Federal Cap-and-Trade Program

Meredith Fowlie

10.1 Introduction

A growing sense of urgency is fueling efforts to pass domestic climate change legislation now, rather than waiting for a coordinated global agreement to emerge. Debates about how and when to implement these policies have been dominated by concerns about potentially adverse impacts on domestic industrial competitiveness, trade flows, and emissions leakage. Policymakers are looking to strike an appropriate balance between curbing domestic greenhouse gas (GHG) emissions and protecting the competitive position of domestic manufacturing in the near-term.

Border tax adjustments offer one approach to "leveling the carbon playing field," as discussed in chapter 3 by Krishna in this volume.[1] This chapter considers an alternative approach. Proposed federal climate change legislation includes provisions that would freely allocate emissions allowances to eligible industries using a continuously updated, output-based formula. These free permit allocations are designed to offset both direct and indirect

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1. An important concern with regard to these countervailing measures is that they may not pass World Trade Organization (WTO) scrutiny. Border tax adjustments included in the House bill were criticized by President Obama who noted that "we have to be very careful about sending any protectionist signals" ("Rust Belt Democrats say Obama was 'wrong' to criticize trade provisions," *E&ENews PM,* 07/07/2009). Available at: http://www.eenews.net/public/eenewspm/2009/07/07/1.

compliance costs in eligible sectors, while preserving some incentive for individual firms to reduce their emissions intensity.

The potential benefits of these proposed allocation provisions, including the mitigation of emissions leakage and the moderation of adverse competitiveness impacts, have been well documented (US EPA, EIA, and Treasury 2009). This chapter draws attention to the fact that these benefits come at a cost. When output-based rebates are offered to a subset of the sources in an emissions trading program, a greater share of the mandated emissions reductions must then be achieved by sources excluded from rebating provision. This can significantly undermine the economic efficiency of permit market outcomes.

The chapter makes two important contributions. First, it extends the previous literature on output-based allocation updating in order to characterize cost-benefit trade-offs inherent in proposed output-based allocation updating provisions.[2] A simple analytical model is used to investigate the welfare consequences of allocating permits via output-based updating in one or more industries in a GHG emissions trading program. In a first-best policy setting, output-based permit allocation updating reduces welfare vis-à-vis auctioning or lump-sum permit allocations.[3] If emissions regulation is incomplete (meaning that a subset of the emitting sources are exempt from the regulation for some reason), the benefits of output-based rebating can exceed the costs. The net welfare implications of output-based rebating depend on a variety of factors, including the elasticity of domestic demand and supply, the emissions intensity of domestic and foreign production, and the price responsiveness of imports.

Second, the chapter illustrates how cost-benefit trade-offs can inform decisions about the appropriate scale and scope of these allocation-based incentives. Among the most fundamental questions in the design of cost mitigation measures is: Who should be eligible for this assistance? From an economic efficiency perspective, output-based rebates should only be offered in cases where the benefits to the industry receiving the rebate exceed the costs imposed on other sectors and stakeholders. The analytical model is used to derive eligibility criteria that are consistent with a standard, albeit stylized, welfare maximization concept. This exercise helps to highlight qualitative differences between the eligibility criteria defined in proposed legislation and those derived from a theoretical welfare maximization exercise.

2. A growing literature investigates the efficiency implications of output-based allocation updating. Previous work has demonstrated how output-based allocation updating will generally undermine the efficiency of permit market outcomes in first-best policy settings (Bohringer and Lange 2005; Fischer 2001; Sterner and Muller 2008) and that allocation updating has the potential to be advantageous when there are preexisting distortions to contend with (Bernard, Fischer, and Fox 2007; Fischer 2003; Fischer and Fox 2007).

3. A first-best setting, in this context, is one that is free of market distortions or failures, other than the environmental externality that the emissions regulation is designed to address.

Although this chapter is germane to ongoing policy debates, it is important to put this analysis in context. The underlying model assumes a fairly stylized objective function for the policymaker; political constraints are ignored entirely. In practice, the political viability of any federal climate change policy is going to depend significantly on the distribution of costs and benefits across politically powerful constituencies. Permit allocation is the most important lever that policymakers have to use to alter the distributional implications of an emissions cap-and-trade program, so it seems inevitable that concessions will be made in order to design an emissions trading program that is supported by key stakeholders. An important objective of this chapter is to draw attention to the welfare costs incurred when these concessions come in the form of output-based rebates.

The chapter proceeds as follows. The next section provides an overview of permit allocation design in cap-and-trade programs, with an emphasis on the political economy of these design decisions. Section 10.3 briefly summarizes the output-based rebating provisions in the proposed federal climate change legislation currently being considered by Congress. Section 10.4 presents a simple analytical framework that can be used to characterize the advantages and disadvantages of output-based updating provisions. Section 10.5 brings the analysis to bear upon the eligibility issue. Section 10.6 concludes.

10.2 Permit Allocation as Industry Compensation

Historically, policymakers have chosen between two types of permit allocation approaches: auctioning and grandfathering. Under an auction regime, emissions permits are sold to the highest bidder. In contrast, grandfathered permits are freely distributed in lump-sum to regulated sources based on predetermined, firm-specific characteristics.

In theory, provided standard assumptions are met, the efficiency properties of the permit market equilibrium are achieved regardless of whether permits are auctioned or grandfathered.[4] This so-called "independence property" has important policy implications (Hahn and Stavins 2010). If the initial distribution of permits plays no role in the determination of emissions and abatement outcomes in equilibrium, emissions permits can be freely allocated to pursue political objectives (such as establishing a constituency for the market-based regulation).

Economists have generally argued in favor of auctioning permits when

4. Assumptions include: perfectly competitive input and output markets, no preexisting regulatory distortions (such as factor taxes), zero transaction costs, complete information, lump-sum free allocations, and compliance-cost-minimizing firms. This result is closely related to a seminal paper by Coase (1960) and has been formally demonstrated in an emissions permit market context by Montgomery (1972).

auction revenues can be used to offset factor taxes or other preexisting distortions.[5] However, policymakers have routinely chosen to forego auction revenues in favor of handing permits out for free to regulated entities.[6] The ability to make concessions to adversely impacted and politically powerful stakeholders via grandfathering has played an essential role in securing widespread support for the adoption of emissions trading programs.

A pure grandfathering approach is unlikely to be a politically feasible option in the context of a federal GHG trading program, primarily due to the unprecedented value of the permits to be allocated.[7] A lump-sum allocation of all GHG permits to regulated sources would likely result in significant overcompensation (Bovenberg and Goulder 2001). Pure auctioning is also unlikely because politically powerful industry stakeholders are united in their opposition to this approach (at least in the near term).[8]

In this politically charged climate, output-based updating of permit allocations has emerged as something of a Goldilocks solution. Proposed output-based updating provisions are designed to offset the average effect that emissions regulation would otherwise have on producers' variable operating costs. Industry is compensated—but not overcompensated—for the compliance costs incurred. Because the number of permits a firm is freely allocated is increasing with its output, equilibrium levels of domestic manufacturing activity will exceed those associated with auctioning or grandfathering. This in turn implies larger domestic market shares in trade-exposed markets, fewer manufacturing jobs lost, and less emissions leakage.

The economic benefits and political advantages of output-based updating come with strings attached. An important drawback is that the independence property no longer holds. Making future permit allocations conditional on current production choices undermines the efficiency of the permit market outcome by dampening (or eliminating) incentives for consumers to reduce their consumption of goods produced by industries receiving output-based rebates. Increased production (and emissions) in these industries shifts more of the compliance burden to sources outside the provision. Contingent allocation updating therefore introduces important trade-offs between

5. A summary of the literature that considers the permit allocation design choice in the presence of distorted factor markets is provided by Goulder and Parry (2008).

6. A majority of permits are distributed freely to regulated entities in Southern California's RECLAIM program, the European Union's Emissions Trading Program (EU ETS), the National Acid Rain Program (ARP), and the regional NO_x Budget Trading Program.

7. The Congressional Budget Office estimates that emissions permits allocated annually under the federal cap-and-trade system proposed by the Senate in 2009 could be worth up to $300 billion a year by 2020 (CBO 2009).

8. The US Climate Action Partnership, a nonpartisan coalition comprised of twenty-five major corporations and five leading environmental groups, has urged Congress to use some portion of allowances to buffer the impacts of increased costs to energy consumers, and to provide transitional assistance to trade-exposed and emissions-intensive industry (United States Climate Action Partnership [USCAP], "A Blueprint for Legislative Action," January 2009). Available at: http://www.us-cap.org.

reducing the compliance cost burden for a specific sector and minimizing the overall economic cost of achieving mandated emissions reductions.

10.3 Proposed Measures to Address Near-Term Competitiveness Impacts

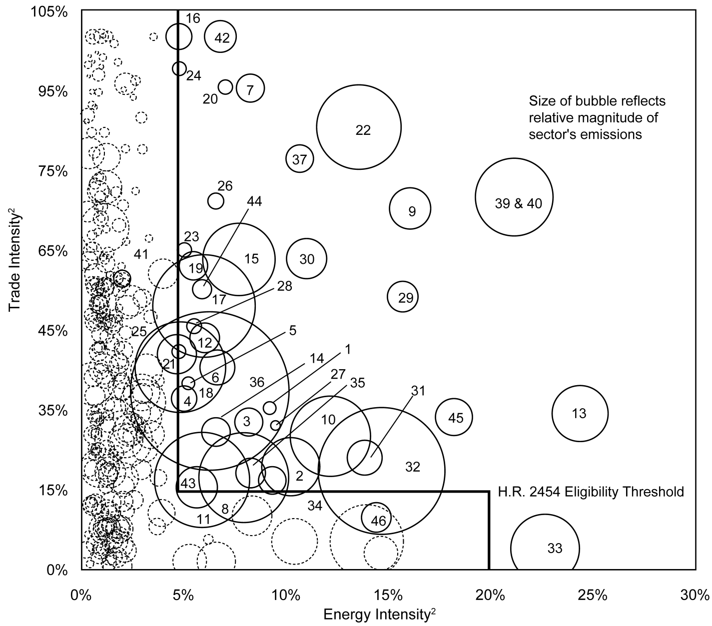
Climate change legislation passed in the House in 2009, but ultimately dismissed by the Senate, would have establishd a multisector cap-and-trade system in which a subset of industries are eligible for rebates (in the form of a free permit allocation) for direct and indirect compliance costs.[9] Figure 10.1 illustrates the proposed eligibility criteria. Eligibility is determined at the six-digit NAICS industry-classification level. The size of each industry-specific circle reflects annual greenhouse gas emissions in 2006. The horizontal axis measures energy expenditures as a share of the value of domestic production. The vertical axis measures the combined value of exports and imports as a share of the value of domestic production plus imports. This measure is intended to capture the extent to which an industry is exposed to foreign competition.

An industry is defined to be "presumptively eligible" for output-based rebates if energy intensity or greenhouse gas emissions intensity is at least 5 percent and import penetration is at least 15 percent. Industries with energy or emissions intensities exceeding 20 percent are also eligible regardless of trade intensity. The broken line in figure 10.1 traces out this eligibility threshold. Industries lying to the right of this line are presumptively eligible to receive rebates under this provision.

Recent analysis suggests that forty-four manufacturing industries are presumptively eligible based on these criteria. Taken together, these industries account for 6 percent of all manufacturing employment and 12 percent of the total value of annual manufacturing shipments (US EPA, EIA, and Treasury 2009). Approximately 15 percent of the total allocation is set aside for output-based rebating. This annual set-aside exceeds the total emissions of presumptively eligible industries in 2006.

The potential benefits of this output-based rebating provision have been analyzed in detail. Multiple recent studies of H.R. 2454 predict that output-based rebating will significantly mitigate, if not eliminate, negative impacts on energy-intensive manufacturing outputs and emissions leakage (EIA 2009; US EPA 2009; US EPA, EIA, and Treasury 2009). Although much work has been done to document the benefits of this compensating provision, there have been few, if any, attempts to estimate the costs.

9. Direct compliance costs are calculated as the product of the eligible entity's output two years prior and the greenhouse gas emissions intensity for all entities in the sector. Rebates for indirect emissions costs are based on the eligible entity's electricity use, the average electricity intensity in the sector, and an estimate of the emissions intensity of the electricity consumed by the eligible entity.



"Presumptively Eligible" for "Trade-Vulnerable" Allocations

Not "Presumptively Eligible" for "Trade-Vulnerable" Allocations

1. Malt Manufacturing (311213)
2. WetCom Milling (311221)
3. Rendering and Meat By product Processing (311613)
4. Yarn Spinning Mills (313111)
5. Tire Cord andTire Fabric Mills (314992)
6. Reconstituted Wood Product Manufacturing (321219)
7. Pulp Mills (322110)
8. Paper (except Newsprint) Mills (322121)
9. Newsprint Mills (322122)
10. Paperboard Mills (32213 0)
11. Petrochemical Manufecturing (325110)
12. Inorganic Dyeand Pigment Manufacturing (325131)
13. Alkalies and Chlorine Manufacturing (325181)
14. Carbon Black Manufacturing (325182)
15. All Other Basic InorganicChemicalMfg. (325188)
16. Cyclic Crude and Intermediate Manufacturing (325192)
17. All Other Basic Organic Chemical Mfg. (325199)
18. Plastics Material andResinManufacturing (325211)
19. Synth etic Rubber Manufacturing (325212)
20. Cellulosic Organic Fiber Manufacturing (325221)
21. Noncellulosic Organic Fiber Manufasturing (325222)
22. Nitrogenous Fertilizer Manufacturing (325311)
23. Vitr. China Plumbing Fixture and Other Mfg. (327111)
24. Vitreous China and Other Pottery Mfg. (327112)
25. Porcelain Electrical Supply Manufacturing (327113)
26. Ceramic Wall and FloorTile Manufacturing (327122)
27. Other Structural Clay Product Manufacturing (327123)
28. Nonclay Refractory Man ufasturing (327125)
29. Flat Glass Manufecturing (327211)
30. Other Pressed/Blown Glass and Glsswr. Mfg. (327212)
31. Glass Container Manufacturing (327213)
32. Cement Manufactoring (327310)
33. Lime Manufacturing (327410)
34. Ground or Treated Mineral and Earth Mfg. (327992)
35. Mineral Wool Manufecturing (327993)
36. Iron and Steel Mills (331 111)
37. Electrometalluigical Ferroalloy Product Mfg. (331112)
38. Iron/Steel Pipe/Tube Mfg. from Purchsd. Steel (331210)
39. AluminaRefining(331311)
40. Primary Aluminum Production (331312)
41. Primary Smelting an d Refining of Copper (3 31411)
42. Smltg./Rfg. of Nonfrs.Mtl. (ex Cpr. and Almn.) (331419)
43. Iron Foundries (331511)
44. Carbon and Graphite Product Manufacturing (335991)
45. Iron OreMining(212210)
46. Copper Ore and Nickel Ore Mining (212234)

Fig. 10.1 Energy intensity, trade intensity, and emissions of US manufacturing sectors at the six-digit NAICS code-level

Source: "The effects if H.R. 2454 on international competitiveness and emissions leakage in energy-intensive and trade-exposed industries: An interagency report responding to a request from Senators Bayh, Specter, Stabenow, McCaskill, and Brown." December 2, 2009; and EPA analysis.

Notes: 1. Petroleum refining is not depicted because it is explicitly excluded from H.R. 2454's allocations to "trade-vulnerable" industries. Also, 91 other sectors, with 126MMTCO2e of emissions, are not depicted due to lack of trade-intensity data. One of these, iron and steel pipe and tube manufacturing from purchased steel (331210; 2.5 MMTCO2e) is expected to be eligible based on language in the bill. Four others meet the energy-intensity threshold, each with two to three MMTCO2e of emissions: beet sugar manufacturing, broadwoven fabric finishing mills, steel foundries (except investment), and metal heat treating. Twelve sectors with a calculated trade intensity greater than 100 percent are depicted here with an intensity of 100 percent (the maximum possible intensity). The two copper sectors (212234 and 331411) do not meet the energy or trade intensity thresholds specified in H.R. 2454, but are expected to be eligible based on other language in the bill.

2. Energy-intensity and trade-intensity measures are as defined in H.R. 2454 and elsewhere in this report.

10.4 The Costs and Benefits of Output-Based Rebating

This section provides a framework for analyzing the cost-benefit tradeoffs inherent in output-based allocation updating. To keep the analysis tractable and intuitive, I make several simplifying assumptions:

1. General equilibrium effects, including interactions with preexisting factor taxes, are not considered.
2. Throughout the analysis, the permit price τ is an exogenous parameter, equivalent to assuming that the aggregate marginal abatement cost curve is flat in the neighborhood of the constraint imposed by the emissions cap. This assumption is likely to be approximately true in a federal GHG trading program.[10]
3. I focus exclusively on the short-run implications of output-based rebates. Because output-based rebating is intended as a temporary stop-gap measure, an analysis that conditions on initial technological characteristics is important.[11]
4. Operating costs and emissions rates are assumed to be immutable technology characteristics in the short run. In fact, many industries have some ability to reduce their emissions intensity in the short run through fuel switching or input substitution. Short-run abatement opportunities will lower the costs of output-based updating, all else equal.
5. The model does not capture heterogeneity in cost structure and emissions intensity across producers within an industry. This rules out any reallocation of production to relatively clean firms (which would reduce the costs of output-based rebating).
6. Social welfare is defined to be the value of consumption less the costs of industrial production less costs associated with greenhouse gases emitted as a consequence of this production and consumption.

10.4.1 Rebating Compliance Costs in an Autarkic Industry

I first consider a perfectly competitive industry in which there is no trade with unregulated jurisdictions (i.e., the "autarkic" case). This exercise helps to lay the foundation for the more complicated, trade-exposed industry case. It is relevant to any permit regime that would make industries with no trade exposure, but exceptionally high emissions intensities, eligible for output-based allocations.

10. Keohane (2009) estimates the slope of the marginal abatement cost curve in the United States to be 8.0×10^7 \$/GT CO_2 for the period 2010 to 2050 (expressed in present-value terms and in 2005 dollars). If this value is used to crudely approximate the slope of the permit supply function, a 10 percent reduction in the emissions of "presumptively eligible" industries over this forty-year period is associated with only a \$0.25/ton decrese in permit price.

11. Output-based allowance allocations for emissions-intensive US industry are portrayed as a "stop-gap measure." "The Carbon Leakage Prevention Act (H.R. 7146) Output-Based Allowance Allocation for Emissions-Intensive U.S. Industry Rep. Jay Inslee (D-WA) and Rep. Mike Doyle (D-PA)." Available at: http://otrans.3cdn.net/5c61e8367815ece533_7om6bhijz.pdf.

The industry is comprised of N identical sellers producing a homogeneous good q and generating greenhouse gases. These producers have convex cost functions $C(q_i)$, linear marginal costs cNq_i, and a constant emissions rate e per unit of output. Market output is denoted $Q = \sum_{i=1}^{N} q_i$. The inverse demand function is $p(Q) = a - bQ$.

Firms in this industry are required to participate in a greenhouse gas emissions trading program. To remain in compliance, producers must hold sufficient permits to offset their emissions eq. I assume that all firms comply with the program and that the aggregate cap binds such that $\tau > 0$. A firm's short-run profit function is:

$$\pi_i = p(Q)q_i - C(q_i) - \tau(1 - s)eq_i + \tau L_i,$$

where $C(q_i)$ captures firm-level operating costs and s is the rate at which compliance costs are rebated to firms, $s \in (0,1)$.

This simple model nests the three classes of permit allocation regimes under consideration. The firm's lump-sum permit allocation is L_i. Let $\bar{E}$ represent the total number of permits to be allocated for free to this industry. Under complete auctioning, $L_i = 0 \; \forall \; i$ and $s = 0$. Under complete grandfathering, $\sum_i L_i = \bar{E}$ and $s = 0$. Under complete output-based rebating, $L_i = 0 \; \forall \; i$ and $s = \bar{E} / Q$.

The assumption of identical firms implies that $Q = nq_i$. Profit maximization implies that the equilibrium level of output in this perfectly competitive industry is:

$$Q_A^* = \frac{a - \tau e + s\tau e}{b + c}, \tag{1}$$

where the subscript A denotes the autarkic case and c denotes the slope of the aggregate (i.e., industry) marginal cost curve.

Conditioning on the model parameters τ, a, b, and c, we can express the welfare implications of production and pollution activities in this industry as a function of s:

$$W_A(s) = \int_0^{Q(s)} p(x)dx - \int_0^{Q(s)} C(x)dx - \tau e Q(s). \tag{2}$$

This welfare measure captures the benefits from consumption less the costs of production less damages from industry emissions.

The net welfare impact of offering an output-based rebate (relative to the welfare obtained under a more standard auctioning or grandfathering permit allocation regime) can thus be expressed as:

$$W_A(s) - W_A(0) = -\frac{e^2\tau^2 s^2}{2(b + c)} < 0. \tag{3}$$

Figure 10.2 provides a graphical illustration of the partial-equilibrium welfare consequences of output-based allocation updating at a rate of $s = 1$

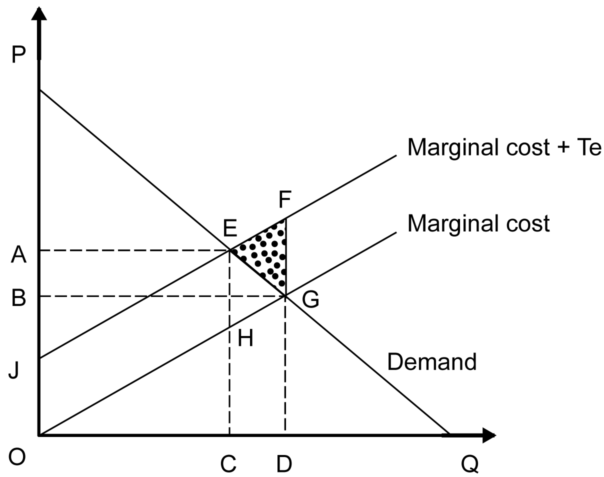


Fig. 10.2 Welfare impacts of an output-based rebate of environmental compliance costs in an emissions-intensive industry with no trade exposure

relative to a baseline policy regime in which permits are grandfathered or auctioned (such that $s = 0$). In the baseline case, quantity C is sold at price A. When compliance costs are rebated in full, a quantity D is sold at a price of B. The net increase in producer and consumer surplus induced by the output-based permit allocation updating is area EGH. Note that rebating also induces an increase in industry emissions of $(D - C)e$.

System-wide emissions are subject to the same binding cap across all allocation regimes, so any rebate-induced increase in emissions from this industry must be offset elsewhere. Put differently, when output-based rebates are offered to this industry, abatement in other industries under the cap or purchases of permits from other countries must rise relative to grandfathering or auctioning levels. By assumption two, there is a sufficient supply of abatement from sources outside the industry to offset this increase in emissions at a per unit cost of τ. The costs of permit allocation updating manifest as an increase in the abatement costs incurred at sources outside this industry. In figure 10.2, this cost is represented by area $EFGH$. Subtracting this rebate-induced cost from the benefits yields a welfare cost equal to the shaded area EFG.[12]

Two insights from this autarkic case are worth highlighting. First, auctioning or grandfathering welfare dominates output-based allocation up-

12. Figure 10.2 also helps to illustrate some of the distributional consequences of output-based rebating. Producers in this industry will prefer the output-based rebating to an auctioning regime; profits increase from AEJ under auctioning to BGO with a full output-based rebate. However, producers will most prefer grandfathering if producer surplus $AEJ + \tau L > BGO$.

dating.[13] This is because the rebate-induced decrease in abatement costs incurred by the industry receiving the rebate is smaller (in absolute value) than the rebate-induced increase in abatement costs incurred in other sectors under the cap.

Second, the net welfare cost of output-based rebating (vis-à-vis grandfathering or auctioning) is increasing with emissions intensity.[14] The costs of output-based updating manifest as increases in the overall costs of achieving the mandated emissions cap. Intuitively, the more emissions-intensive the industry, the larger the effect of a given output-based rebate s on total industry emissions in equilibrium, the greater the required increase in emissions abatement among other sectors and sources.

10.4.2 Rebating Compliance Costs in a Trade-Exposed Industry

In order to extend the analysis to a trade-exposed industry, a linear import supply schedule is added to the model:

$$p(Q^M) = d + gQ^M, \tag{4}$$

where Q^M represent the quantity of imports supplied at price p. At any price below d, import supply is zero. As the slope of the import supply schedule g approaches infinity, this model reduces to the autarkic case.

Subtracting import supply from aggregate demand yields the residual demand curve faced by domestic producers:

$$p(Q^D) = \frac{ag + bd}{b + g} - \frac{gb}{b + g} Q^D. \tag{5}$$

Profit maximization by price-taking firms implies that domestic production in equilibrium is:

$$Q^{D^*} = \frac{bd - b\tau e + bs\tau e + g(s\tau e + a - \tau e)}{bc + g(b + c)}. \tag{6}$$

Note that as the slope of the import supply curve approaches infinity (and import pressure approaches zero) this quantity approaches Q_A^*. Solving for the equilibrium price and substituting into equation (4), imports in equilibrium are:

$$Q^{M^*} = \frac{ac - bd - cd + b\tau e - bs\tau e}{bc + bg + cg}. \tag{7}$$

13. The analysis in the text omits the following two examples of second-best considerations. First, in an imperfectly competitive industry, the implicit production subsidy can mitigate the preexisting distortion associated with the exercise of market power, and output-based allocation updating can welfare-dominate auctioning or grandfathering, even in the autarkic case. Second, output-based allocations can be used to reduce the distortionary effects of factor tax distortions (Fischer and Fox 2007).

14. To see this, note that the derivative of equation (3) with respect to e is negative. In figure 10.2, the height of the area that defines the net welfare cost of updating is τe. The area of this parallelogram is increasing with e.

Note that equations (6) and (7) together imply that import market share in the absence of emissions regulation, $Q^M/(Q^M + Q^D)$, is $c/(c + g)$.[15]

With imports added to the model, two additional arguments are added to the welfare function:

$$(8)\ W_{TE} = \int_0^{Q(p,s)} p(x)dx - \int_0^{Q^D(p,s)} C(x)dx - pQ^M(p) - \tau e^D Q^D(p,s) - \tau e^M Q^M(p).$$

The third argument in equation (8) captures expenditures on imports. The last argument measures damages from import-related emissions. The emissions intensity of imports is e^M. Emissions in foreign jurisdictions are penalized at the same rate as domestic emissions (τ per unit of emissions). This assumes that the domestic permit price serves as an adequate measure of marginal emissions damages and that the damages caused by an incremental change in emissions are independent of the source. This will be true for greenhouse gases provided there are no co-emissions of local pollutants. The welfare measure in equation (8) ignores any surplus accruing to foreign firms; only costs and benefits affecting domestic stakeholders are accounted for.

Substituting equations (5), (6), and (7) into (8) yields a measure of welfare in terms of the model parameters $a, b, c, d, e, g, \tau, s$. Subtracting $W_{TE}(0)$ from $W_{TE}(s)$ captures the welfare effect of allocation updating vis-à-vis grandfathering or updating. A comprehensive analysis of how this effect varies systematically with different model parameters is beyond the scope of this chapter. Instead, a more general and conceptual discussion provides the essential intuition.

In a trade-exposed and emissions intensive industry, the relative welfare effect $W_{TE}(s) - W_{TE}(0)$ can be decomposed into three parts:

1. The effect on domestic economic surplus (measured by the first three arguments in equation [8]). This effect will be positive for two reasons. Similar to the autarkic case, an increase in the level of production and consumption generates more producer and consumer surplus. Add to this the transfer of surplus from foreign to domestic producers as the share of the domestic market served by foreign imports decreases under updating.

2. The effect on domestic emissions (and associated costs). As in the autarkic case, the rebate-induced increase in production leads to an increase in domestic emissions. All else equal, this increases abatement costs incurred in other industries subject to the cap.

3. The effect on foreign emissions. Foreign imports are reduced under output-based updating, as are the emissions associated with those imports.

15. This measure of trade exposure is intended to be analagous to the measure used to determine eligibility for output-based rebates (see figure 10.1). In this simple modeling framework, domestic production and imports are valued at the equilibrium output price and exports are assumed to be zero.

This mitigation of emissions leakage is an important benefit of output-based updating in a trade-exposed industry.

In sum, allocation updating in a trade-exposed industry increases the direct costs of achieving the mandated emissions reductions. However, unlike the autarkic case, it confers additional welfare benefits in the form of leakage mitigation and a transfer of surplus from foreign to domestic producers. These additional benefits will, in some trade-exposed industry contexts, justify the costs of allocation updating. For any given set of model parameters a, b, c, d, τ, s, and g, there is a corresponding threshold emissions intensity below which the benefits of updating exceed the costs.

10.5 Welfare Implications of Output-Based Rebates

The foregoing analysis has implications for determining which industries should receive output-based rebates. In this section, I derive the eligibility criteria used by a policymaker seeking to maximize social welfare as defined by equation (8). In keeping with the provisions in proposed federal legislation, I assume that the output-based rebates will refund compliance costs in full (i.e., $s = 1$) and that eligibility determinations will be based on two observable industry characteristics: a measure of import penetration ($c/[c + g]$), and emissions intensity e.

The derivation proceeds as follows. First, in order to define eligibility criteria in terms of emissions intensity and import penetration parameters exclusively, I must assume values for the other model parameters τ, a, b, c, d, and e^M. Let θ represent a given set of these parameter values. Conditional on θ, I identify all of the e and $c/(c + g)$ combinations that are associated with a welfare level under updating $W_{TE}(1)$ that is greater than or equal to the corresponding welfare level under auctioning or grandfathering $W_{TE}(0)$.

Figure 10.3 illustrates results for two different θ values (θ_1 and θ_2).[16] The solid line represents the welfare-maximizing eligibility threshold associated with θ_1. This line connects all of the combinations of e and $c/(c + g)$ which, given θ_1, yield equivalent welfare outcomes $W_{TE}(1) = W_{TE}(0)$. All points to the left (right) of this line are associated with industry contexts in which output-based updating welfare dominates (is welfare dominated by) auctioning or grandfathering regimes. The broken line is the eligibility threshold associated with a different set of assumed parameter values θ_2.

The most striking difference between the derived thresholds in figure 10.3 and the proposed threshold in figure 10.1 is that the relationship between emissions intensity and eligibility status is reversed. Under proposed allocation designs, the most emissions-intensive industries are presumptively eligible for output-based compensation, presumably because these industries stand to benefit the most from the provision. In figure 10.3, industries with

16. The model is not parameterized to represent any industry in particular. Simple parameter values are chosen to maximize expositional clarity (values are reported in figure notes).

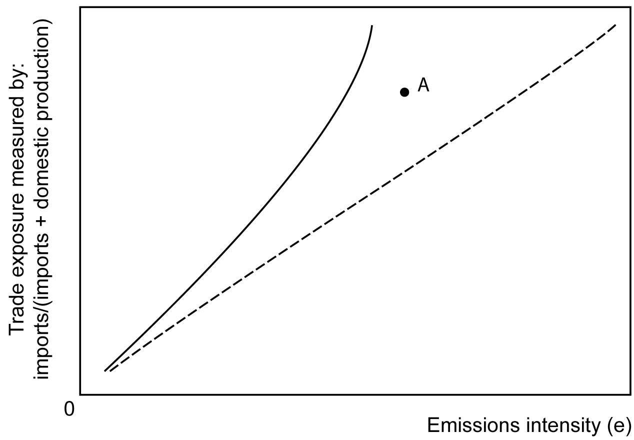


Fig. 10.3 Welfare-maximizing eligibility thresholds

Notes: These eligibility thresholds are derived from the unconstrained welfare-maximization exercise described in the text. Lines connect all points that correspond with a net welfare impact of zero given parameters in θ. Points to the left of the curve are associated with positive welfare changes (i.e., output-based rebating is welfare improving). Points to the right are associated with negative welfare changes. Assumed parameter values associated with the solid line: $\theta_1 = \{a = 50; b = 1; c = 1; d = 0; e^m = 1; \tau = 5; s = 1\}$. The broken line is associated with a set of parameters θ_2 that is identical to θ_1 except that $e^m = 3$. An industry at point A is ineligible given θ_1 because costs exceed the benefits accruing from output-based rebates. This industry is eligible given θ_2 because the benefits—including increased benefits associated with leakage mitigation—outweigh the costs.

high emissions intensities are not eligible for output-based rebates because the benefits accruing to the industry receiving the rebate are smaller than the costs to the economy as a whole.

Figure 10.3 also helps to illustrate how the sign of the net-welfare effect of allocation updating cannot be completely determined based on emissions intensity and import share alone. Put differently, when eligibility rules are determined based on emissions intensity and trade exposure measures exclusively, there is no one eligibility threshold that fits all industries. Parameter values in θ_1 and θ_2 are identical except that the import emissions intensity parameter e^M is higher in θ_2. An industry located at point A is eligible if it can be described using the parameter values in θ_1, but ineligible if it is described by the values in θ_2. Intuitively, the benefits from allocation updating will be greater when imports are more emissions intensive and the emissions leakage potential is greater.

10.6 Conclusion

This chapter presents a framework for thinking about the cost-benefit trade-offs inherent in output-based allocation updating. A simple analytical model is used to examine the welfare impacts of providing output-based rebates to an industry regulated under market-based environmental regulation. In a perfectly competitive industry with no exposure to competition from unregulated imports, these welfare impacts are unambiguously negative. However, when domestic producers compete with firms in less stringently regulated jurisdictions, the benefits of output-based updating may exceed the costs. In this context, the net welfare impacts of introducing output-based rebates will depend on a number of factors, including the emissions intensity of domestic production and the price elasticity of supply and demand.

The chapter concludes with an analysis of one of the most fundamental issues in allocation-based cost mitigation: eligibility. The model is used to demonstrate the stark contrast between the eligibility criteria contained in proposed legislation and those implied by economic welfare maximization.

Although the eligibility requirements in figure 10.1 differ qualitatively from those derived in this chapter, they are consistent with interest group theories of regulation. When policy impacts are concentrated among few and costs are diffusely distributed among many, these few have an incentive to advocate for surplus redistribution (or compensation) at the expense of the larger, but relatively disinterested, many (Olson 1965; Stigler 1971). Output-based rebates offer a politically palatable means of redistributing surplus from foreign firms and the majority of industries where compliance costs are expected to be relatively insignificant (industries to the left of the eligibility threshold in figure 10.1) to a minority of industries that expect to experience significant adverse impacts under federal GHG emissions regulation (industries to the right of the threshold in figure 10.1). A politically viable climate policy regime will need to shelter these politically powerful industries from significant adverse impacts. This chapter draws attention to the costs incurred when output-based rebates are chosen as the vehicle for transferring surplus to these important industries.

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Comment Lawrence H. Goulder

Output-based emissions allowance allocation (OBA) has been proposed in climate policy discussions as a way of avoiding international emissions leakage and of preserving the competitive position of energy-intensive, trade-exposed firms. The OBA differs from allocation based on auction-

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