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

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Abstract

U.S. adoption of a cap-and-trade program for greenhouse gases could place some domestic producers at a disadvantage relative to international competitors who do not face similar regulation. To address this issue, proposed federal climate change legislation includes a provision that would freely allocate (or rebate) emission allowances to eligible sectors using a continuously updating output-based formula. Eligibility for the rebates would be determined at the industry-level based on emissions (or energy) intensity and a measure of import penetration. Dynamic updating of permit allocations has the potential to significantly mitigate adverse competitiveness impacts and emissions leakage in eligible industries. It can also undermine the cost-effectiveness of permit market outcomes as more of the mandated emissions reductions are achieved by sources deemed ineligible for rebates. This chapter investigates how both the benefits and the costs of output-based updating vary systematically with observable industry characteristics. Stark differences between proposed eligibility criteria and those consistent with standard measures of economic efficiency are identified. The analysis underlines the importance of taking both benefits and costs into account when determining the scale and scope of output-based rebating provisions in cap-and-trade programs.

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1 Introduction

Debates about how and when to implement federal climate change policies have been dominated by concerns about potentially adverse impacts on domestic industrial competitiveness, trade flows, and emissions leakage. Absent efforts to "level the carbon playing field", imposing a mandatory cap on U.S. emissions in advance of a comprehensive global climate change agreement could result in the loss of domestic market share to unregulated imports. Any associated emissions leakage would offset emissions reductions achieved by domestic sources under the cap.

These concerns are best addressed through a harmonization and coordination of the global policy response to climate change. However, a growing sense of urgency is fuelling efforts to pass domestic climate change regulation now, rather than waiting for a coordinated global agreement to emerge. In pursuing this strategy, policy makers are looking to strike an appropriate balance between curbing domestic emissions and protecting the competitive position of domestic manufacturing in the near-term.

Compensation for emissions-intensive and trade-exposed industries is a key component in leading federal climate change policy proposals currently under consideration. Proposed legislation includes a provision that would freely allocate greenhouse gas (GHG) emissions allowances to eligible industries using a continuously updated, output-based formula.[1] These output-based rebates are designed to completely offset both direct and indirect compliance costs in eligible sectors while preserving some incentive for individual firms to reduce their emissions intensity. Under current proposals, industries that have energy or emissions intensities exceeding 5 percent and import penetration in excess of 15 percent are deemed to be "presumptively eligible" for this assistance.

The potential benefits of proposed output-based rebating 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 will be achieved by sources excluded from rebating provision. This can significantly undermine the economic efficiency of permit market outcomes.

The chapter presents a framework for thinking about this cost-benefit trade-off. A simple analytical model is used to investigate the welfare consequences of offering an output-based rebate (either directly or indirectly via permit allocation updating) to one or more industries in a GHG emissions trading program. In a first-best policy setting, output-based allocation updating will reduce welfare vis a vis auctioning or lump-sum permit allocations.[2] 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 will 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.

[1] Border tax adjustments offer another approach to protecting domestic industry. By penalizing emissions embodied in foreign imports, regulators can in principle expand the reach of domestic regulation. An important concern with regard to these countervailing measures is that they may not pass WTO scrutiny. Border tax adjustments included in the House bill were outwardly criticized by 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). The legislation proposed by the Senate also includes language that indicates an intention to add border tax adjustments on imports.

[2] 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.

Among the most fundamental questions in the design of cost mitigation measures is: Who should be eligible for 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 model is used to illustrate how the eligibility criteria defined in proposed legislation differ from those derived in a standard welfare maximization exercise. Whereas proposed eligibility criteria are well aligned with the benefits accruing to the industry receiving the rebate, they are poorly aligned with the costs to the economy as a whole.

Although this paper is germane to ongoing policy debates, it is important to put these findings in context. The underlying model assumes a fairly stylized objective function on behalf of the policy maker; political constraints are ignored entirely. In practice, the political viability of any federal climate change policy is going to depend significantly on how costs and benefits are distributed across politically powerful constituencies. Permit allocation is the most important lever that policy makers have to use in altering 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 paper 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 3 briefly summarizes the output-based rebating provisions in the proposed federal climate change legislation currently being considered by Congress. Section 4 presents a simple analytical framework that can be used to characterize the advantages and disadvantages of output-based updating provisions. Section 5 brings the analysis to bear upon the eligibility issue. Section 6 concludes.

2 Permit allocation as industry compensation

Regulatory agencies have been allocating tradable emissions permits under the auspices of local, regional, and nationwide emissions cap-and-trade programs for over a decade. Historically, policy makers 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 pre-determined, 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.[3] This so-called "independence property" has important policy implications (Hahn and Stavins, 2010). If the initial distribution of permits plays no role in determining 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) without compromising the economic efficiency properties of permit market outcome.

[3] Assumptions include: perfectly competitive input and output markets, no pre-existing regulatory distortions, 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 a an emissions permit market context by Montgomery (1972).

Economists have generally argued in favor of auctioning permits when auction revenues can be used to offset factor taxes or other pre-existing distortions.[4] However, policy makers have routinely chosen to forego auction revenues in favor of handing permits out for free to regulated entities.[5] 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. This is primarily due to the unprecedented value of the permits to be allocated.[6] A lump-sum allocation of all GHG permits to regulated sources would likely result in significant overcompensation (Bovenberg and Goulder, 2001). With the Congressional Budget Office Director warning that a failure to auction permits "would represent the largest corporate welfare program that has even been enacted in the history of the United States", the Obama administration initially came out in support of auctioning of all permits. [7] Politically powerful industry stakeholders are united in their opposition to this proposal (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.[9] 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 reducing the compliance cost burden for a specific sector and minimizing the overall economic cost of achieving mandated emissions reductions.

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

[5] 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 NOx Budget Trading Program.

[6] 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).

[7] "Approaches to Reducing Carbon Dioxide Emissions: Hearing before the Committee on the Budget U.S. House of Representatives", November 1, 2007. (testimony of Peter R. Orszag)

[8] The US Climate Action Partnership (USCAP) is a non-partisan coalition comprised of 25 major corporations and 5 leading environmental groups. In January 2009, the group issued its "Blueprint for Legislative Action" in which it 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.

[9] For a more detailed treatment of the efficiency implications of output-based updating, see Bohringer and Lange (2005); Fischer (2001).

3 Proposed measures to address near-term competitiveness impacts

Climate change legislation recently passed in the House and reported by committee in the Senate would establish a multi-sector cap-and-trade system to regulate greenhouse gas emissions.[10] The most important measure to address concerns about near-term competitiveness impacts, job loss, and emissions leakage is an output-based rebate provision. Allowance rebates are provided for both direct compliance costs (i.e. the cost of purchasing permits to offset emissions) and indirect compliances costs (i.e. compliance costs reflected in higher electricity prices). In each year, rebates (in the form of a free permit allocation) for direct emissions 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. Because rebates are based on industry-wide performance benchmarks, the incentives to reduce emissions intensity are preserved to some extent.

Figure 1 illustrates the proposed eligibility criteria. Eligibility is determined at the six-digit NAICS industry classification level. The size of the industry-specific circles reflect 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 import competition.

An industry is defined to be "presumptively eligible" for output-based rebates if energy intensity or greenhouse gas emissions intensity is at least five 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.[11] The broken line in Figure 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 suggest that 44 (or approximately 9 percent) of 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 (approximately $14B worth of permits) is set aside for output-based rebating. This annual set-aside exceeds the total emissions of presumptively eligible industries in 2006.[12]

The potential benefits (in terms of avoided output and emissions leakage) of this output-based rebating provision have been analyzed in detail. In independent analyses of H.R. 2454, both the U.S.Environmental Protection Agency the Energy Information Administration (EIA) find that output-based rebating significantly mitigated negative impacts on energy-intensive manufacturing outputs (US EPA, 2009; EIA, 2009). A recent inter-agency report concludes that proposed output-based allocation rebates would "eliminate almost all- and in some cases, potentially more than all- of those cost impacts, as well as the resulting changes in net imports and associated emissions leakage" (US EPA, EIA, and Treasury, 2009). Although

[10] On June 6, 2009 the House of Representatives passed the American Clean Energy and Security Act (H.R. 2454). On September 30, 2009, Senator Kerry introduced the Clean Energy, Jobs, and American Power Act (S. 1733).

[11] Final determination of eligibility would be made by the US EPA upon enactment of the legislation.

[12] If more allowances are needed to compensate the average compliance costs across eligible industries, firms' rebates will be negatively pro-rated and the average compliance cost will exceed the average rebate in all eligible industries.

there has been much work done to document the benefits of this compensating provision, little (if any) effort has been made to estimate the costs.

4 The costs and benefits of output-based rebating

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

- Within this partial equilibrium framework, the benefits of output-based rebating manifest as direct transfers of surplus from foreign producers and/or increased surplus resulting from increased production and consumption levels. Costs manifest as increases in the intrinsic costs of achieving the mandated emissions reductions. General equilibrium effects, including interactions with pre-existing factor taxes, are not considered.
- I adopt a fairly standard, albeit stylized, welfare metric. 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.
- Throughout the analysis, the permit price τ is an exogenous parameter. This is equivalent to assuming that the aggregate marginal abatement cost curve is flat in the neighborhood of the constraint imposed by the emissions cap.[13]
- I will focus on the short-run implications of output-based rebates exclusively. Technology operating characteristics are assumed to be pre-determined and fixed in the short-run. Because output-based rebating is intended as a temporary "stop-gap" measure, an analysis that conditions on initial technological characteristics can be instructive.[14] However, most industries will have some ability to reduce their emissions intensity in the short-run (i.e. through fuel switching or capital replacement). In these cases, costs imposed by output-based updating would be lower than this analysis suggests.
- The model does not capture heterogeneity in cost structure and emissions intensity across producers within an industry. The ability to reallocate production to relatively clean firms would also reduce the costs of output-based rebating.

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 and is relevant to the proposed permit allocation regime which makes industries

[13] This assumption is likely to be approximately true in a federal GHG trading program that permits offsets. Keohane (2009) estimates the slope of the marginal abatement cost curve in the United States (expressed in present-value terms and in 2005 dollars) to be 8.0 x 10^7 \$/GT CO_2 for the period 2010–2050. Suppose this curve can be used to crudely approximate the permit supply function. If all of the industries deemed to be "presumptively eligible" for allowance rebates reduced their emissions by ten percent for this entire forty year period, the permit price would fall by approximately \$0.25/ ton.

[14] In introducing the Carbon Leakage Prevention Act (H.R. 7146), output-based allowance allocations for emissions-intensive U.S. industry were introduced as a "stop-gap measure". *The Obama-Biden Transition Project.* ""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)." http://otrans.3cdn.net/5c61e8367815ece533_7om6bhijz.pdf accessed April 15, 2010.

with no trade exposure, but exceptionally high emissions intensities, eligible for output-based allocations (see Figure 1).

The industry is comprised of N identical sellers producing a homogeneous good q and generating greenhouse gases as a by-product. These producers have convex cost functions $C(q_i)$ 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 ($C'(q_i) = cq_i$), τ is the equilibrium permit price, and s is the rate at which compliance costs are rebated to firms, $s \in (0,1)$. The firm's lump sum permit allocation is L_i. This simple model nests the three classes of permit allocation regimes under consideration. Let E represent the total number of permits to be allocated for free to this industry. Under complete auctioning, $L_i = 0 \ \forall \ i$; $s = 0$. Under grandfathering, $\sum_i L_i = E$, $s = 0$. Under output based rebating, $L_i = 0 \ \forall \ i$; $s = \frac{E}{Q}$.

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

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

where the subscript A denotes the autarkic case.

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:

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

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:

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

Figure 2 provides a graphical illustration of these partial-equilibrium welfare consequences for the case where $s = 1$. In the baseline case (i.e. a grandfathering or auctioning regime where $s = 0$), 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 is area EGH. The rebate-induced increase in industry emissions incurs a cost of $EFGH$ to offset elsewhere (either through abatement in other industries under the cap or purchases of permits from other countries). The shaded area EFG captures the net welfare impact $W(1) - W(0)$.[15]

Three insights from this autarkic case are worth highlighting. First, under fairly general conditions, the net welfare impact of output-based rebating will be strictly negative.[16] Second, the net welfare costs of output-based rebating are increasing with emissions intensity. Finally, the more elastic domestic supply or demand, the more responsive the equilibrium output quantity is to a given change in operating costs, and the larger the net welfare costs associated with an output-based rebate.

4.2 Rebating compliance costs in a trade exposed industry

In order to extend the analysis to a trade-exposed industry, a linear inverse import supply curve is added to the model. Let Q^M represent the quantity of imports:

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

The residual demand curve faced by domestic producers is thus:

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

Profit maximization on behalf of all price taking firms implies that industry output 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 [4], imports in equilibrium are:

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

Note that [6] and [7] together imply that import market share in the absence of emissions regulation is $\frac{g}{c+g}$.

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

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

Expenditures on imports are $pQ^M(p)$. Imports generate emissions at a constant rate of e^M per unit of output. I assume that marginal damages from emissions are equal to the equilibrium permit price τ.

[15] Figure 1 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 where producer surplus is *AEHO*.

[16] This may not be the case in an imperfectly competitive industry. In imperfectly competitive industries, the implicit production subsidy can mitigate the pre-existing distortion associated with the exercise of market power and output-based allocation updating can welfare-dominate auctioning or grandfathering, even in the autarkic case.

The damages associated with emissions leakage are thus $\tau e^M Q^M(p)$. I also assume that the regulator considers only the welfare effects in her jurisdiction.

Figure 3 graphically illustrates the welfare implications of updating permit allocations so as to fully refund compliance costs to producers in this industry (i.e. $s = 1$) relative to the benchmark case (grandfathering or auctioning) in which. $s = 0$. The figure on the right is very similar to Figure 2, except that now the domestic producers face a residual demand curve (the thick solid line) that is more elastic over the range of prices where importer supply exceeds zero. The figure on the left illustrates a linear import supply schedule. The emissions intensity of domestic and foreign producers is measured by the lower portion of the vertical axis in the right and left figures, respectively. In the benchmark case, a quantity N is sold at a price of B. Domestic firms produce M and foreign producers supply S. When $s = 1$, a quantity P is sold at a price of F. Domestic production increases to O and import supply falls to R.

Conceptually, the welfare impacts of introducing a production based rebate into this trade-exposed industry can be broken into three parts. The first component captures the benefits associated with emissions leakage mitigation. In figure 3, emissions leakage (area Q) is completely eliminated under the complete output-based rebate. The second component measures the net increase in domestic producer and consumer surplus as a consequence of increased domestic production and consumptions levels and a reduction in import market share (area $CDJH$). Finally, the rebate-induced increase in industry emissions must be offset elsewhere. The abatement and/or compliance costs born by other sectors increase by area $LCAI$. Taken together, the net welfare impact of output-based rebating (vis a vis grandfathering or auctioning) is equal to area EIJ plus area Q less area $ACDE$.

In the context of the analytical model, the net welfare impacts of rebating compliance costs at a rate of s are given by:

$$W(s) - W(0) = tm\frac{bstx}{bc+bg+cg} - \frac{\left(2bcdg - 2abcg + 2bcgstx + 2b^2dg - 2b^2gtx + b^2cstx + bg^2stx + 2b^2gstx + cg^2stx\right)stx}{2\left(bc+bg+cg\right)^2}. \quad (9)$$

In what follows, a simple numerical example is used to illustrate the relationships between the net welfare impact of the output-based rebate $W(s) - W(0)$ and industry characteristics represented in the model.

5 Welfare implications of output-based rebates

The analytical framework developed in the previous section can be used to investigate how the welfare implications of output-based rebates can vary with observable characteristics of trade exposed industries. Emphasis is placed on the two factors that are used to determine industry eligibility under proposed legislation: emissions intensity and trade exposure. The analysis concludes with a derivation of the eligibility criteria implied by standard welfare maximization.

5.1 How do welfare impacts vary with emissions intensity?

Plots in the left column of Figure 4 illustrate how the welfare implications of output-based updating can vary with the emissions intensity of an industry. The vertical axis of each graph measures the net welfare impact of fully rebating compliance costs (i.e. $W(1) - W(0)$). The horizontal axes measure the emissions intensity of domestic production. The thick black curves trace out the relationship between these welfare impacts and emissions intensity e in a base case where domestic supply is more elastic than import supply and imports are less emissions intensive than domestic production (specific parameter values are listed in the figure notes). The broken lines plot the same relationship under different assumptions about the import supply elasticity (g), the slope of domestic demand (b), and the emissions intensity of imports (m).

In all cases considered, the benefits generated by an output-based rebate are increasing faster than the costs imposed on the rest of the economy as the emissions intensity of an industry increases above zero. However, as emissions intensity increases, this ceases to be the case. Intuitively, as the emissions intensity parameter increases while other parameters are held constant, the costs imposed on the rest of the economy start to grow faster than the benefits associated with leakage mitigation and increased domestic production in the industry. Beyond some threshold emissions intensity, output-based updating is welfare dominated by grandfathering or auctioning. The three graphs in the left column show how this threshold point will vary with observable industry characteristics. For example, this threshold is increasing with import supply elasticity (upper graph); increasing with the slope of the domestic demand curve (middle graph), and increasing with the emissions intensity of imports (lower graph).

5.2 Net welfare impacts as a function of trade-exposure

Plots in the right column of Figure 4 investigate how [9] varies with the price responsiveness of imports. The larger the slope parameter g (measured on the horizontal axes), the less responsive imports will be to a change in domestic product price. As import supply becomes increasingly inelastic, $W(1) - W(0)$ approaches the welfare cost under autarky (equation 3).

With the exception of the neighborhood around $g = 0$, the net welfare impacts of introducing the output-based rebates are always decreasing as the import supply curve becomes more elastic.[17] As the trade-exposure of the industry decreases, so do the benefits from updating (in terms of both leakage mitigation and preservation of domestic market share). The threshold at which these curves cross the horizontal axis (and welfare effects from output-based rebating turn negative) varies with other industry characteristics. This threshold is increasing as emissions intensity falls (upper), domestic demand becomes more inelastic (middle), and import intensity increases (lower).

[17] In most of the cases considered, the welfare effects of output-based rebating are increasing with g when import supply is very elastic and import penetration is close to (or at) 100 percent. Intuitively, this is because domestic emissions can be increasing faster than leakage is decreasing in the neighborhood of $g = 0$. When import emissions intensity is sufficiently high relative to domestic emissions intensity, the net welfare benefits from output-based rebating are everywhere decreasing as the import supply curve becomes more elastic.

5.3 Deriving social welfare maximizing eligibility criteria

The foregoing analysis has direct implications for determining which industries should receive output-based rebates. Using equation [9] as a point of departure, I derive the eligibility criteria that should be used by a policy maker seeking to maximize social welfare as defined by [8]. In keeping with the proposed provisions, 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: import market share observed in the absence of emissions regulation ($\frac{g}{c+g}$), and emissions intensity e.

How does the eligibility threshold in Figure 1 compare to the that implied by welfare maximization in this model? Conditioning on assumed values for the model parameters: τ, a, b, and c, I set $W(s) - W(0)$ equal to zero and solve for the import market share $\frac{g}{c+g}$ in terms of the emissions intensity parameter e. The resulting equation defines a level set of (9) which can be interpreted as the welfare maximizing eligibility threshold (conditional on the assumed social welfare function [8] and the assumed parameter values). Figure 5 plots this threshold. For industries located to the right (left) of this line, the introduction of the output-based subsidy will be welfare decreasing (increasing).

Comparing Figures 5 with Figure 1, the most striking difference is that the relationship between emissions intensity and eligibility status is reversed. In Figure 5, industries with 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. In Figure 1, the most emissions-intensive industries are all presumptively eligible, even those that do not face competition from unregulated imports.

Figure 5 also helps to illustrate how this welfare-maximizing eligibility threshold varies with other industry characteristics. Put differently, the sign of the net-welfare effect of allocation updating cannot be completely determined based on emissions intensity and import share alone. For example, an industry located at point A is eligible in the base case, but not in a case that assumes more inelastic demand (thus increasing the costs of updating in this relative emissions intensive industry). An industry located at point B is not eligible in the base case, but is eligible in a scenario that assumes imports are more emissions intensive (where the benefits from leakage mitigation will be greater as compared to the base case).

It is important to emphasize that this derivation is predicated on an over-simplified and abstract representation of the policy maker's problem. In practice, policy makers must balance economic efficiency considerations against numerous distributional (and inherently political) concerns when determining which of the industries regulated under an emissions trading program should be eligible for output-based rebates. The purpose of this exercise is to is to highlight some of the trade-offs inherent in the proposed allocation design.

6 Conclusion

This chapter presents a framework for thinking about the cost-benefit trade-offs inherent in output-based allocation updating, and output-based rebating more generally. 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 welfare maximization.

Although the eligibility requirements in Figure 1 are inconsistent with standard notions of static economic efficiency, they are entirely 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 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 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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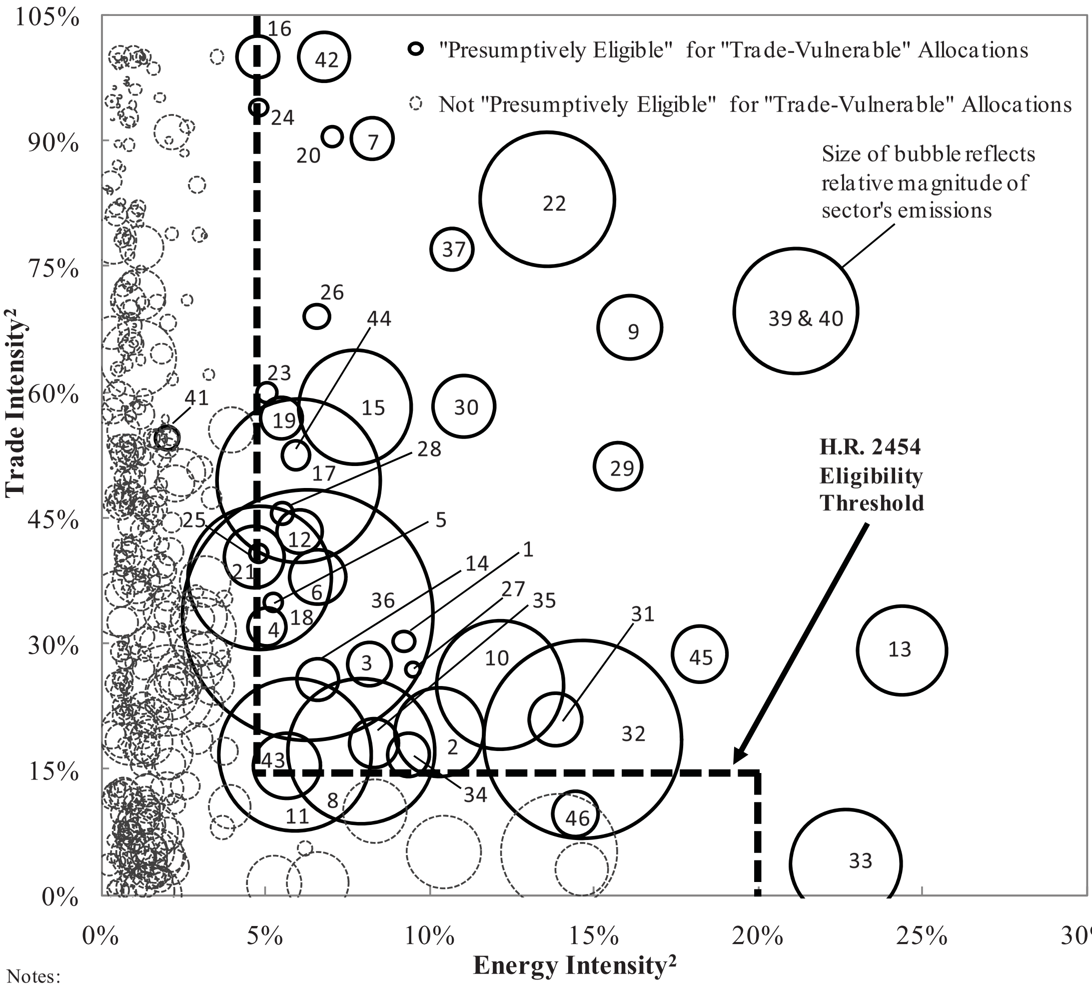

1. Malt Manufacturing (311213)
2. Wet Corn Milling (311221)
3. Rendering and Meat Byproduct Processing (311613)
4. Yarn Spinning Mills (313111)
5. Tire Cord and Tire Fabric Mills (314992)
6. Reconstituted Wood Product Manufacturing (321219)
7. Pulp Mills (322110)
8. Paper (except Newsprint) Mills (322121)
9. Newsprint Mills (322122)
10. Paperboard Mills (322130)
11. Petrochemical Manufacturing (325110)
12. Inorganic Dye and Pigment Manufacturing (325131)
13. Alkalies and Chlorine Manufacturing (325181)
14. Carbon Black Manufacturing (325182)
15. All Other Basic Inorganic Chemical Mfg. (325188)
16. Cyclic Crude and Intermediate Manufacturing (325192)
17. All Other Basic Organic Chemical Mfg. (325199)
18. Plastics Material and Resin Manufacturing (325211)
19. Synthetic Rubber Manufacturing (325212)
20. Cellulosic Organic Fiber Manufacturing (325221)
21. Noncellulosic Organic Fiber Manufacturing (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 Floor Tile Manufacturing (327122)
27. Other Structural Clay Product Manufacturing (327123)
28. Nonclay Refractory Manufacturing (327125)
29. Flat Glass Manufacturing (327211)
30. Other Pressed/Blown Glass and Glsswr. Mfg. (327212)
31. Glass Container Manufacturing (327213)
32. Cement Manufacturing (327310)
33. Lime Manufacturing (327410)
34. Ground or Treated Mineral and Earth Mfg. (327992)
35. Mineral Wool Manufacturing (327993)
36. Iron and Steel Mills (331111)
37. Electrometallurgical Ferroalloy Product Mfg. (331112)
38. Iron/Steel Pipe/Tube Mfg. from Purchsd. Steel (331210)
39. Alumina Refining (331311)
40. Primary Aluminum Production (331312)
41. Primary Smelting and Refining of Copper (331411)
42. Smltg./Rfg. of Nonfrs. Mtl. (ex. Cpr. and Almn.) (331419)
43. Iron Foundries (331511)
44. Carbon and Graphite Product Manufacturing (335991)
45. Iron Ore Mining (212210)
46. Copper Ore and Nickel Ore Mining (212234)

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 126 $MMTCO_2e$ 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 $MMTCO_2e$) is expected to be eligible based on language in the bill. Four others meet the energy-intensity threshold, each with 2 to 3 $MMTCO_2e$ 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% are depicted here with an intensity of 100% (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.
Source: EPA analysis.

Figure 1 : Energy intensity, trade intensity, and emissions of U.S. 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.

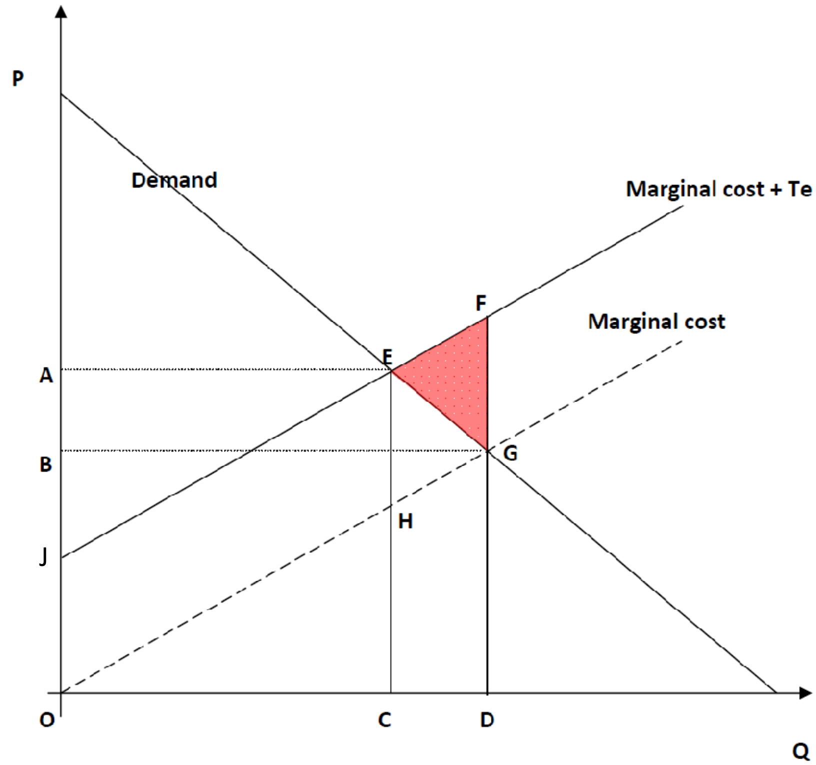

Figure 2 : Welfare impacts of an output-based rebate of environmental compliance costs in an emissions intensive industry with no trade exposure

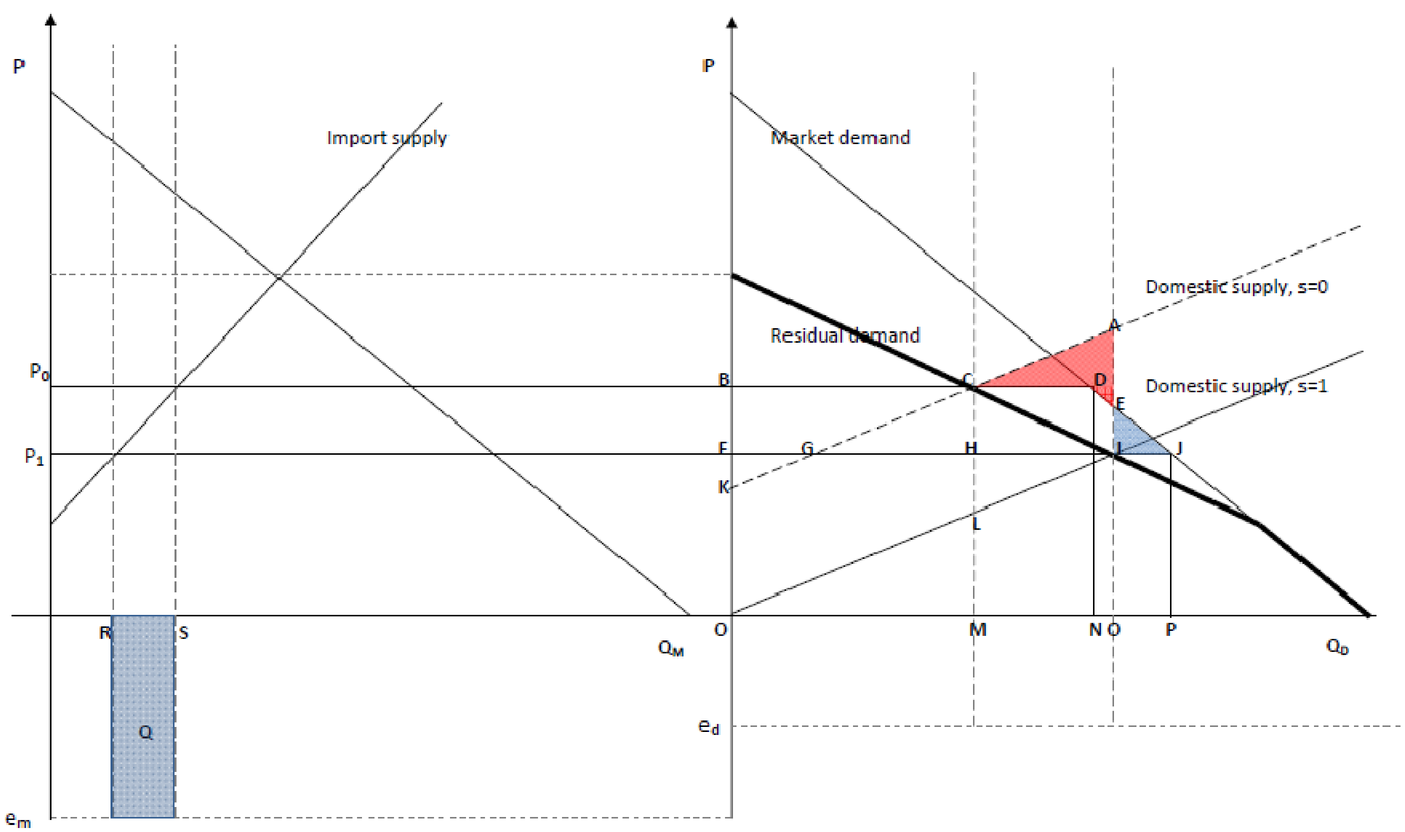

Figure 3 : Welfare impacts of an output-based rebate of environmental compliance costs in an emissions-intensive, trade-exposed industry

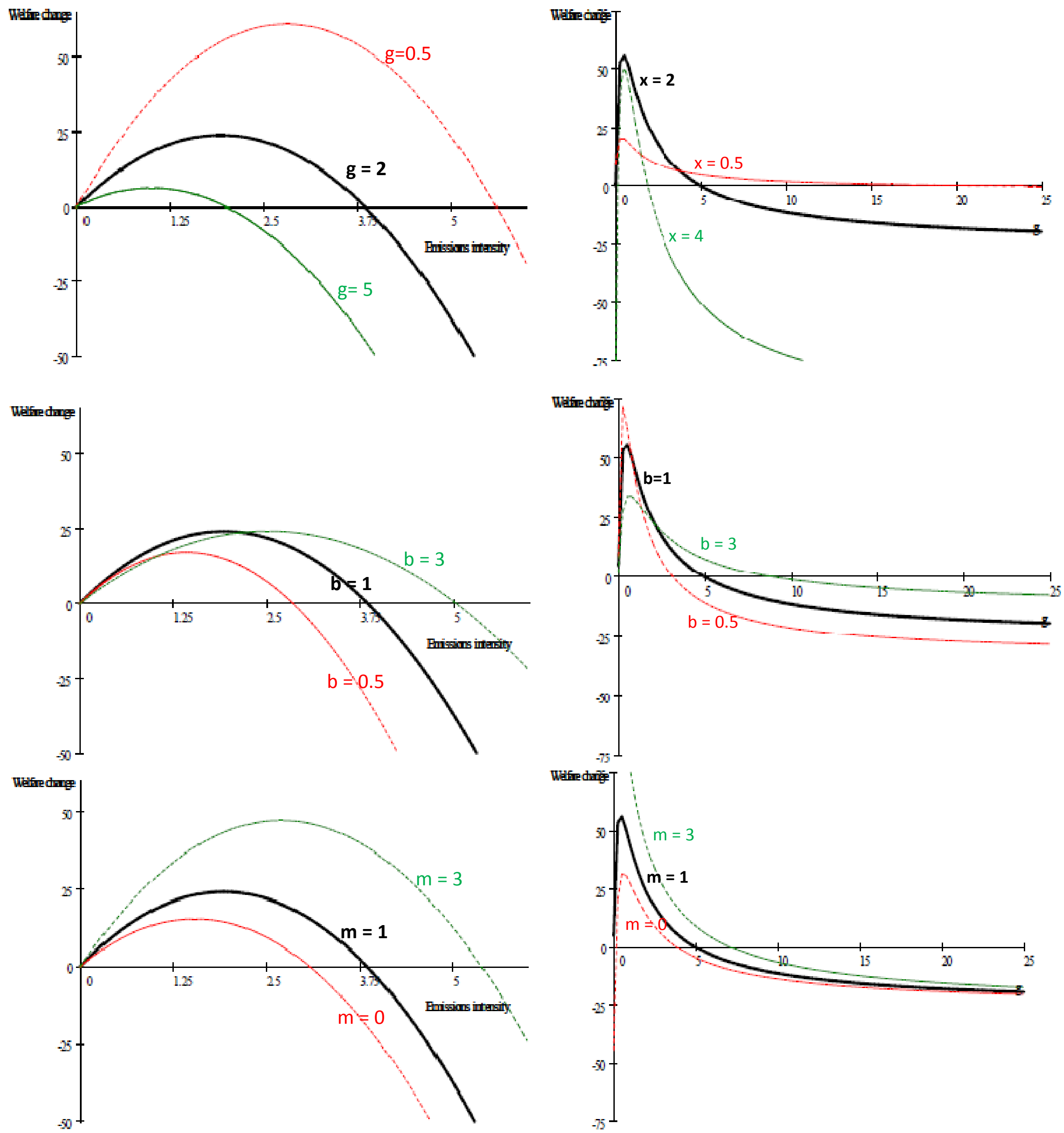

Figure 4 : Welfare impacts of output-based rebates

Notes: The graphs illustrate the welfare impacts of output-based rebating relative to a more standard (i.e. grandfathering or auctioning) permit regime. The vertical axis in each graph measures the change in welfare (i.e. W(0)-W(1)). The horizontal axis measures either industrial emissions intensity (left column) or the slope of the import supply curve (right column). The baseline parameters are: a=50; b=1; c=1; d=0; x=2; m=1; t=5. Graphs on the left illustrate how the relationship between emissions intensity and the net welfare change (i.e. W(1)-W(0)) varies with the slope of the import supply function, the slope of the demand curve, and the emissions intensity of imports. Graphs on the right illustrate how the relationship between the price responsiveness of imports and the net welfare change (i.e. W(1)-W(0)) varies with the domestic emissions intensity, the slope of the demand curve, and the emissions intensity of imports.

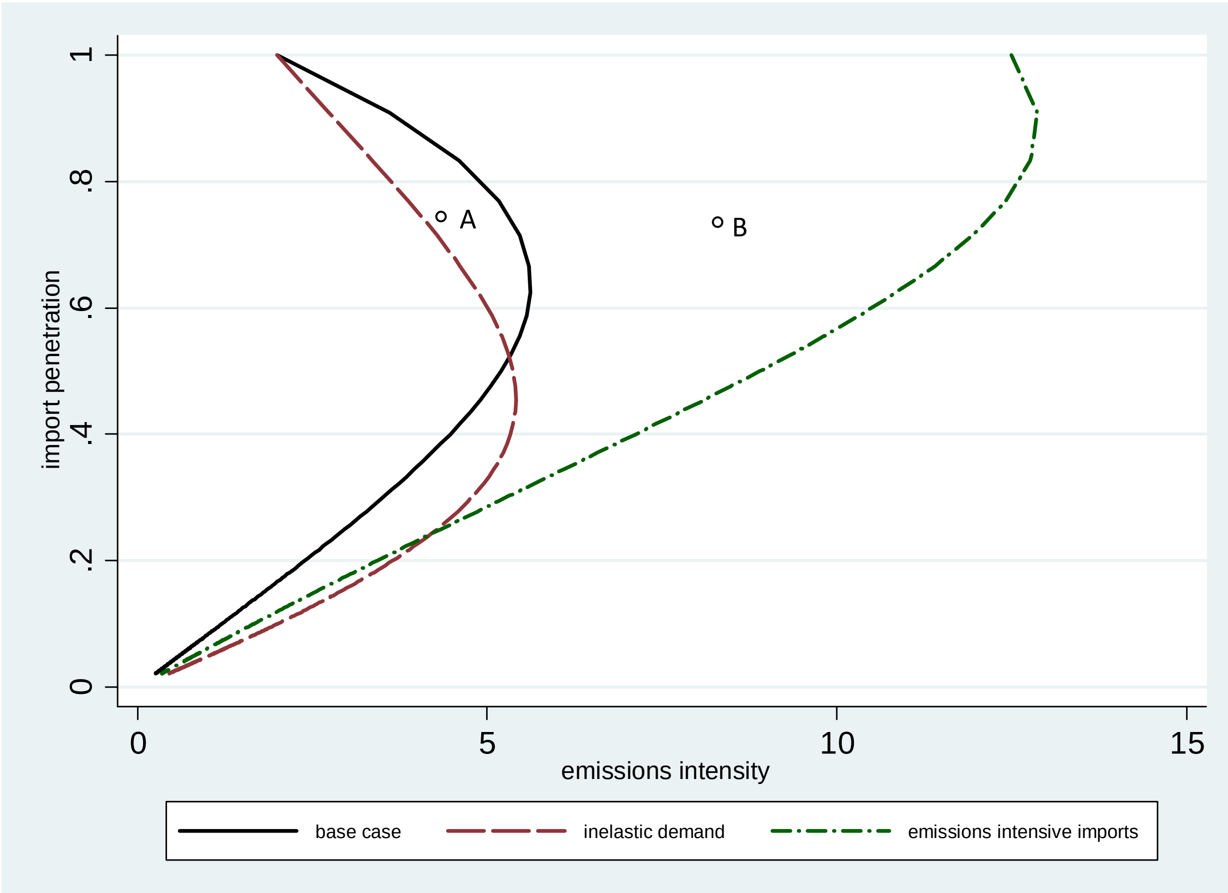

Figure 5 : Welfare maximizing eligibility thresholds

These eligibility thresholds are derived from the unconstrained welfare maximization exercise described in the text. These level sets connect all points that correspond with a net welfare impact (i.e. W(1)-W(0)) of zero. 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 in the base case: a=50; b=1; c=1; d=0; m=1; t=5; s=1. The broken red line is associated with more inelastic demand (b=3). The dashed green line is associated with more emissions intensive imports (m=3). An industry located at point A would be eligible in the base case, but not in a scenario where demand is more inelastic. A more emissions intensive industry located at point B would not be eligible in the base case (as costs exceed the benefits accruing from output-based rebates), but would be eligible in a scenario where imports are more emissions intensive (and thus the benefits associated with leakage mitigation are greater).