Market Power in Performance-based Permit Trading Policies: Walk on the Thin Ice?

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Overview

Partially owing to the political deadlock in Washington DC, US climate policy, historically, has been driven mainly by state or regional effort, such as the Regional Greenhouse Gas Initiative in the northeast United States and California AB 32. One major change recently is the introduction of the Clean Power Plan (CPP). CPP is a new federal-level policy introduced by the US Environmental Protection Agency to cut CO_2 emissions from existing fossil-fuel power plants by 30% below 2005 levels by 2030. While the proposal establishes a state-specific target with various "building blocks" that lay out possible reduction strategies, it leaves states and the power sector with considerable flexibility as for how to achieve their goals. More specifically, a state can decide to adopt either 1) a default "rate-based" standard where tons of CO_2 emissions per megawatt hour of electricity generated is measured, or 2) an equivalent "mass-based" standard, such as in a cap-and-trade (C&T) regime based on their projection of GDP growth. Economic theory suggests that the two approaches would provide incentives that might alter a firm's production decisions in a very different way (Bushnell et al, 2014). Furthermore, whereas the regulatory body at the state level as well as industry might value the "flexibility" to a great extent, the fact that the territory of a regional power/electric market, such as PJM (Pennsylvania-Jersey-Maryland) or NEISO (New England Independent System Operator), typically goes beyond the state boundary and encompasses a number of states makes it challenging to evaluate the effectiveness of the policy.

One emerging issue that has received little attention is the possibility of strategic behavior in rate- or performance-based standards as well as its repercussions or spillovers to the product market. The consequences of market power can include price distortions, production inefficiencies, and a redistribution of income from consumers to suppliers. In fact, the distribution of economic rent or welfare analysis needs further attention when comparing performace- to mass-based policies. In particular, while the government collects all the proceedings when tradable permits are auctioned off in initial allocations, the rate-based policy is inherently revenue neutral. This is mainly because, similar to a renewable portfolio standard, the extent to which a generator needs to pay when complying with the policy depends on its emission rate relative to the performance standard. In the case where its emission rate is greater than the performance standard, it will need to pay an emission cost to cover its emissions, effectively elevating its marginal cost of production. On the other hand, when a generator's emission rate is less than the performance standard, the *negative* cost becomes a subsidy that effectively lowers its production cost, thereby making the generator more competitive. Thus, it is unclear if one policy will outputform the other one on ecoconomic grounds, especially when concerning distributional effects.

Methods

We use a market-equilibrium approach that accounts for transmission constraints, nodal pricing, and market power. At each node, we allow for a number of generating fleets that could be owned by different companies. These firms compete in a pool-typed of power market while subjecting themselves either to a mass- or rate-based policy. An ISO (independent system operator) is assumed to maximize the usage of transmission resources. We consider five scenarios in our analysis varying by choices of polices or assumption concerning strategic behavior in power and emissions permit markets. Scenario (5) was solved first to obtain the total emsisions, which will be used as an effective emissions cap for the other scenarios: (1) perferct competition with mass-based policy, (2) oligopoly competition with mass-based policy, (3) oligopoly competition with rate-based policy, (4) Stackelberg with mass-based policy, and (5) Stackelberg with with rate-based policy.Depending on market structure, we follow Hobbs (2001) and Chen et al (2006) in formulating the problem either as a Linear Complementarity Problem (LCP) or Mathematical Program with Equilibirum Constraints (MPEC). If firms are allowed to exercise market power in the permit market, then a Stackelberg-type of leader-follower formulation is considered when a leader could fully and correctly anticipate reactions by followers, including follower producers, ISO, and consumers. In this case, the resulting bi-level problem may be re-formulated as an MPEC, which is challenging to solve with currently available commercial solvers because of 1) complementarity conditions representing followers' first-order conditions and 2) bilinear terms in leader's objective function. We get around these obtstacles by using disjunctive constraints and binary expansion, respectively (Gabriel and Leuthold, 2010), which enables us to re-cast the problem as a mixed integer linear program (MILP). While this transformation might be at the expense of precision of the solution, the mixed integer algorithm guarantees convergence and enables inferring the solution quality through duality gap.

Results

The models are implemented for a three-node test network with preliminary results summarized in Table 1. Several obserations emerge from Table 1. First, with same market structure, owing to cross-subsidy to low-emission expensive fleets, the rate-based policy would lead to lower sale-weighted prices compared to its mass-based counterparts, e.g., (3) vs (2) and (5) vs (4). This results in a higher quantity demanded by consumers, thereby leading to higher consumers' surplus. Second, the leader (1), marked with underline, can benefit greatly under the rate-based standard as its profit in those cases is higher than that in the mass-based scenarios. Third, other producers also benefit from ability of leader to exercise market power under the rate-based policy. Finally, even with "greater" market power by the leader, when considering government revenue, the additional consumers' surplus gained under a rate-based policy actually could lead to an overall increase in total social welfare.

Table 1: Preliminary Results

Attribute\Scenarios		(1)	(2)	(3)	(4)	(5)
Sale-weighted price [$/MW]		76.6	81.3	75.1	85.7	79.2
Permit Price [$/ton]		73.2	40.9	96.1	39.4	120.7
Total CO_2 [tons]		663.9	663.9	663.9	663.9	663.9
Consumers' Surplus [$]		73745.5	68733.8	74276.2	61897.0	69251.9
Producers' Surplus [$]		11547.2	39396.5	45583.5	43949.4	61949.4
ISO Revenue [$]		8034.0	6187.1	10607.1	8589.2	10486.6
Arbitrage Revenue [$]		0.0	0.0	0.0	0.0	0.0
Government Revenue [$]		48588.1	27160.4	0.0	26170.1	0.0
Social Welfare [$]		141914.8	141477.8	130466.8	140605.8	141687.9
Total Sales [MW]		1329.3	1293.6	1347.8	1280.5	1327.9
Producer Surplus [$]	**1**	1123.0	9317.8	11088.6	11190.6	14115.4
	2	0.0	11615.9	11211.1	10409.5	14962.0
	3	10424.2	18462.8	28010.3	22349.3	32872.0
Price [$/MW]	**1**	80.7	85.8	81.8	95.8	87.5
	2	52.8	61.1	44.9	57.6	47.8
	3	86.2	80.4	88.9	76.7	84.7
Demand [MW]	**1**	904.4	873.3	897.6	811.7	862.4
	2	233.9	185.8	279.6	205.9	263.0
	3	191.0	234.5	170.7	262.9	202.4

Conclusions

Strategic manipulation of the permit market has been an active research area for decades. However, the rate-based standard stipulated by the federal CPP brings a new twist to the problem. We analyze this problem by formulating it as a leader-follower or Stackeberg-type game and solve by re-formulation as an MILP. We show that the rate-based standard might effectively lower consumers' price through cross-subsidies to the marginal technology. To our surprise, the, rate-based standard can actually outperform its counterpart when considering government revenue in the form of proceedings from auctions in a mass-based policy. However, the generating portfolio of the leader might either enhance or restrain its market power in the rate-based emission policy. We leave this to our future research.

References

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