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Incentives for cost reduction and cost padding in electricity markets with overlapping "green" regulations

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A R T I C L E I N F O

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A B S T R A C T

We examine overlapping regulations in electricity markets. Using an example based on a stylized model of a competitive energy market, we study cost-reduction and cost-padding incentives by "green-energy" producers in an electricity market employing an emissions tax and the simultaneous use of a green quota for the generation portfolio and a fair rate-of-return constraint implemented via a system of feed-in tariffs. We show *inter alia* that when subsidies are phased out, exploitation of the green technologies full cost-reduction potential is a Nash Equilibrium but emissions will increase. In addition, green-energy producers can engage in collusive cost padding to increase profits even as they satisfy the policymaker's desired green quota.

1. Introduction

Around the world, concerns about carbon emissions have led to ambitious environmental targets, both in terms of emissions reductions and renewable energy (RE) market penetration. For example, the European Union (EU) has recently implemented the 2030 Framework for Climate and Energy calling for a 40% reduction in greenhouse gas emissions (relative to 1990 levels) and an increase in the share of RE to at least 27% by 2030 (European Commission, 2014). Recent research has demonstrated a number of unintended consequences and paradoxes associated with so called "overlapping" regulations involving emissions reductions and RE promotion. For example, Böhringer et al. (2008) demonstrate the existence of excess costs from the simultaneous use of emissions taxes and an emissions trading system in the EU. Böhringer and Rosendahl (2010) demonstrate that increasing a RE quota (i.e., a "green quota") under the simultaneous use of an emissions trading scheme will increase the production level of the most emissions intensive fossil-fuel based producer. In addition, in a general equilibrium framework, Eichner and Pethig (2010) examine some distributional aspects of combining the EU type emissions trading scheme with emissions taxes, concluding that the emissions taxes should be eliminated. Currier (2014) demonstrates that the simultaneous use of investment cost reduction policies and green certificate systems in RE markets will lead to increased emissions. Most recently, Böhringer and Behrens (2015) provide an analysis of the manner in which various RE promotion policies interact with an emissions trading scheme.

This research note contributes to the literature on overlapping regulations in electricity markets. One frequently employed RE support mechanism is a system of "feed-in tariffs" (FIT). Under a FIT system, grid operators are obliged to take in electricity generated by RE (green) producers. The green-energy producers are then compensated for each unit of electricity generated, regardless of the higher cost of generation compared to conventional technologies. In other words, the green-energy producers receive a subsidy paid in the form of a premium added to the market price of the electricity. These subsidies are typically "generation cost based" and designed to promote investor confidence by ensuring a "reasonable" rate-of-return on the RE investment (i.e., recovery of all costs of building and operating the RE installation and a fair rate-of-

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return to investors). However, the subsidies will be phased out as technological improvements in the RE production chain lead to lower costs and RE installations become cost competitive with fossil-fuel based (black-energy) producers (Couture and Gagnon, 2010). Therefore, analysis of incentives for cost control on the part of green-energy producers is an important issue.

Using an example based on a stylized model of a competitive electricity market, we study cost reduction and cost padding incentives by green-energy producers in an electricity market employing an emissions tax and the simultaneous use of a green quota and fair rate-of-return constraint implemented via a system of FITs, financed by an end-user tax on electricity. We show *inter alia* that when the subsidies are phased out, exploitation of the green technologies full cost-reduction potential is a Nash Equilibrium. However, green-energy producers can engage in collusive cost padding to increase profits even as they satisfy the policy maker's desired green quota.

2. The model

We consider a closed competitive electricity market with a single black-energy producer producing output y under constant returns to scale with constant marginal and average cost c_y. Emissions E are proportional to output: $E = \lambda y$, $\lambda > 0$. There are n identical green-energy producers with a strictly convex twice continuously differentiable cost function $C(x)$. Green-energy producers generate zero emissions. Total production is $q = nx + y$. Inverse market demand is $p(q)$, with $p'(q) < 0$.

The black-energy producers face an emissions tax $\phi > 0$. Green-energy producers receive a per-unit production subsidy $s \geq 0$ that is financed by an end user tax t on electricity. Subsidies are set to ensure that green-energy producers earn a “fair” rate of return. Finally, the policymaker has imposed a “green quota” requiring that a share α of total energy originate from green-energy producers.

Market equilibrium is described by the following set of equations:

$$p(q) = p \tag{1}$$

$$q = nx + y \tag{2}$$

$$p - t - \phi = c_y \tag{3}$$

$$p - t + s = MC(x) \tag{4}$$

$$(p - t + s)x - C(x) = \overline{\pi} \tag{5}$$

$$nsx = t(nx + y) \tag{6}$$

$$nx = \alpha(nx + y) \tag{7}$$

Eqs. (1) and (2) are market demand. Eq. (3) is profit maximization in the black-energy sector. Eq. (4) is green-energy producer profit maximization and (5) is the green-energy producers' fair rate of return (profit) constraint. Finally, (6) ensures revenue neutrality of the FIT and (7) is the green quota.

3. An example

To examine the green-energy producers' incentives for cost reduction and cost padding under overlapping rate-of-return and green-quota regulations, we assume linear demand $p = 100 - q$. Furthermore, we assume $c_y = 1$, $\lambda = 3$ and $n = 2$ with $C(x) = cx^2$, $c > 0$. Cost reductions from reduced manufacturing and installation costs in RE equipment and an experiential learning curve in RE generation are reflected in reductions in the true value of the cost parameter c. Finally, we assume $\overline{\pi} = 200$.

We begin by assuming that the *initial values* of the RE cost parameter and green quota are $c = 8$ and $\alpha = .2$. In this scenario, with $s = 37.5$, the equilibrium values of the variables are $\phi = 41.5$, $t = 7.5$, $p = 50$, $q = 50$, $x = 5$, $y = 40$. Green-energy producers earn the normal rate of return (i.e., $\overline{\pi} = 200$) and the green quota is met since $2(5) = .2(2(5) + 40)$. Furthermore, total emissions from black-energy production are $E = 3(40) = 120$.

Since the policy maker has deemed that green-energy producers are eligible for support, we assume that there is a value of the green quota greater than or equal to .2 and a *minimal* level of the RE cost parameter, attainable when all potential RE cost reductions have been realized, for which the green quota is satisfied and green-energy producers can earn a normal rate-of-return in the absence of any subsidization (i.e., green-energy producers are fully cost competitive with black energy-producers). We further assume that the policy maker has determined that technological improvements in the green-energy production chain can reduce c to 1.56. With a green quota of $\alpha = .35$, green-energy producer profits will be $\overline{\pi} = 200$ *with zero subsidy*. We thus state the following key assumption:

> The policy objective is the complete phase out of the green subsidies accompanied by an increase in the green quota from .2 to .35 as the cost parameter is reduced from $c = 8$ to $c = 1.56$.

In the above scenario, with $c = 1.56$, $\alpha = .35$ and $s = 0$, the equilibrium is $\phi = 34.3169$, $t = 0$, $p = 35.3169$, $q = 64.6831$, $x = 11.3195$, $y = 42.044$ and $\pi = 200$. We observe somewhat paradoxically that emissions from black-energy production have now *increased* to $E = 126.132$. The reason for this result is that the simultaneous decrease in cost and increase in the green quota raise market output and lower market price. Since the subsidy is reduced to zero, the end user tax is reduced to zero and the lower market price results in a reduced emissions price, thereby increasing emissions.

To examine cost incentives of green-energy producers, we continue to assume that the subsidies have been phased out completely and let $\hat{c}_i \geq 1.56$ denote firm *i's* actual observed cost parameter value, $i = 1,2$. If $\hat{c}_i = 1.56$, firm i is fully exploiting its cost-reduction potential. If $\hat{c}_i > 1.56$, firm i is engaging in cost padding, in terms of wasteful expenditures, managerial perquisites, or simple rent seeking.[1]

We first state Proposition 1:

> After RE subsidies are phased out, exploitation of full cost-reduction potential by green-energy producers is a Nash Equilibrium.

Our proof is as follows:

With $s = t = 0$, we parameterize the model by $(\hat{c}_1, \hat{c}_2)$ yielding equilibrium green-energy producer profits

$$\pi_1 = \frac{122500(\hat{c}_1)(\hat{c}_2)^2}{(10\hat{c}_1 + 10\hat{c}_2 + 7\hat{c}_1\hat{c}_2)^2}$$

[1] In the present context, rent seeking may include political efforts to maintain subsidization and lengthen the time period of support eligibility.