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Tradable credit markets for intensity standards

Ivan Rudik [1]

Dyson School of Applied Economics and Management, Cornell University, 475J Warren Hall, Ithaca, NY 14850, USA

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ABSTRACT

Many environmental standards are expressed in terms of intensity rather than absolute levels. In some cases, intensity standards are associated with tradable credit markets to help reduce firms' compliance costs. I develop a jurisdictional model of credit trading under an intensity standard, framed in terms of a Renewable Portfolio Standard for electric utilities. I find that regulators of firms with low compliance costs always allow for inter-jurisdictional credit trade. Regulators of firms with high costs of compliance allow for credit trade under the condition that extra-jurisdictional credits count less towards compliance compared to credits generated within the jurisdiction. Counter-intuitively, increasing the stringency of the intensity standard when credit trading is possible can have the opposite of the intended effect and actually decrease renewable electricity generation. Using numerical simulations, I show that heterogeneity in terms of renewable costs or externalities across jurisdictions are not sufficient for inter-jurisdictional credit trading to be a stable equilibrium outcome.

Despite growing concerns about pollution and climate change, first-best environmental policies for mitigating pollution are uncommon. The first-best policies that have had political success are typically cap-and-trade systems, or are limited both spatially and in terms of stringency.[2] Second-best policies, such as intensity standards, have gained more traction despite their shortcomings in achieving efficient outcomes. In particular, a majority of states in the US have passed a Renewable Portfolio Standard (RPS), which mandates that a minimum percentage of an electricity provider's retail sales come from renewable sources. Complying with intensity standards like an RPS can be burdensome for firms with high costs of renewable production. In particular, electricity providers cannot simply reduce non-renewable electricity to meet an RPS because they must still provide enough electricity to satisfy highly inelastic retail demand. Moreover, increasing the percentage of renewables in the generation mix raises concerns about intermittent generation. Indeed, some economists have noted that an RPS policy may be a prohibitively expensive policy tool for achieving a given level of emissions reductions (Fischer and Newell, 2008).

To help reduce compliance costs, policymakers can couple intensity standards with tradable credit systems, similar to how policymakers have developed tradable permit markets for cap-and-trade regulation. Tradable credits allow for renewable production to be reallocated towards lower cost firms and actually achieves the cost-efficient outcome under intensity targets, equating marginal costs across firms that face the same standard.[3] A majority of RPS states allow for inter-state Renewable Energy Credit (REC) trading. Under REC trade, electricity providers are awarded one REC for each megawatt-hour of renewable sales, and RECs can potentially be unbundled from the energy itself. REC markets are highly active with inter-state trading volumes reaching tens of millions of megawatt-hours annually. Despite the apparent benefits of REC trade in terms of reducing compliance costs, there is significant heterogeneity across states in the degree of restrictions on inter-state REC trade. Some states have taken a lassez-faire approach to trade and placed no restrictions on where a REC was generated, while others have completely banned out-of-state RECs.[4]

The heterogeneity in REC trade restrictions across states is a peculiar outcome given the economic evidence on gains from trade. Despite this tension between economic intuition and reality, credit trading under

E-mail address: irudik@cornell.edu.

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[2] For example, carbon taxes in the United States are only at the city or county level. A clear exception to this is EU-ETS.

[3] There may be caveats in terms of what units the credits are in, see McKitrick (2001) and Holland et al. (2009) for further details.

[4] Several of the trade-eligible states, such as Delaware, are heavily reliant on out-of-state RECs, obtaining up to 94% of the amount necessary to meet the RPS via inter-state trade in 2012 (Heeter et al., 2015). Yet other states, like Iowa or New Mexico, restrict their utilities to obtain RECs solely from in-state generation.

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intensity standards has yet to be the primary focus of study.[5] I develop an analytical model of a jurisdictional regulator and a representative electricity firm. The regulator sets an RPS that the firm must meet. In the model, the regulator selects her policy instrument to address two objectives: to reduce pollution externalities from non-renewable electricity generation, and to spur additional in-state energy from clean and renewable sources. In addition to the RPS, the regulator also chooses whether or not to allow the firm to engage in inter-jurisdictional REC trading. Using the model, I characterize the incentives firms and regulators face under REC trade, and analyze what drives jurisdictions to restrict firms from trading RECs.

This paper adds to a rich literature initiated by Helfand (1991) whose analysis of intensity standards demonstrated regulating multiple polluting outputs can actually lead to increases in emissions.[6] Holland et al. (2009) come to the same conclusion in their study of California's low carbon fuel standard; amongst the existing literature, their model is most similar to the one developed in this paper.[7] Parallel to these results, I find a new perverse outcome where increasing the stringency of an intensity standard can actually reduce renewable energy generation when REC trade is allowed because of how REC trade alters the relationship between an RPS and its implicit renewable subsidy.

This is the first in depth analysis of trade under intensity standards that also closely matches the characteristics of real world REC markets.[8] Trade under intensity standards is briefly analyzed by Holland et al. (2009), who demonstrate that trading effectively minimizes costs subject to the market low carbon fuel standard. Similarly, McKitrick (2005) finds permit trading under intensity standards can be efficient, as long as a permit is a unit of pollution *intensity* with a specific exchange rate between firms.

Extending the existing literature, I allow for a regulator to choose both the stringency of the intensity standard and also whether or not firms in her jurisdiction can trade credits with extra-jurisdictional firms. Using this framework I demonstrate how REC trading changes the regulator's policy instrument by pinning the firm's shadow cost to the REC price instead of it being a function of the regulator's RPS stringency. This alteration of the shadow cost actually changes the sign of the effect of RPS on renewable generation from positive to negative. In addition, I show that whether a utility is a credit seller or credit buyer simply depends on the size of the utility's shadow cost compared to the REC price. Building off of this insight, the primary result of interest is that regulators of firms that would be REC buyers if trade was allowed (due to high relative costs of renewables or a very stringent RPS) allow for REC trading, but only if the RECs purchased from other jurisdictions count less towards compliance than RECs generated within-jurisdiction. This is because allowing for freer trade can potentially worsen local pollution externalities beyond the gains from firm cost reductions. This finding draws parallels to the pollution haven literature showing that relaxing trade restrictions for goods can increase pollution (Copeland and Taylor, 1994; Taylor and Copeland, 2004). I also demonstrate that symmetric jurisdictions are better off by strictly not allowing for REC trade. Standard economic intuition suggests that the regulators of each jurisdiction should be indifferent between allowing for trade or not. However, allowing trade *does* change outcomes for symmetric firms under intensity standards: in response to opening up trade, regulators strategically adjust their jurisdictional RPS policy to capture rents in the REC market, shifting away from the no-trade optimal levels and reducing welfare. This highlights how strategic responses by regulators can actually deteriorate and even completely offset any benefits of allowing REC trade.

Finally, I compute a stylized numerical REC trade coalition formation game where the jurisdictions are heterogeneous over their cost structures, damages from pollution, and their preferences for having renewable energy generated within-jurisdiction. I show that REC trade coalitions typically do not form because of strategic RPS selection, and when they do form they are small. When a stable equilibrium outcome with REC trade arises in the settings I explore, it is actually dominated by another stable equilibrium with no trade at all.

The paper is organized as follows. I begin by describing the firm's problem and how an RPS affect firm decision-making. I then characterize the determinants of REC buying and REC selling firms. Finally, I describe the regulator's problem, provide the conditions under which a jurisdiction will engage in inter-jurisdictional REC trade, and then use a numerical simulation to investigate a richer setting where regulators play a REC trade coalition formation game while also strategically selecting their RPS stringencies.

1. A model of a firm in a competitive REC market

Suppose there is one representative price-taking firm in an arbitrary jurisdiction that supplies electricity to a representative consumer within that jurisdiction.[9] The firm generates two types of electricity: renewable electricity, q_r, and non-renewable electricity, q_n.[10] The firm sells its total electricity generation, $q_r + q_n$, to the representative consumer at the retail market price P.[11] The consumer has a continuous, twice-differentiable, strictly increasing, and strictly concave utility function $u(q_r + q_n)$ where $u(0) = 0$ and $\lim_{q_r+q_n \downarrow 0} u'(q_r + q_n) = \infty$. The cost functions for each source of electricity, $C_r(q_r)$ and $C_n(q_n)$, are continuous, twice-differentiable, strictly increasing, and strictly convex.[12]

The market is regulated by a social planner who selects the level of an RPS, α, such that $\alpha \in [0, 1]$. The RPS mandates the minimum percentage of renewable energy in the firm's electricity portfolio. Without the ability to trade RECs, this constrains the firm's electricity generation to satisfy $\frac{q_r}{q_r+q_n} \geq \alpha$.[13] From herein assume that the RPS is always binding and the regulator's preferences (defined later) are such that the optimal α is strictly greater than 0. The firm complies with the RPS by retiring renewable energy credits (RECs). For each unit of renewable energy generation, the firm is awarded one REC. Given total output

[5] Hollingsworth and Rudik (Forthcoming) use a simple model to motivate an empirical analysis of how one state's RPS can affect generation in another state that may not even be on the same electricity grid. Decisions to engage in REC trade form a close parallel to the International Environmental Agreement literature which analyzes incentives for countries to form coalitions for emissions reductions. See Barrett (1994) and Karp and Simon (2013) for details on early and more recent work.

[6] McKitrick (2001) analyzes an intensity standard and find that intensity standards should be heterogeneous across firms and stringency should be a function of firm size to achieve efficient outcomes.

[7] Lemoine (2016) also analyzes California's LCFS but allows the regulator to also control the emissions ratings for fuels in order to achieve greater welfare levels.

[8] Bento et al. (2018) study RPSs in a general equilibrium setting but without an explicit treatment of jurisdictional policymaking or inter-jurisdictional REC trade.

[9] Here I will not index by jurisdiction to economize on notation. Firms in different jurisdictions may have heterogeneous cost functions and face consumers with different utility functions, but this heterogeneity does not directly affect their decision-making. It only has an impact through the effect on the REC market price.

[10] I abstract away from intermittency. REC trade could be beneficial in smoothing out uncertain generation from renewable plants and is a line of research left for future work.

[11] In a given year, retail electricity demand may be close to perfectly inelastic and the retail market price would be effectively fixed. This does not change the results.

[12] The majority of the renewable power sold by utilities is bought from independent power producers (Fremeth and Shaver, 2014). In this static setting we can think of the firm as a utility who contracts with the cheapest independent producers first in order to meet renewable energy needs.

[13] Technically RPS regulate a utility's electricity *sales*, but in this stylized model I use them interchangeably.