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Economics of additionality for environmental services from agriculture ☆

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ABSTRACT

We present a model of additionality for offsets sold from agriculture to industrial sector sources regulated by cap-and-trade. We consider a potential policy where agricultural sources would not be covered by cap-and-trade requirements but would be eligible to receive offsets whenever their emissions fall below a policy-specified baseline, and would not be penalized for emissions above their baseline. Major results are: (1) The optimal baseline should be set above the average counterfactual emissions of participating farms, an unexpected result that has been missing from the literature. (2) The optimal trading ratio should be greater than one (a ton of offsets counts for less than a ton of covered emissions) even under emissions certainty. Previous research has justified such trading ratios by emissions uncertainty. (3) Emissions uncertainty does not justify a change in the baseline if the accompanying emissions model is unbiased. (4) An optimal combination of policies is to subsidize offsets and tighten the baseline relative to the no-subsidy case.

1. Introduction

A large number of agricultural and environmental policies provide payments to induce farmers to take actions, such as growing trees or reducing fertilizer use, to provide environmental and resource conservation services, including carbon sequestration and reduced greenhouse gas emissions, runoff control, soil retention, and wildlife habitat preservation. Examples in the U.S. of payment-based approaches include the Conservation Reserve Program (CRP), the Environmental Quality Incentives Program (EQIP), and the Conservation Stewardship Program (CSP), which together accounted for \$3.0 billion in 2010 public expenditures on nearly 70 million acres. These payments substitute, in whole or in part, for the direct regulation generally used for other (industrial) sources of negative externalities. New (water quality) and proposed (greenhouse gas) cap-and-trade programs that involve trading between regulated point sources and unregulated nonpoint (agricultural) sources continue this dichotomy. Among greenhouse gases, agriculture is the largest source of certain types of anthropogenic nitrogen pollution. Proposed policies would offer payments to farmers for voluntarily reducing emissions by reducing nitrogen fertilization. This compares to industrial sources that would be required to hold emissions permits.

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A different treatment for agriculture is motivated by the substantial heterogeneity of land characteristics and production practices, which makes direct monitoring of emissions impractical.[1]

A common feature of these performance-based payment policies is that they offer payments for environmental services that improve upon a policy-specified, farm-specific baseline and do not penalize environmental services that are worse than the baseline. This asymmetry is the source of problems of non-additionality, leakage, and permanence, each of which arises because no price (i.e., tax) is established for decreases in environmental services and because not all relevant farm and farmer characteristics are observable to the regulator who sets the baseline. This paper focuses on additionality under a voluntary baseline policy in the case of incomplete information.[2] Environmental services for which payments are received are additional if and only if they would not be provided in absence of the payments.

Payments for non-additional environmental services occur with these programs due to incomplete information. Baselines and other policy features, however, can reduce the extent of this non-additionality. This paper examines optimal policy design in this context. The model assumes industrial sources of greenhouse gases are regulated by a cap-and-trade system, but can buy offset credits from farmers where reduced farm use of nitrogen fertilizer is considered as a generator of offsets. Farmers receive offset credits according to the calculated (or estimated) amount by which specific observable production practices reduce emissions below a regulator-determined farm-specific baseline. The model is also applicable to the case where credits are purchased with direct government payments similar to existing conservation programs if emissions credits are used to relax the cap imposed by cap and trade, which is roughly the approach taken by North Carolina's Tar-Pamlico Nutrient Trading scheme. In both cases, the price received by the farmer per unit of estimated emissions reduction is assumed to be equal to the allowance price for permits traded among firms regulated by cap and trade. We assume farmers are competitive price-takers.

We model this policy as a principal-agent problem, a common approach for analyzing adverse selection, which is the essence of the additionality problem. A standard welfare model is used to solve for the optimal farm-specific baseline subject to uncertainty about unobservable characteristics. We use a linear rather than nonlinear pricing approach because it better reflects current and proposed offset programs and provides a more transparent policy rationale.[3] We find that linear pricing yields a remarkably rich set of results regarding the effects of seven important economic and policy questions: (i) greater curvature in environmental damages, (ii) greater cross-sectional variation in participation costs, (iii) reduction in mean emissions abatement costs, (iv) uncertainty in modeled emissions by which offset credits are awarded, (v) imposition of a regulator-imposed trading ratio between agricultural offsets and industrial-source allowances, (vi) institution of an offset subsidy, and (vii) alteration of the cap on the covered-sector.

The incomplete information, linear pricing approach has been previously modeled by Montero [18] and Bento et al. [2]. Their work obtains optimal results at the aggregate level regarding the tradeoff between non-additional emissions and the participation level by abstracting from the standard generalities of production theory at the micro level. We obtain unique complementary results for optimal design of offsets policy within a specific uncovered sector by abstracting from permit price variation. We generalize their assumption of constant marginal costs of emissions reductions at the firm level by focusing on optimal policy design within an uncovered sector such as agriculture that has detailed farm-level data available for policy purposes. Non-constant marginal costs are motivated by standard production theory and lead to partial rather than complete elimination of emissions by individual participants. This generates an additional tradeoff between emissions reductions and production possibilities that has important implications for optimality of baseline policy.

Conceptually, our contribution relative to these previous studies can be understood in the context of a two-stage approach to the optimal design of offsets policy: a first-stage of structuring offsets policy efficiently within individual uncovered sectors *given the permit price*, and a second-stage that considers optimal setting of the covered sector cap and resulting permit price given optimal policy features in the uncovered sectors. We provide the first-stage analysis necessary for this approach. Ultimately, the features of optimality at both stages must be joined for practical empirical application. However, combining both levels of generality for theoretical purposes prevents transparent presentation of analytical results. This is the sense in which our results complement the work of Montero [18] and Bento et al. [2]. Our final result, which considers reducing the cap, shows that our model is consistent with Montero's primary result while examining aspects of optimal offsets policy within the uncovered sector.[4]

Our basic result is that the baseline should be greater than average business-as-usual emissions among firms that choose to sell offsets, at least when the volume of offsets does not appreciably affect the marginal value of offsets to the covered sector and the initial cap is not set implausibly low. We find that the role of a "safety margin," such as was proposed in Waxman–Markey bill, does not apply for the average participant even though it applies at the margin of participation.[5]

[1] Unlike the case with industrial sources, imposition of farm-specific government program requirements has been common dating back at least to the crop allotments of the 1950s because farms are highly heterogeneous. For example, current government crop insurance programs require field-specific crop and yield histories that are used to set field-specific crop insurance premiums. Similarly, other conservation programs such as the CRP and EQIP provide payments with eligibility based on field-specific conditions.

[2] Non-additionality is not an issue in models that assume complete information such as Rosas et al.'s [21] simulation analysis of a nonlinear offset program for N_2O emissions, and Ghosh et al.'s [5] multi-dimensional baseline analysis of water quality trading among dairy farmers.

[3] Mason and Plantinga construct a nonlinear pricing model of additionality where the price for offset credits depends on how many credits are sold, which gives the regulator additional policy instruments and guarantees weakly superior social welfare. A nonlinear pricing model would be equivalent to awarding offset credits as a nonlinear function of a farm's emissions reductions, which complicates program administration. However, some of these gains are possible under a combination of baseline and trading ratio policies as we demonstrate below.

[4] Bento et al. [2] also examine an optimal trading ratio but do not derive analytical results.

[5] The Waxman–Markey bill called for a "conservative estimate" and "margin of safety" so that offsets are "additional" to an "activity baseline."