Journal of Environmental Economics and Management 66 (2013) 1–14

Contents lists available at SciVerse ScienceDirect

Journal of Environmental Economics and Management

journal homepage: www.elsevier.com/locate/jeem

The additionality problem with offsets: Optimal contracts for carbon sequestration in forests ☆

Charles F. Mason [a,*], Andrew J. Plantinga [b,1]

[a] Department of Economics & Finance, University of Wyoming, Laramie, WY 82071, United States
[b] Bren School of Environmental Science and Management, University of California, Santa Barbara, CA 93106, United States

ARTICLE INFO

Article history:
Received 21 December 2011
Available online 19 April 2013

Keywords:
Carbon sequestration
Incentive contracting
Offsets
Additionality

ABSTRACT

Carbon offsets are a frequently discussed tool for reducing the costs of an emissions reduction policy. However, offsets have a basic problem stemming from asymmetric information. Sellers of offsets have private information about their opportunity costs, leading to concerns about whether offsets are additional. Non-additional offsets can undermine a cap-and-trade program or, if the government purchases them directly, result in enormous government expenditures. We analyze contracts for carbon sequestration in forests that mitigate the asymmetric information problem. Landowners are offered a menu of two-part contracts that induces them to reveal their type. Under this scheme, the government is able to identify ex post how much additional forest each landowner contributes and minimize ex ante its expenditures on carbon sequestration. To explore the performance of the contracting scheme, we conduct a national-scale simulation using an econometric model of land-use change. The results indicate that for an increase in forest area of 61 million acres, government expenditures are $5.3 billion lower under the contracting approach compared to a uniform subsidy offered to all landowners. This compares to an increase in private opportunity costs of just $110 million dollars under the contracts. Thus, the contracting scheme is preferable from society's perspective.

1. Introduction

Reducing emissions of greenhouse gases to lessen the impact of future climate change is likely to result in large net benefits globally. However, reducing emissions will impose significant costs. One recent estimate of the costs of achieving optimal abatement of greenhouse gas emissions through control of industrial CO_2 emissions was $2.2 trillion [17], which underscores the appeal of any scheme that might lower the costs of carbon reduction. One way to reduce costs that has

☆ We thank, without implicating, participants at the 2011 Allied Social Science Meetings; 2010 NBER summer institute (Energy and Environmental Economics); the Toulouse conference on Firms, Environment and Natural Resources; the 2010 Heartland Environmental and Resource Economics workshop; the 4th World Congress of Environmental and Resource Economists; and seminar participants at the London School of Economics, University of California—Santa Barbara, University of Paris, University of Puget Sound, University of Siena, and Williamette University. Special thanks are due to Dave Lewis, Brian Murray and Steve Polasky. Two anonymous referees and the Managing Editor provided constructive criticisms that greatly improved the content and presentation of our paper. Funding from the U.S. Department of Energy (grant # DE-FC26-05NT42587) and the U.S Forest Service (grant #PNW 09-JV-11261955-067) is gratefully acknowledged.

* Corresponding author. Fax: +1 307 766 5090.
E-mail addresses: bambuzlr@uwyo.edu (C.F. Mason), plantinga@bren.ucsb.edu (A.J. Plantinga).
[1] Fax: +1 805 893 7612.

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http://dx.doi.org/10.1016/j.jeem.2013.02.003

received a great deal of attention is the use of offsets. The idea is that countries could meet emissions targets by substituting lower-cost offsets for reductions in emissions from energy production.

A particularly promising type of offset involves carbon sequestration in forests. Numerous studies have found that forest sequestration can be used to offset a substantial share of carbon emissions at costs that are similar to or lower than those associated with energy-based mitigation approaches [21,34,28]. Other offset categories include carbon storage in agricultural soils and the transfer of clean energy technologies to developing countries not subject to emissions targets. Some types of forest and energy offsets are allowed under the Clean Development Mechanism (CDM) of the Kyoto Protocol, and there is interest in expanding their use under future agreements.[2]

Despite their potential to reduce costs, offsets have a basic problem stemming from asymmetric information. Sellers of offsets have private information about their opportunity costs of mitigating or abating emissions. This implies that only the seller knows whether she would have undertaken the activity in the absence of a payment for the offset. This leads to the oft-expressed concern about "additionality": offsets are not true incremental adjustments if they would have happened anyway.[3]

The additionality of offsets is important in two respects. First, governments will want to avoid paying for non-additional offsets in order to limit their expenditures. A number of studies have argued that government expenditures can reduce net social benefits if there are opportunity costs to raising public funds [1,5,6,8]. The government costs associated with purchases of offsets could be enormous. For example, in the U.S. an average of 1.3 million acres was deforested annually between 1982 and 1997 [32]. While this produced significant carbon emissions that might be avoided at reasonable cost, one must consider that the area of (non-federal) forest in the U.S. is approximately 400 million acres. If the government were to implement a subsidy for avoided deforestation and apply it uniformly across all forested acres, then in the extreme case it would subsidize all forest land when less than 1% of the area would have been deforested. Of course, the government can avoid large expenditures by levying taxes instead of paying subsidies. We regard this option as politically unviable, especially in the context of private landowners in the U.S.

Second, to legitimately use offsets to meet emissions reduction targets, such as those stipulated under international treaties, the government must be able to verify that they are additional. Procedures that fail to clearly identify the increment of sequestration produced have been soundly criticized [20], and, thus, concerns about additionality have been a stumbling block for inclusion of offsets, particularly those from avoided deforestation, in international efforts to address climate change [19]. Even when a private entity such as a regulated emissions source purchases offsets, it faces the same problem as the government does with asymmetric information. As long as it is required to verify the purchase of additional offsets, a private entity will want to avoid paying for non-additional offsets as well as limiting its expenditures on the offsets that are additional. However, sellers have an incentive to exploit the asymmetric information by claiming to have high opportunity costs.

In this paper, we propose a contracting scheme for carbon offsets and investigate its performance empirically with a national-scale simulation. Our paper combines modern contract theory with a careful application of econometric results based on a concrete example. The distinguishing feature of our empirical analysis is that we estimate the distribution over agent types using revealed preference data on individual land-use decisions. As such, we are able to obtain meaningful estimates of the costs, to the principal and agents, associated with employing optimal contracts.[4] In our application, we study a national-scale policy that addresses an environmental problem of critical importance. The estimates we obtain allow us to articulate the potential welfare gains from the use of sophisticated contracts that are based on defensible, empirically-based parameter values. Importantly, our results show these potential welfare gains are significant, in a variety of geographical contexts.

Our theoretical model adapts a standard principal-agent framework [12,22] to the problem at hand. The principal's objective is to maximize expected net societal benefits from afforestation and avoided deforestation (collectively, forestation), where forestation benefits are tied to an exogenously determined carbon price and costs are defined in terms of government expenditures. The problem may be regarded as one of adverse selection: the principal is assumed to know the distribution over landowners' opportunity costs, but not the realization for any particular individual; as a result, the amount of land any particular agent would have placed in forest absent a payment is not observed by the principal.[5] In the

[2] See, e.g., UNFCCC [31]. In principle, all carbon sources and sinks could be included under an emissions control policy, such as a cap-and-trade program. There are practical obstacles to this approach in the case of offsets from forests and agricultural lands due to the large and diverse population of landowners and apparent political obstacles-as suggested by the Kyoto Protocol negotiations-in the case of developing countries.

[3] More generally, additionality arises whenever the government seeks to procure an impure public good from agents with private information. It has also been studied in the context of government subsidies for R&D and job creation [18,10].

[4] A small number of earlier studies, of the French telecommunication and urban transport sectors [4,9] and Midwestern agricultural producers [24], have used a similar approach. There are many papers that apply contract theory to specific problems, though these studies do not draw on detailed econometric evidence to parameterize the distribution over agent types (e.g., [3,2]). One also finds empirical studies of existing contracts (e.g., [35,30]) that recover the type distribution under the assumption that optimal contracts are in place. Finally, Nemes et al. [16] conduct an experimental analysis of an offset problem; as with most experimental papers, they analyze behavior by financially motivated subjects, rather than naturally observed behavior.

[5] Viewed in this way, the problem is one of hidden information. van Benthem and Kerr [33] consider a similar framework to ours, but do not consider the potential for the principal to reduce information rents by the use of two-part contracts; instead, they focus on the role of landowner size on contract efficiency. Using a variation of the law of large numbers, they argue that efficiency increases with the size of the landowner's holdings. Montero [15] considers a problem in which the government wishes to buy a certain amount of offsets from a group of firms whose costs are private information; once a