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How should a forest carbon rent policy be implemented?

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ABSTRACT

Forest economics literature commonly uses two alternative ways to apply carbon payments to forest owners: a carbon rental policy and a policy where carbon compensations are based on subsidies and taxes. Conditions under which these two policy schemes lead to similar market outcomes are identified: We show that perfect capital markets and rational expectations over carbon prices are required for the equivalency of the two policy schemes. However, the basic principles with which the two policies would need to be implemented suggest that the carbon rent policy could be more easily put into practice. Furthermore, we suggest a way how to integrate the forest carbon policies into an emission trading scheme. We show that a fully compensatory carbon rent policy in the EU would require 10–50% of the emission trading revenues depending of the interest rate and expected carbon price inflation. If implemented at the global level, the policy would need even significantly higher shares of hypothesized global emission permit revenues. The policies can utilize baseline trajectories of forest carbon that reduce the costs at desired level, but distort forest owners' valuation of the carbon flows.

1. Introduction

Policies accounting for the carbon sequestration benefits of forests have raised attention in the literature at least since papers by Englin and Callaway (1993) and van Kooten et al. (1995). The basic question is how to design carbon policies for forests in such a way that forest owners would take the sequestration benefits into account at a socially optimal level. The model by van Kooten et al. (1995) is based on subsidies for the carbon increments of a growing forest and on taxes that penalize harvesting the carbon stock at the end of a rotation. Carbon subsidies would encourage planting of trees and investments in silviculture that promote tree growth, while carbon taxes would discourage harvest and the subsequent release of CO_2 (stored carbon) into the atmosphere. Related to private ownership of forest land, this model can be thought of as a policy where the government gradually, over the course of the rotation cycle, purchases the carbon stock that accrues in the forest owner's land while the landowner is required to purchase back the carbon content at the time of harvesting.

The subsidize-and-tax model seems to be the standard approach used in the literature to model forest related carbon sequestration policies (see e.g. Romero et al., 1998). This approach is supported by the observation that "It is not the age of trees or standing timber volume that is important, but rather, the rate of tree growth" (van Kooten et al., 1995). Analysis with market equilibrium models using either biomass or age-structured descriptions of the forest resources confirms that this approach is, indeed the correct way to organize carbon policies for forests (Tahvonen, 1995; Lintunen and Uusivuori, 2014). Yet, another approach to model the sequestration policies has been suggested in literature. This approach is based on the value of existing carbon stocks in the forest and on the periodic rents paid on these (Sohngen and Mendelsohn, 2003; Sedjo and Marland, 2003; Uusivuori and Laturi, 2007). In what follows we separate these two approaches by using the term *carbon purchase policy* when referring to the growth based subsidize-and-tax policies, and the term *carbon rent policy* when referring to the carbon stock based policies.

It is of interest, from both theoretical and practical point of views, to assess the equivalency of the two ways of organizing a carbon compensation system for forests. Our aim in this paper is two-fold. First, we analyze analytically the equivalency of the carbon purchase and rental systems, and derive the conditions under which the two approaches are equivalent. In the simple context when net present value is maximized with constant prices, the equivalency is fairly obvious, but we show that in a more general model setting the equivalency will depend, e.g. on price expectations. Second, after our analytical part, we discuss the administrative and practical issues – such as fiscal burdens – related to the implementation of the two approaches. We propose a way to implement a full-scale carbon sequestration policy within a cap and trade system. The policy encompasses all forest resources, as opposed to project-based approaches used in many carbon offset projects extending the emission trading systems. We show that the carbon purchase policy implies high establishment costs as the regulator has to purchase the existing carbon stock at the beginning of imposing a cap and trade system. In the carbon rent system, the monetary flows go only one way, as the forest owners do not pay carbon payments to the regulator

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during a rotation cycle, which suggests that the policy could be implemented more easily and with smaller transaction costs both in the developed and developing economies. In practice, the policies have focused on emission offsetting and, therefore, on additional carbon removals using business-as-usual baselines and forest management reference levels (e.g. UNFCCC, 2011 and CEPA, 2014). If the policy is accompanied with carbon stock baselines, the costs can be substantially reduced. The main drawback of the baseline approach is a loss of full internalization of the climate benefits.

We relate the costs of the proposed full compensation carbon sequestration policy to the revenues from the emissions permit auctions in the EU-ETS system and show that a fully compensating forest carbon policy could be funded with about 10–50% of the revenues from the permit auctions when interest rate net of carbon price inflation ranges from 1% to 5%. In the case of the US, the costs relative to the hypothesized emission trade income flows are slightly higher and at the global level, the relative costs are 30–160%. This suggests that in global context either a partial compensation policy needs to be developed or/and the policy needs to be restricted to those forests that are actually being under active management or under a threat of immediate harvest. In practice, this can be done using baseline projections of future biomass carbon stocks. However, we argue that in a full-scale policy, these baselines do not need to follow the business-*as*-usual projections but can be determined more freely.

A forest-carbon policy tends to increase the land expectation value. This value increase gives incentives to manage forest in a way that carbon stock is increased but also to keep the land in forestry use and reforest and afforest parcels of land. For example, the Compliance Offset Program of California's greenhouse gas cap-and-trade program acknowledges carbon offsets by all these means (CEPA, 2014). However, in this study, we focus on the case of increasing carbon stocks on a fixed land area, but the policy has direct consequences also on land-allocation. The analysis of induced land-use changes is beyond the scope of the paper.

The paper is structured as follows. In Section 2 we describe briefly the carbon purchase model by van Kooten et al. (1995) and highlight its apparent equivalency with the carbon rent policy. In Section 3 we show the equivalence of the carbon rent and the purchase schemes in a more general model. In Section 4 we compare the implementation of the carbon purchase and carbon rent policies. Section 5 concludes.

2. Carbon purchase and carbon rent in a continuous-time land-value model

The basic connection between carbon purchase and carbon rent policies is directly observed from van Kooten et al. (1995). They proposed the following land expectation value optimization problem of Hartmann type

$$\max_T LEV(T) := \left[(pq(T)-k)e^{-rT} + R_c(T)\right]\left(1-e^{-rT}\right)^{-1} - c \tag{1}$$

with a carbon subsidy scheme over the rotation

$$R_c(T) := p_c\left[\int_0^T v'(t)e^{-rt}\mathrm{d}t - (1-\alpha)v(T)e^{-rT}\right], \tag{2}$$

where p is the timber price, p_c the carbon price and k the per hectare harvest and regeneration costs. Functions $q(t)$ and $v(t)$ present the volume of wood and stock of carbon for a hectare of land. Interest rate is denoted by r. Parameter $\alpha \in [0,1]$ is a so-called pickling factor that tells the assumed share of harvested timber stored in harvested wood products. The subsidy scheme (Eq. (2)) can be understood as a carbon purchase policy, where the regulator first buys the sequestered carbon while the forest owner subsequently buys it back when harvesting occurs. Since only the amount of carbon not directed to wood products is bought back, the pickling factor reduces the carbon tax faced by a forest owner at the moment of harvest.

By a straightforward application of integration by parts and assuming $v(0) = 0$, the value of subsidy scheme can be written as

$$R_c(T) = p_c\left[r\int_0^T v(t)e^{-rt}\mathrm{d}t + \alpha v(T)e^{-rT}\right]. \tag{3}$$

Thus, the carbon purchase subsidy scheme is compatible with a policy where forest owners receive a flow of carbon rent payments

$$\rho_c(t) = rp_c v(t) \tag{4}$$

plus an end payment

$$S_c(t) = \alpha p_c v(T) \tag{5}$$

at the time of harvest. Under this carbon rent policy setting the forest owner gets a rent-like payment for storing carbon into the forest stand, i.e. the regulator does not buy but rents the sequestered carbon. At the moment of harvest the forest owner is compensated for contributing to a permanent carbon storage if the pickling factor α is positive. Thus, the carbon purchase and carbon rent policies are equivalent in NPV terms in a continuous time setting with constant prices. As the maximization problems for the two problems are equivalent, the actions enforced by the policies are equal.

3. Carbon purchase and rent policies in a general discrete-time model

3.1. The model

To be able to compare the two carbon compensation policies, it is necessary to study to what extent the equivalence of carbon purchase and carbon rent policies prevails in a more general context illustrating the forest owner's decision problem. We will show that the equivalency result can be retained in this more general context, but that it is not as trivial as demonstrated above. The forest owner cares, in a non-additive manner, for both the consumption level, c_t, and the amenity services provided by the forest, A_t. In addition, the forest consists of several age-classes. The forest owner is assumed to have access to perfect capital markets. He chooses infinite-horizon consumption and harvest sequences, $\{c_t, \theta_t\}_{t=0}^{\infty}$, that maximize the net present value of the utility flows. The harvest decision, θ_{at}, determines the share of land to be harvested for every age-class, x_{at} (Uusivuori and Kuuluvainen, 2005). Thus, the optimization problem is

$$\max_{\{c_t,\theta_t\}_{t=0}^{\infty}} U := \sum_{t=0}^{\infty} \beta^t u(c_t, A_t) \tag{6}$$

subject to

$$\delta s_{t+1}^i = s_t + y_t + \pi_t + \sigma_t^i - c_t, \tag{7}$$

$$x_{1,t+1} = \sum_a \theta_{at} x_{at}, \tag{8}$$

and

$$x_{a+1,t+1} = (1-\theta_{at})x_{at}, \tag{9}$$

where the discount factor for utility stream, β, is based on forest owner preferences and the discount factor for wealth, $\delta = (1 + r_\Delta)^{-1}$, is based on the periodic market interest rate r_Δ. The per hectare amenity services, η_a, are assumed to be age-class dependent. The amenity services are received only on the forest land that is not harvested during the current period. Thus, the total amenity services are