Journal of Forest Economics 24 (2016) 130–156

Contents lists available at ScienceDirect

Journal of Forest Economics

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

On the economics of forests and climate change: Deriving optimal policies

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ARTICLE INFO

Article history:
Received 3 December 2015
Accepted 17 May 2016

JEL classification:
Q23
Q43
Q50
Q54

Keywords:
Climate policy
Forest carbon
Non-industrial private forest owners
Effective emission factor
Age-structured forest
Optimization
Bioenergy

ABSTRACT

First-best optimal forest sector carbon policy is examined. Using a forest and energy sector model with a carbon cycle module we show that the renewability and carbon neutrality arguments do not warrant emission free status of wood use. As a general optimality principle, the release of carbon is penalized by a tax and carbon capture is subsidized. However, under the biomass stock change carbon accounting convention, the land owners pay for the roundwood emissions and, to avoid double counting, the use of roundwood is treated as emission free. Yet, the carbon accounting convention followed does not affect the equilibrium outcome. The bioenergy from harvest residues is not emission free either. Furthermore, we show that an optimal policy subsidizes the production of wood products for their carbon sequestration. Correspondingly, carbon removals by biomass growth are subsidized and the harvest residue generation taxed. Numerical solution of the model shows that, although the use of wood is not emission free, it is optimal to increase the use of wood, possibly also in the energy sector. Before the wood use can be increased, the forest biomass will be increased. This carbon sink decreases the net emissions until the forest resources reach a new equilibrium.

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http://dx.doi.org/10.1016/j.jfe.2016.05.001

1. Introduction

Literature has pointed out an obvious conflict between carbon sequestration in forests and the use of forest biomass (e.g. Schlamadinger and Marland, 1996; Marland and Schlamadinger, 1997; Righelato et al., 2007). As a result, the society needs to choose between carbon sink and biomass use. The choice has proven to be a difficult one. Not only is the choice complicated by the non-permanent carbon storage both in soil and wood products (Aalde et al., 2006), but the whole scientific basis of substitution benefits is under debate (e.g. Fargione et al., 2008; Searchinger et al., 2008; Melillo et al., 2009; Wise et al., 2009; Schlesinger et al., 2010; Lippke et al., 2010; Gunn et al., 2012; Miner et al., 2014) The suggested solutions to the problem vary from fixing flawed carbon accounting conventions (Searchinger et al., 2009; Haberl et al., 2012) to an assessment of benefits and costs of substitution through life-cycle analysis (Cherubini et al., 2011; Helin et al., 2013). Thus, there seems to be no agreement on this globally important question.

We analyze the use of forests in climate change mitigation using economics. First we specify a model economy and couple it with a carbon cycle module including forest biomass in its multiple forms. We next solve the competitive equilibrium with carbon externalities by optimizing the use of forest biomass when the costs and benefits of carbon flows are determined by the social cost of carbon (e.g. Pearce, 2003).[1] The model solution then allows us to derive the optimal policies regulating the forest carbon flows. Especially, we introduce input-use-specific *effective emission factors* that can be used as a basis for Pigouvian taxation (Pigou, 1920). By implementing these optimal policies, the economy finds the optimal ways to use forests when both the economic constraints and carbon externalities are taken into account.

We find that when optimal policies are set for a carbon accounting convention where actual physical flows of carbon are followed, the policies are different from the ones currently implemented. For example in the EU emissions trading system, the wood use is treated emissions free which contradicts the actual physical carbon flows. To demonstrate the role of carbon accounting conventions, we analyze an alternative carbon accounting based on changes in biomass stock. We show that although the policy instruments are different under the two conventions, the economy-wide equilibrium implied by the optimal policies is independent of the convention used. Finally, we solve the model numerically and illustrate the way a small-open economy with abundant forest resources reacts to the introduction of the optimal policy. It is illustrated how such an economy first reduces harvests and uses forests as carbon sink, but as the forest carbon stock increases, the wood supply increases allowing a transition toward increased use of forest biomass.

Instead of taxes (Pigou, 1920), the emission regulation could also be based on a system of tradable permits (Montgomery, 1972) or a combination of both (Roberts and Spence, 1976).[2] While, for example, in an asymmetric information setting, carbon taxes seem to outperform tradable quotas (e.g. Hoel and Karp, 2002), in a deterministic and competitive model framework, both policy instruments can be used in enforcing the social optimum. For notational ease, we present the policies as if they were based on emission taxes, however, the real world implementations of the presented policies could utilize, for example, an emission trading system.

There is a large body of literature of economic assessments addressing the role of forests in climate change mitigation. One line of literature estimates the cost function of carbon sequestration into forest biomass and its potential on mitigating climate change (e.g. Sedjo et al., 1995; Stavins, 1999; Richards and Stokes, 2004). Furthermore, Englin and Callaway (1993), van Kooten et al. (1995) and Sohngen and Mendelsohn (2003), discuss the optimal carbon policies and the role of forests. In addition, Cunha-e Sá et al. (2013) have applied the market level model of forest vintages to analyze carbon sequestration in forests under different carbon benefits. However, these models do not take into account the possibility of using wood for input substitution. On the other hand, studies that do address the possible conflict between input substitution and carbon sequestration have typically used models that do not fully

[1] In the climate economic literature the term social cost of carbon refers to present value of marginal damages caused by a marginal increment in atmospheric CO_2 stock.

[2] In practice, there is a large number of possible climate policy instruments from which to choose (e.g. Stavins, 1997).