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Immediate and long-run impacts of a forest carbon policy—A market-level assessment with heterogeneous forest owners

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ABSTRACT

Sequestering carbon in forests and wood products is an inexpensive way to reduce the atmospheric carbon concentration. However, its full potential is not utilized in present climate policies. Optimizing sequestration, while continuing to harvest wood for materials and energy, could reduce the economic burden of mitigation efforts. Optimal sequestration can be incentivized by subsidizing carbon storage according to its social value. We analyze the dynamic market-level impacts of implementing a forest carbon policy by using the Finnish Forest and Energy Policy model (FinFEP). We find that sizeable and immediate increases in carbon sinks can be obtained, even with low carbon prices. High carbon payments strongly increase the carbon sink in the short run, but this impact diminishes over time. Low payments have a milder but longer-lasting impact. Forest owners' valuations of forest amenities also affect the magnitude and dynamics of harvest and carbon sequestration results. Thus, a realistic description of forest owner behavior is needed to assess the impacts of forest carbon policies. Moreover, we show that a market-level model is necessary for assessing the regional carbon sequestration impacts and costs. Relying on stand-level models with fixed timber prices may yield overly optimistic results.

Introduction

The potential of forest carbon sinks in mitigating climate change is well-understood in scientific literature since the 1990's (Houghton et al., 1990). Under the United Nations Framework Convention on Climate Change (UNFCCC), it is mandatory to report carbon stocks and fluxes in Land Use, Land-Use Change and Forestry (LULUCF) sector. However, the use of climate policy instruments that regulate the development of forest carbon sinks has been sporadic. The Paris agreement (UNFCCC, 2017) seeks to limit global warming to 1.5–2° centigrade above the pre-industrial level. To reduce the economic burden of mitigating climate change, a cost effective climate policy should be an objective. Such a policy would incentivize mitigation measures in the order of cost—starting from the cheapest and then moving on to more expensive measures. Carbon sequestration in forests could have a role in these endeavors, as considerable reductions in net emissions might be obtained at relatively low cost (e.g. Vass and Elofsson, 2016). In this study we analyze the market-level impacts of a policy that fully internalizes the carbon externality of forestry.

In the literature, two approaches have been suggested to provide forest owners an incentive to take carbon sequestration benefits into account at a socially optimal level. A flow-based forest carbon policy subsidizes carbon capture by growing biomass and taxes the release of this carbon (van Kooten et al., 1995). An alternative way to design a forest carbon policy is to pay forest owners a 'carbon rent', which is based on the carbon stock on a forest stand (Sohngen and Mendelsohn, 2003; Uusivuori and Laturi, 2007). Lintunen et al. (2016) show that these two schemes provide identical incentives for forest owners. In our study, a forest carbon policy is implemented as a carbon rent – scheme. In addition, we augment the policy with a subsidy for forest carbon that is stored in the harvested wood products (HWP). The resulting policy gives socially optimal incentives both for the forest owners and the wood processing industry, in a case where the life-time of HWP is exogenously given (Lintunen and Uusivuori, 2016).

Implementation of forest carbon policy immediately increases the monetary value of the standing stock and bare land, thus changing the relative value of harvested and standing timber. This makes it optimal to lengthen rotations (Hartman, 1976; van Kooten et al., 1995; Lintunen et al., 2016). In addition, the policy delays and lowers the intensity of thinnings but increases their number (e.g. Pohjola and Valsta, 2007; Pihlainen et al., 2014).

The impacts of carbon pricing on forests have often been studied

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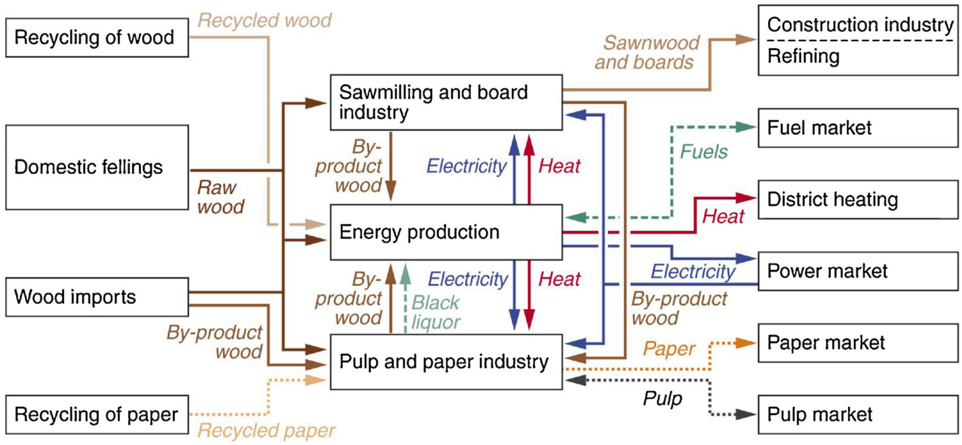

Fig. 1. Material flows between forest and energy sector modules in the FinFEP-model.

using stand-level models (see e.g. van Kooten et al., 1995; Pihlainen et al., 2014; Pohjola and Valsta, 2007). Stand-level analyses can provide detailed information on the impacts of a forest carbon policy on the forest management, such as rotation length and timing and intensity of thinning operations. However, the stand-level analysis has two important shortcomings. First, the endogenous reaction of timber prices to a forest carbon policy shock cannot be analyzed in a stand-level model, as timber markets are not included in this type of models. This can be a serious defect since timber prices might react strongly to the increased value of standing stock due to the forest carbon policy. Second, in stand-level analysis, timber harvest impacts can only be evaluated in a new steady state even if short, medium and long term impacts are likely to differ considerably.

Previously, Sjølie et al. (2013, 2014) and Lecocq et al. (2011) have included carbon pricing in their timber market models. Sjølie et al. (2014) compared the forest sector's climate change mitigation potential in Norway under the Kyoto Protocol (KP) to unlimited carbon sequestration policy with no caps on forest carbon credits. Their results suggested that carbon offsets were higher in the short run under Kyoto Protocol policy than under unlimited policy but KP policy failed to utilize carbon sequestration potential in the long run. Sjølie et al. (2013) evaluated the importance of market adjustment on the potential and costs of mitigating climate change through carbon sequestration and utilization of bioenergy. With full market adjustment the carbon offsets were substantially larger than in the case of limited adjustment with constant harvest levels, implying that in both policy implementation and modelling efforts the full potential should be involved. In both studies carbon prices varied from 0 €/t CO_2 to 100 €/t CO_2. Lecocq et al. (2011) explored three policies to mitigate climate change in the French forest sector; namely stock and substitution policies and combination of these. Their results suggested that payment for carbon sequestration in forest stock was the only of these policies that improved the net carbon balance under the period 2010–2020. However, the political acceptance of this policy was found to be questionable as the consumer surplus was decreased.

Our study contributes to the literature on the market-level impacts of forest carbon payments. We utilize the FinFEP (Finnish Forest and Energy Policy) partial equilibrium model (Lintunen et al., 2015) to analyze the detailed impacts of an unexpected implementation of carbon payments on forest carbon flows, timber markets, forest industries and energy production. Our analysis captures the endogenous timber price adjustment and provides an adjustment path, thus exhibiting impacts in the short, medium, and long run. The results reflect the economic optimization behavior of forest owners as they respond to the new policy regime after its implementation. In addition, we demonstrate how the age-structure of forests affects the dynamic impacts of the policy. We expand upon the earlier analyses by taking into account the variation in the forest owner characteristics by including owners with amenity values. In addition, we assess the value of market-level modeling compared to the stand-level approaches by contrasting the carbon sequestration results of the full model with a model run that uses exogenously fixed timber prices. To our knowledge, this kind of comparison has not been presented in the earlier literature.

The model, the data and the studied scenarios are reviewed in Section 2. Results are presented in Section 3. In Section 4, the importance of endogenous timber price adjustment is demonstrated. In Section 5 we discuss our findings and contrast them with earlier literature. Section 6 concludes.

Model, data and scenarios

Model

We analyze the effects of a forest carbon policy using the FinFEP (Finnish Forest and Energy Policy) partial equilibrium model covering the forest and energy sectors in Finland. In the model, the supply of wood is based on the detailed forest inventory data and a description of landowner behavior. The demand for wood is based on a detailed technological description of the wood using industries and is driven by exogenous demand functions for final goods made of wood. As wood is utilized by forest industries and the energy sectors, both sectors are integrated in the model. The model consists of five modules: energy processing, pulp and paper processing, wood-product processing, final good demand and timber supply. The modules are linked to each other through the material flows between processes, see Fig. 1. The processing modules have been previously used for separate policy analyses. Kangas et al. (2009) examined the wood fuel use decision of a single co-combusting power plant when emission trading is combined either with a feed-in-tariff or a production subsidy. Lintunen and Kangas (2010) introduced an energy market setup and examined the market outcomes under the same policy setup. The impacts of production, input and investment subsidies in promoting the biofuel production in the pulp and paper sector were analyzed in Kangas et al. (2011), and in the case of pellet production in Finnish sawmills in Mäkelä et al. (2011). In both studies the relative effectiveness of these instruments were compared. In the FinFEP model, forest and energy sector firms maximize the NPV of profit streams and the representative forest owners maximize Hartmanian (Hartman, 1976) type of objective functions. Here, we outline the elements of the model that are essential for understanding how the studied policies are implemented in the model. Lintunen et al. (2015) provide a more comprehensive description.

Timber supply in the FinFEP-model is based on stand-level management decisions of individual forest owners. The forest owners apply even-aged timber management and choose the intensity and timing of