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Negative leakage: The key role of forest management regimes

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ABSTRACT

A model of two regions with a common wood market is introduced. Regions may be of two types, according to their forest management regime, namely managed forest plantations (M) and unmanaged open access forests (U). It is found that when regions are of the same type, unilateral climate policy in the forestry sector leads to (positive) carbon leakage. However, when regions are of different types, unilateral climate policy results in negative carbon leakage. Thus, policies aimed at increasing diversity in management regimes, within a wood market, stimulate the emergence of market forces that preserve and enhance forest carbon.

Introduction

Climate change epitomizes the well-known economic problem of under-provision of public goods: While all countries benefit from the services provided by the Earth's atmosphere individual countries have minor incentives to undertake climate mitigation actions. The main reason is that the costs of unilateral mitigation actions exclusively accrue to proactive countries, while the benefits are enjoyed by all countries and regions (Barret, 2007). Beyond the public good nature of the Earth's atmosphere, climate governance has, at least, one additional feature that hinders unilateral mitigation from happening, namely the possibility of carbon leakage (Hoel, 1994).

There exists an extensive literature on carbon leakage in the context of fossil fuels and industrial processes. Carbon leakage here occurs when efforts to reduce emissions by one country or group of countries affect market prices, thereby providing incentives to third parties to increase their fossil fuel exploitation or usage (Hoel, 1994; Golombek et al., 1995; Kuik and Gerlagh, 2003).[1] If carbon leakage offsets or more than offsets unilateral mitigation (Babiker, 2005), strategies that minimize its negative effects ought to be considered (e.g. Böhringer et al., 2017; Fisher and Salant, 2017).[2] The emphasis of the literature on carbon leakage in the analysis of fossil fuels can be, partially, explained by two reasons. Firstly, fossil fuels and industrial processes account for 65% of total greenhouse gas emissions (GHG) emissions while forestry and land use change only account for 11% of total GHG emissions (IPCC, 2014). Secondly, while the Kyoto protocol was, by its own nature, prone to carbon leakage, it did not cover, in practice, forestry. This was mainly due to alleged difficulties associated with the measurement of forest carbon stocks and project additionally.

In recent years, forest offsetting has been recognized as an important climate mitigation strategy (Kindermann et al., 2008; van der Werf et al., 2009) and the issue of forest carbon leakage has become an important policy concern. Chomitz (2002) notes that carbon leakage is as important to the forestry sector as it is to the energy sector. The literature that studies leakage in relatively large forest interventions where market prices are expected to change, or market-based leakage, is rather limited. This is somewhat surprising as the transition to a low carbon economy requires non-marginal mitigation actions in the forestry sector (IPCC, 2014). This literature comprises a few numerical analyses (Gan and McCarl, 2007; Kuik, 2014 and Aaheim et al., 2018) and a handful of theoretical papers (e.g. Harstad, 2012; Harstad and Mideksa, 2017). Notably, the production of forest carbon in this body of work is homogenous in the sense that spillover effects typically occur across regions with similar types of forests and under similar forest management regimes. This, we argue, is only a special case of a more general problem where market interactions may occur across regions

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[1] Supply-side leakage occurs when a country or group of countries unilaterally restrict the supply of fossil fuels that results in increases in international energy prices thereby incentivizing fossil fuel extraction in other countries or regions. Demand-side leakage occurs when the demand for fossil fuels is reduced unilaterally in a given region with a subsequent fall in energy prices and increased energy consumption in other regions.

[2] Leakage can be measured as the ratio between increase in CO_2 emissions in third countries or regions due to emissions reductions in countries or regions undertaking climate mitigation. In a review of the literature, Harstad (2012) reports that most estimates of leakage are between 5% and 25%, although the number may be higher.

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that may or may not be under the same forest management regime. In fact, forests can be broadly classified as natural forests and forest plantations where each is often associated with particular governance structures; e.g. Aukland et al. (2003); FAO (2016).[3] The importance of management regimes in determining the effectiveness of strategies aimed at preserving and enhancing forest carbon in targeted areas has already discussed in the literature; e.g. Blackman et al. (2017); Larson et al. (2012).

This paper explores, in a simple theoretical framework, how forest management regimes may affect carbon leakage. Our analysis is based on a partial equilibrium model of two regions with a common wood market where regions may be of two types, according to their forest management regime. We consider unmanaged open access natural forests (type U) and managed forest plantations (type M).[4] Open access, which is typically the result of costly exclusion, leads to the tragedy of the commons and over exploitation of the forest resource (Hardin, 1968), i.e. deforestation. On the other hand, well-defined property rights enable forest owners to manage plantations in a profit maximizing manner (e.g. Faustmann, 1849).

Following the leakage literature (e.g. Hoel, 1994; Babiker, 2005; Harstad and Mideksa, 2017), we assume that one region implements climate mitigation policy (the active region), while the other region only reacts to changes in market prices. Climate mitigation takes very different forms in the two forest management regimes considered in this paper. Climate mitigation in open access natural forests is aimed at reducing deforestation (through, for instance, increased monitoring or the implementation of conservation programs) whereas in managed forest plantations climate mitigation seeks to enhance or expand existing forest stocks (through, for instance, an afforestation subsidy). Climate mitigation thus affects atmospheric CO_2 concentration via reductions of existing emissions flows into the atmosphere (reduced deforestation), or via enhancement of forest carbon stocks (reforestation/afforestation).[5] Notably, the two climate mitigation strategies considered here have diametrically different effects on timber prices. Reduced deforestation implies a reduction in the supply of timber and an associated increase in timber prices. On the other hand, an expansion of a forest plantation not only enhances carbon stocks, but it also ensures a higher timber yield or production. This constitutes an expansion of timber supply that depresses timber prices. As a result of this asymmetry, unilateral forest carbon management does not necessarily lead to (positive) carbon leakage. In fact whether there is positive or negative carbon leakage depends on the forest management regime of the active region vis-à-vis that of the passive region.

The paper proceeds as follows: Section 2 reviews the literature on forest carbon leakage, Section 3 introduces our carbon leakage model and Section 4 concludes with a discussion of results and policy implications.

[3] While both class of forests store carbon, each provide specific environmental services: "*The similarities and differences between natural and planted forests is a topic of debate among many stakeholders interested in forest change. Natural forests contribute to conserving the diversity of genotypes and to maintaining the natural tree species composition, structure and ecological dynamics. Planted forests are often established for the purpose of production and/or protection of soil and water. Well managed planted forests can provide various forest goods and services and help to reduce the pressure on natural forests*" FAO (2016).

[4] The insights of our model are also applicable to un-manged forest plantations and managed natural forests. However, by definition, un-managed forest plantations are unlikely to emerge while the management of natural forests remains an important local and global policy challenge (Barbier, 2012).

[5] See Table A1 in the Appendix A for an illustration of this two type of climate mitigation strategies in the context of the United Nations REDD-Plus mechanism.

Literature review of forest carbon leakage

This literature review is organized into three subsections, namely theoretical analyses, numerical analyses and impact evaluations. The literature often distinguishes between two types of leakage, namely activity-shifting leakage and market-based leakage; e.g. Aukland et al. (2003); Schwarze et al. (2002) and Wunder (2008). Activity-shifting leakage comprises a change in shadow-prices whereas market-based leakage entails a change in market prices.[6] The theoretical and numerical papers typically discuss market-based leakage. The impact evaluations in the literature estimate leakage rates in relatively small forest conservation programs where no changes in market prices are expected.

Theoretical analyses

There are only a few theoretical papers where forest carbon leakage is a central component of the analysis. Using a contract theory framework, Harstad (2012) shows how a coalition of countries seeking to unilaterally implement climate policy may overcome the risk of carbon leakage by purchasing coal reserves or forest reserves in countries outside the coalition. Harstad and Mideksa (2017) develop a theoretical model to study the design of optimal forest conservation contracts (i.e. reduced deforestation contracts) in the presence of carbon leakage. Whether the principal, who values conservation, decides to contract with the district or with the central government depends on whether property rights over forests are weak or strong. Leakage in these two papers occur through changes in market prices. In a study where prices are exogenous, Angelsen and Delacote (2015) show how PES that targets agricultural expansion influence non-sustainable harvesting of forest products (degradation). The qualitative results on leakage depend on the relationship between land and labor and on whether these factors are substitutes or complement in the net return function.

Numerical analyses

A number of Computable General Equilibrium (CGE) models indicate that including forest carbon offsets in "regional" or "global" carbon trading markets may reduce the carbon price by 30% to 80% (Bosello et al., 2014; Michetti and Rosa, 2012; Tavoni et al., 2007). Sohngen and Mendelsohn (2003) found carbon sequestration via reduced deforestation and afforestation should be one-third of total abatement (or approximately one-half of energy abatement). Findings in other studies of the potentials in avoiding deforestation and forest degradation as a part of a strategy to mitigate climate change indicate clear weaknesses of this assumption. Kohonen-Kurki et al. (2012) show that the effect on carbon uptake from initiatives taken to protect forests or avoid deforestation may be reduced radically by weak institutions.[7]

Using data from India, Aaheim et al. (2018) find in a numerical

[6] At least other three types of carbon leakage are considered in the literature: 1) life-cycle emissions shifting, 2) ecological leakage (Schwarze et al., 2002) and 3) temporal leakage (Fisher and Salant, 2017). Life-cycle emission shifting occurs when mitigation affects emissions upstream or downstream activities. Ecological leakage occurs when a change in emissions is induced by a change in the ecosystem in surrounding areas. Temporal leakage, as opposed to spatial leakage, occurs when, as a result of climate policy, agents reallocate emissions over time without necessarily reducing total emissions. The model introduce in this paper focuses on spatial (market-based) leakage. Finally, it should be noted that forest protection policies could result in another type of carbon leakage, "non-forest leakage", which is induced by cropland expansion in non-forested areas that are not subject to forest protection schemes (Popp et al., 2014).

[7] Further problems may arise because of unclear property rights (Larson et al., 2012) and lack of transparent transfer mechanisms from the party who aims to increase carbon uptake to the party who restricts deforestation and forest degradation (Streck and Parker, 2012; Luttrell et al., 2012).