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On the economics of tropical deforestation: Carbon credit markets and national policies ☆

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ABSTRACT

This paper contributes to the economics of deforestation by presenting a formal, infinite horizon dynamic model describing the use of tropical forest resources. As an alternative to clearing the forest, a landowner has the option to sell it to an international carbon crediting program. The model is used to investigate corrective incentive programs needed to ensure a socially optimal level of forest resources. Optimal conditions for a land income tax and carbon compensation rate are derived. The paper shows that the optimality of national carbon compensation policies crucially depends on the land income taxation. In the presence of an optimal land income tax-subsidy program, the government may need to pass on to the landowners the very carbon compensation that it receives from the international community to ensure a socially optimal tropical forest stock. However, the government may need to over-transfer or under-transfer the carbon compensation depending on whether the pre-existing land income tax is below or above the optimal level, respectively. This suggests that the pre-existing sub-optimality in land income taxation in a given country can be corrected by adjusting the carbon compensation. Therefore, a carbon compensation scheme should take into account existing national policies that affect forest clearing.

1. Introduction

Globally, about 13 million hectares of forests are lost every year (FAO, 2010), which accounts for up to 17 percent of the total annual greenhouse gas (GHG) emissions in the world (IPCC, Intergovernmental Panel on Climate Change, 2007). The Stern Review (2007) has identified the avoidance of deforestation to reduce emissions as a potential key element of cost-effective climate policy for the future. Avoiding deforestation in developing countries may significantly cut emissions at a low cost over a short period of time (see, e.g., Grieg-Gran, 2008; Kindermann et al., 2008). In response the Reducing Emissions from Deforestation and Degradation in developing countries -plus (REDD+) is seen as an important component of the post-Kyoto climate regime.[1]

The core idea of REDD+ is that the global community rewards those who take action to reduce deforestation and forest degradation. Therefore, REDD+ can ideally serve as a multi-level (international, national and local) payment for environmental services (PES). At the international level, service buyers will pay service providers (i.e. governments or sub-national entities in developing countries) to provide an environmental service, such as reduced emissions from deforestation and degradation. At the national level, national governments or other intermediaries will be the service buyers who will pay the service providers

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[1] Reducing Emissions from Deforestation and Degradation (REDD) was endorsed by the United Nations Framework Convention on Climate Change (UNFCCC) at its Bali Conference of Parties (COP13) in December 2007 as a mechanism for combating the global warming and the climate change. The mechanism was included in the climate agreements reached during the UNFCCC COPs (16, 17 and 18) held in Cancun, Mexico (2010), Durban, South Africa (2011) and Doha, Qatar (2012), respectively. The concept of REDD is expanded over time to include, in addition to reducing emissions from deforestation and forest degradation, the sustainable management and conservation of and the enhancement of carbon stocks in forests and referred to as REDD+.

(land owners), for example, to reduce emissions by conserving tropical forests[2] (Angelsen and Wertz-Kanounnikoff, 2008, p.12). The above discussion implies that the decision on the design of economic incentive program to distribute benefits among actors for implementing REDD+ in a country lies in the hand of the government of that particular country. In this development, an interesting research question is modeling the economics of tropical deforestation under a REDD plus-type carbon compensation scheme across an infinite time frame and investigating the optimal carbon compensation policy for national governments taking into account the existing policies such as taxation.

A rich literature base has used dynamic models to investigate tropical deforestation from a range of perspectives.[3] Walker and Smith (1993) and Mateo (1997) used optimal stopping and optimal control models, respectively, to analyze the tropical-forest clearing policy of a private agent, such as a concessionaire and rancher. Using a dynamic modeling approach, Bulte and van Soest (1996) showed that encroachment by shifting cultivators may save virgin tropical forests from being cleared by concession loggers. Furthermore, analyses using dynamic models demonstrated that tropical deforestation decreases with securer property rights (Mendelsohn, 1994; Amacher et al., 2009a,b) and an increase in non-timber benefits from forests (Amacher et al., 2009a,b), but increases with greater corruption and dependency of local people on forests (Barbier et al., 2005) as well as rising agricultural prices and profits from marketing timber (Hartwick et al., 2001). Angelsen (1994) also used a dynamic model to show that policies affecting the factors that govern the advancement of the agricultural frontier in forests, such as agricultural price, minimum wage and technological level can influence the intensity of tropical deforestation. As the above discussion suggests, the models used in these studies did not incorporate carbon sequestration[4] and thus did not study tropical deforestation under carbon compensation or derive policy rules, e.g. for REDD mechanism.

This paper contributes to the formal analytical modeling of the deforestation problem by incorporating into it a carbon crediting option for the owner of tropical forestland. We use an infinite time horizon dynamic optimization model to explain the economics of tropical deforestation under a REDD plus-type scheme of carbon compensation. The carbon crediting option in this scheme is reversible in the sense that a landowner can redeem the credited forestland to his use by purchasing it from the carbon credit program. This allows the landowner to retain the option of turning the credited forestland to other uses if he or she finds it profitable.

Society values both timber and non-timber services from privately controlled forests. However, if the private agent is not paid for these non-timber services, the private optimal forest stock will remain smaller than the socially optimal one. When the amenity services of forests are a public good which the private sector does not fully value, divergence occurs between the social and private optima (von Kooten et al., 1995; Caparrós and Jacquemont, 2003; Tassone et al., 2004). Policy intervention such as tax could be used to dissolve this divergence.

Tahvonen (1995) and Romero et al. (1998) concluded that to remove the divergence of social and private optima, forest carbon sequestration should be subsidized and any carbon emissions, be it from burning of forest biomass or forest clearing, should be taxed. Englin and Klan (1990) and Koskela and Ollikainen (1997, 2003) showed that forest taxes could be used as Pigouvian taxes to correct the negative externalities that private harvesting imposes on society and thus to equate the private optima with the social optima. These studies modeled forests as a renewable resource rather than treating forests as non-renewable resource or explicitly focusing on tropical deforestation. There is abundant literature discussing the extraction of non-renewable resources which dates back to the seminal work by Hotelling (1931). Applied to forests, Brown and Wong (1993) modeled Russian and Mæstad (2000) modeled tropical forests as non-renewable resource and discussed optimal timber extraction. These two studies, however, did not consider any carbon policy or taxes.

Policy measures such as taxing timber harvest income can induce less harvesting, which could contribute to increasing forest and carbon stocks (Wibe and Gong, 2010). Busch et al. (2012) used a numerical land-use change model and showed that a tax-and-subsidy at a constant carbon price would be more effective than a voluntary PES-type program for reducing carbon emissions under REDD+ in Indonesia. Similarly, Pfaff et al. (2013) argued that domestic policies, such as tax-and-subsidy, could reduce deforestation when designed with local support and information, although according to Barua et al. (2012) taxes alone may be ineffective in curbing forest loss. In a review study, Karsenty (2010) argued that taxes alone are insufficient to ensure sustainable tropical forest management; and proposed that they should serve as a component of a consistent set of actions and public policies for the best effect. Kerr (2013), also in a review study, argued that policies which complement price signals would be important for REDD+ implementation. Therefore, combining policy instruments could be important for REDD+ implementation. To the best of our knowledge, however, no analytical or empirical study has shown how a policy program can be designed combining taxes with other public policy tools such as carbon compensation to prevent tropical deforestation.

In this paper, we apply a deforestation model to investigate the optimal rates of land income tax and carbon compensation that ensure a socially optimal tropical forest stock. We also study how the carbon compensation policy of a national government should be determined in the presence of land income taxation. To derive socially optimal policy rules, we model deforestation for both the social planner and private sector. We base our description of the private sector on utility-maximizing individuals, communities, or firms, and then refer to them as 'private forestland owners' or 'private landowners'.[5]

This paper offers a number of policy-related contributions to the literature on tropical deforestation. First, it is shown that the land income tax rate required to enforce a socially optimal size of a tropical forest stock in private ownership should equal the proportional difference between the social and private amenity valuations of tropical forests. Second, the existence of an optimal land income taxation policy may require the government to pass the same amount of carbon compensation that it receives from the international community to private forestland owners to ensure a socially optimal tropical forest stock. However, under a pre-existing sub-optimal land income taxation policy, it may be optimal for the government to either over-transfer or under-transfer any such carbon compensation depending on whether the pre-existing land income tax is below or above the optimal level, respectively. In the complete absence of a taxation policy, the government may require to over-transfer such carbon compensation to private landowners.

[2] Still, in practice the issues of to whom to pay and how to pay have posed political challenges. As a result, in recent years, the focus of REDD+ shifted further toward a broader set of policies that can be implemented under less restrictive conditions (Angelsen and Rudel, 2013).

[3] Barbier and Burgess, (1997), Hardie and Parks (1997), Parks et al. (1998), Alix-Garcia, (2007), Amacher et al. (2009a,b p. 166–173), and Angelsen, (2010) used static models to study tropical deforestation under competitive land-use options. See Kaimowitz and Angelson (1998), Angelsen and Kaimowitz (1999), Angelsen (1999), and Amacher et al. (2009a,b p. 163–165) for comprehensive reviews on analytical and other models of tropical deforestation.

[4] Sohngen and Mendelsohn (2003) used an optimal control model to study deforestation under carbon sequestration without strictly focusing on tropical forests, but rather on all types of forests in the world. In addition, among the studies mentioned in the text, Mendelsohn (1994) and Barbier et al. (2005) considered non-timber benefits of forests in their models without explicitly referring to carbon sequestration.

[5] According to RRI (Rights and Resource Initiative) and ITTO (International Tropical Timber Organization) (2009), globally about 31 percent of tropical forests fall under the direct ownership of indigenous and local communities, private individuals, and firms, and another 4 percent of tropical forests fall under formal public ownership are designated for the use of local communities and indigenous groups. This substantial ownership of tropical forests by the private sector makes it a very important player in policy discussions aiming to avoid tropical deforestation.