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Controlling deforestation in the Brazilian Amazon: Regional economic impacts and land-use change

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ABSTRACT

Brazil confirmed targets for reducing greenhouse gas emissions in 2008, including an 80% reduction in deforestation in the Amazon by 2020. With this in mind, we investigated the trade-off between environmental conservation and economic growth in the Amazon. The aim of this study is to project the economic losses and land-use changes resulting from a policy to control deforestation and the rise in land productivity that is necessary to offset those losses. We developed a Dynamic Interregional Computable General Equilibrium Model for 30 Amazon regions with a land module allowing conversion between types of land. The results have shown that the most affected regions would be soybeans and cattle producers as well as regions dominated by family farms. To offset these impacts, it was estimated that an annual gain of land productivity of approximately 1.4% would be required.

1. Introduction and Background

Deforestation in the Brazilian Amazon has attracted the attention of researchers and public authorities toward methods and policies that involve both its measurement and control. In addition to the importance of conserving one of the largest biomes of ecological diversity (Peres et al., 2010) and harboring the largest area of primary forest in the world – 35% of the world's total primary forest (FAO, 2010) – the region has become the target of policies to reduce deforestation because it constitutes an important measure in the mitigation of emissions of greenhouse gases (GHG).

The Amazon region has already lost about of 15% of its total forest area. However, according to INPE (2013), there was a decline in deforestation rates from 2004 to 2012. This decline is related to economic factors, such as the reduction in international soybean and beef prices and the appreciation of the Brazilian currency, which discouraged exports. Another contributing factor is the increased surveillance of the Amazon, which has been made possible by the implementation of government programs, such as the Action Plan for the Prevention and Control of Deforestation in the Amazon (Soares-Filho et al., 2009; Assunção et al., 2012).

Arima and Veríssimo (2002) pointed out that the three major forms of deforestation in the Amazon are: (i) the conversion of forest into pasture for livestock; (ii) cutting and burning to convert forest into crops for family farming; and (iii) deployment of grain crops by agro-industry. Of these, the conversion of forests into pasture is predominant (Margulis, 2003). They have also argued that the drastic reduction in tax incentives for agricultural enterprises in the late 1980s lead to a reduction in the pace of deforestation, which, however, did not occur. In the 1990s, other factors than the government development projects[1] became more decisive in the maintenance of deforestation, primarily predatory logging, extensive livestock farming and agrarian reform settlements.[2]

Some projections suggest that deforestation, despite a reduction in its rates between 2004 and 2012, may expand in the coming decades. Soares Filho et al. (2005) estimated that the projected

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[1] The government development projects appear to affect deforestation, mainly in the decades of 1970 and 1980 (Pfaff, 1999).

[2] Land reform policies and violent conflict in the Amazon region can be seen in Alston et al. (2000).

deforestation will eliminate 40% of the current 5.4 million km^2 of forests by 2040 if the occupancy patterns follow the trajectory of the last two decades. Moreover, an increase in deforestation implies a growth of GHG emissions associated with changes in land use. According to Gouvello (2010)'s estimates, the total emissions from land-use change and forests in Brazil may grow by 25% by 2030, reaching an annual rate of 916 thousand tons of CO_2 equivalent, which may compromise the target reductions of reducing GHG proposed by the Brazilian government.

The latest deforestation estimates in the Amazon published by INPE (2013) showed that from 2012 to 2013, there was an approximate 30% increase in the deforestation rate, which seems to confirm these previous projections. Although it is the second lowest rate recorded by INPE since the monitoring system began in 1988, it is an indication that deforestation could increase in the future. The prospect of increased deforestation in the Amazon has even more force when considering the adoption of some measures in the New Forest Code,[3] which was approved in May 2012. Included among the points of the New Code is a reduction of the limit of the legal reserve (RL) in the region[4] and a regularization of the smallholder farmers, excluding them from the obligation of recovering areas that were deforested in permanent preservation areas (APPs.) According to IPEA (2011), the recovery of deforested legal reserves would offset the emissions of 3.15 billion tons of carbon, which would be enough to meet the Brazilian government's four-year target to reduce emissions from deforestation.

This target assumed by the Brazilian government was presented in 2009 at COP15.[5] The proposal was a voluntary reduction in GHG emissions mainly through an 80% reduction in deforestation by 2020. Thus, combating deforestation in Brazil has become a priority for the government as well as for the international organizations that are concerned with global warming's effects. According to Fearnside (2005), an effective surveillance and the collection of taxes from those who do not have authorization from the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) should be accompanied by the necessary understanding of the social, economic and political aspects of the region. Bringing this concern to the economy of the regions in the Amazon, the question arises as to how the control of deforestation can restrict agricultural expansion, which represents an important economic activity in the region. Without alternatives for growth in agriculture and other sectors, which are indirectly affected, there may be a tradeoff between the goals of regional economic growth and the preservation of the forest.

Some options are indicated to reconcile the economic growth of the region with sustainable development and the reduction of deforestation. For example, the intensification of agriculture by increasing land productivity. This increase in productivity would allow the same area, which has been deforested, to produce a greater output amount without expanding the deforested area as crop or pasture land through additional deforestation.

In this context, it is relevant to investigate the aspects of a possible tradeoff between environmental conservation and economic growth in the region. Furthermore, it is important to understand the relationship among agricultural activities with the land occupation and use. The goals of this paper, therefore, are: (i) to evaluate the impacts of land-use policies on regional growth in Amazon[6]; (ii) to investigate the role of agricultural technical improvement in the region. We built an interregional dynamic computable general equilibrium model (CGE) for 30 regions in the Amazon and the rest of Brazil, called REGIA (Interregional General Equilibrium Model for the Brazilian Amazon).[7] REGIA has a module of land-use change that enables it to model the conversion of different categories of land use. The incorporation of the land module into REGIA is fundamental in the analysis of the effects of a policy that restricts land use and directly affects the agricultural activity in the region.

The development of economic models with land use change module has been started with Darwin et al. (1995). The advantage of CGE models with land use specification is the possibility to capture the economic effects of changes in the pattern of land. Thus, CGE models would incorporate the behavior of producers toward demand of land according to the different possibilities of use. Due to the optimizer behavior, the allocation of land would be directed to the productive uses that provide the highest return (Farias, 2012). Usually, CGE models with land use in the literature can be divided into two different approaches, the comparative static and the dynamic models. However, it is observed that the process of land use change is a highly dynamic process (Heistermann et al., 2006). Therefore, land use decisions do not depend only on the past and current uses, but on future expectations - especially in sectors such as forestry, where long-term planning is essential. The disadvantage of comparative statics models is the inability to describe trajectories and the future behavior of land use. This makes REGIA more appropriate for studies focusing on deforestation.

According to Heistermann et al. (2006), an important aspect of the land use treatment in the production process is its heterogeneity. The land productivity may vary between products, regions and time. The main reasons for the differences, as pointed out by the authors, are the biophysical characteristics of the land, such as climate and soil. One way to introduce this heterogeneity is to adopt the imperfect substitutability between the different sectors and uses. Another advantage of REGIA is to model this heterogeneity through a transition matrix which drives the movements of land between uses.

Therefore, REGIA was used to simulate a scenario considering the targeted deforestation reduction of 80% by 2020 in accordance with the National Plan on Climate Change – PNMC (2008), followed by a zero deforestation policy from 2021 to 2030 which is part of the most recent proposal of the Brazilian government. Moreover, a simulation was performed to estimate the land productivity gains needed to offset the adverse effects of the deforestation policy on the Amazon economy.

2. Methodology

2.1. REGIA model

REGIA is a Computable General Equilibrium model (CGE) with a recursive dynamic and land-use module for 30 regions of the Brazil-

[3] The Brazilian Forest Code was created by Law No. 4771 on September 15, 1965. The Code sets limits on property use, which must coincide with existing vegetation on the ground for the common good of all inhabitants of Brazil. The first Brazilian Forest Code was established by Decree No. 23,793, on January 23, 1934.

[4] The portion to be preserved in the current Forest Code is 80%, but is decreased to 50% in states that have 65% of their territory designated as protected areas or indigenous lands.

[5] COP15 (United Nations Conference on Climate Change), held from December 7–18, 2009, in Copenhagen brought together 193 member countries of the United Nations Framework Convention on Climate Change. Its proposal was to define a global action agenda to control global warming and ensure the survival of the human species.

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[7] REGIA refers to the aquatic lily pad that is typical of the Amazon region. It has a large leaf-shaped circle, which lies on the surface of the water, and can grow to be up to 2.5 meters in diameter and support up to 40 pounds if well distributed on its surface.