



## Analysis

# Relationship between openness to trade and deforestation: Empirical evidence from the Brazilian Amazon



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## ABSTRACT

One of the objectives of this paper is to investigate how international trade has affected the dynamics of deforestation in the Brazilian Amazon at the level of the municipality. This analysis focuses on the expansion of crop and cattle activities, and other determinants of deforestation such as GDP per capita, conservation areas and property rights. We combine standard econometrics with spatial econometrics to capture the socioeconomic interactions among the agents in their interrelated economic system. The data used in this study correspond to a balanced panel of 732 municipalities from 2000 to 2010. The main findings suggest that as openness to trade in the Amazon increases, deforestation also increases. We also find that it is the production of soybeans and beef cattle that drives deforestation in the region. The property rights indicator also has a significant impact in deforestation. Moreover, as the GDP per capita goes up, deforestation increases. The conservation areas have a negative impact on deforestation.

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## 1. Introduction

Since the 1980s, it has been internationally recognized that tropical forests, which are home to much of the world's biodiversity, are also very important to global climate regulation (Barbier, 2001). In recent years, economic development in these forests, which are mostly located in very poor regions along the equatorial line, has resulted in substantial destruction of the forest cover. Finding ways to slow down this process has become one of the top priorities of any environmental development agenda, and the factors contributing to the current rapid deforestation deserve further investigation.

The Brazilian Amazon, the focus of this paper, is a large area (61% of the country) divided into nine states.<sup>2</sup> It is home to 12% of the population of Brazil. The overexploitation of the forest resources is driven, for the most part, by economic interests from outside the area. In the 1970s, the government provided subsidies and incentives for mining, crop, and beef production, and supported gigantic road projects that brought new settlers from other parts of the country into the rainforest frontier (Mahar, 1989). Federal and state governments failed to regulate this settlement, with the result that there is considerable confusion about the ownership of key environmental resources. For the last few

decades, frontier regions of the Amazon have been a major scene of land conflicts between cattle ranchers, squatters, miners, indigenous groups, and public authorities. In addition, since the enactment of free trade agreements in the 1990s, international markets for timber and agricultural commodities have been driving further deforestation in the region (Brandão et al., 2006).

The connections between deforestation and cattle ranching, agriculture, poorly defined property rights, road construction, and population growth have been extensively studied (Reis and Guzman, 1992; Pfaff, 1999; Walker et al., 2000; Weinhold and Reis, 2001; Andersen et al., 2002; Mertens et al., 2002; Margulis, 2004; Chomitz and Thomas, 2003; Pfaff et al., 2007; Diniz et al., 2009; Araujo et al., 2009; Rivero et al., 2009; Barona et al., 2010). However, to the best of our knowledge, there are very few studies that investigate the relationship between deforestation and openness to trade in developing countries.

One objective of this paper is the examination of how economic variables, including international trade and the expansion of agriculture and the cattle industry, and political issues have affected the dynamics of deforestation in the Brazilian Amazon. We combine standard econometrics with spatial econometrics in order to capture the socioeconomic interactions among the local, regional, and international agents in the Amazon region.

This paper has five sections in addition to this introduction. The second section presents a review of the literature and compares the theoretical models adopted in this work with models applied in other studies. The third section presents the main hypothesis. The fourth section discusses the methodology, data, and specifications of the estimating models used to test the relationship among explanatory

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<sup>2</sup> These states are Acre, Amapá, Amazonas, Mato Grosso, Rondônia, Roraima, Tocantins, Pará and parts of Maranhão (Fig. 1).

variables and deforestation. The fifth section presents the results. The main results indicate a positive relationship between the economic variables examined, as well as the property rights indicator, and deforestation. The sixth section presents our conclusions.

## 2. Literature Review and Theoretical Background

Angelsen and Kaimowitz (1999) discuss more than 140 published studies that assess the causes of deforestation, classified according to two criteria—scale and methodology. The scale criterion concerns the unit of analysis—microeconomic (households, firms or farmers), regional, or macroeconomic (national). The methodology criterion classifies studies as to whether they are analytical, empirical, or simulation models. Angelsen and Kaimowitz rank the variables used by models of deforestation as: (1) the magnitude and location of deforestation; (2) the agents of deforestation; (3) the variables selected; (4) the parameters affecting agents' decisions; and (5) macroeconomic variables and policy instruments.<sup>3</sup>

Both classifications, in terms of criteria and type of variables, may be important for assessing the strengths and weaknesses of the works in different contexts of analysis. Microeconomic models use microdata and tend to focus on the specific behavior of landowners (or families) (e.g., Bluffstone, 1995; Angelsen, 1999; Chomitz and Thomas, 2003) in relation to deforestation. These models consider the existence of credit and subsidies for agricultural production, years of schooling of the landowners, and land use intensity. However, they ignore broader causes of deforestation, such as the indirect effects of foreign trade and paved roads in the area of forest cover.

The empirical macroeconomic models use aggregate data, which can be found relatively easily, even for developing countries such as Brazil, Ecuador, Indonesia, Malaysia, and Thailand (Allen and Barnes, 1985; Cropper and Griffiths, 1994; Deacon, 1994; López and Galinato, 2005). One of the main data sources is the Food and Agricultural Organization (FAO), which provides information such as soil type, forest coverage, and population density. However, aggregated data aggregated are represented as average figures, often for a number of regions, which might distort the accuracy of the estimates for any given area. In Brazil, the adoption of a state-level analysis of deforestation from aggregate data is undesirable, since the dynamics of deforestation are quite different in different states.

Regional models are an appropriate solution in these cases, because they are based on local data and can be used to analyze an issue, such as deforestation, in a broader context than at the micro level. In addition, the regional-level model, with its disaggregation of data, allows a higher-quality analysis about the region under study than the macro-level analysis. In other words, the use of regional data allows researchers to avoid making erroneous inferences from highly aggregated data while ensuring that local features are incorporated into the analysis.

The major empirical findings with regard to the drivers of deforestation in developing countries emerge from Allen and Barnes (1985) and Angelsen and Kaimowitz (1999). They found substantial evidence that deforestation is likely when forested lands are more accessible; when prices of agricultural commodities and timber are high; when rural wages are low; and when there are opportunities for trade. On other hand, they did not find evidence that increases in population, migration, productivity, land tenure, input prices, land markets, and poverty per se contribute directly to deforestation.

Cattle ranching, and more recently, the capital-intensive production of soybeans for supplying foreign markets, particularly China, have put great pressure on the Brazilian rainforest. Nowadays, Brazil is one of the largest exporters of soybeans and the world's largest exporter of beef: one third of all beef exports are from the Amazon (McAlpine

et al., 2009). Margulis (2004), analyzing land use data, found that cattle ranching has been one of the major drivers of deforestation. However, he suggests that large and mid-size farms have contributed more to deforestation than smaller farms.

In the Brazilian Amazon, one important issue is the weak enforcement of property rights, particularly in public lands. If public land is not incorporated and legally protected, it is open to illegal occupation (Fearnside, 2001). Fearnside reports that violent conflicts for land between ranchers, small farmers, squatters, and indigenous tribes are common in the region, particularly in the so-called “arc of deforestation,” a large tract of land on the southern and eastern fringes of the Amazon Basin. The majority of “private” lands are concentrated in medium and large properties (>100 ha) or vastly larger ones (>2000 ha) (McAlpine et al., 2009). In fact, farmers have an incentive to clear large parts of virgin forest; otherwise, they would lose their land to expropriation or to invasion (Fearnside, 2001).

There are no official statistics about the enforcement of property rights in the Amazon states. Araujo et al. (2009) used proxies for the lack of enforcement, such as the number of land conflict-related homicides and expropriation initiatives undertaken by the INCRA, the government agency responsible for the supervision and distribution of land in public lands. They showed that most landholders do not have legal title to their land, and insecure land property rights contribute to higher rates of deforestation.

One report published by the researchers of NGO Imazon in 2010 estimated that the state of Pará is one of the most affected by land uncertainty in the Amazon region (Brito and Barreto, 2010). They report that 36% of Pará territory lacks well-defined land rights, and it is in the undefined portions of the territory that 70% of the deforestation occurs.

A handful of studies have looked directly at the relationship between the degradation of renewable natural resources and international trade (Chichilnisky, 1994; Brander and Taylor, 1996; and Ferreira, 2004). Generally speaking, the conclusion of these studies is that if property rights to the environmental resource in question are ill-defined, then trade between two countries does not make both better off in terms of resource allocations and income, as is usually claimed by the proponents of international trade. Chichilnisky, for example, assumes a trade agreement between two hypothetical countries—a “north country” and a “south country”—where the property rights to a natural resource in the south country, which exports goods based on that natural resource, are ill-defined. She shows that although trade is able to equalize output and factor prices between north and south, it does not improve resource allocation in the south country. Since the south is poor and owns a subsistence sector (labor), tax policies on the use of the resource that decrease the price of the resource would lead to even more extraction (overproduction) of the common property.

Ferreira (2004) supports the idea that the lack of property rights in an exporting country leads to overexploitation of commonly owned resources. She built a model that exploits the difference between the marginal and the average product of labor in two hypothetical countries, also called “north” and “south,” assuming that both countries share similar technological levels, stocks of natural resources, and available labor. The main reason for trade is not the difference in the resource abundance in the two countries, but the difference in property rights over natural resources: the north has better-defined property rights than the south. Thus, increases in prices brought by trade shift up the value of the marginal product and the value of the average product curves, inducing labor migration from the manufacturing sector to the harvest sector in the south. Ferreira concludes that even as the south becomes a net exporter, it experiences losses from trade. In addition, the elimination of trade distortions enlarges the effects of property rights distortions, which also damage the south country.

Brander and Taylor (1995) analyze another hypothetical open, small-country economy. Natural resources are abundant, and property rights are not enforced. In accord with Ricardian economics, the authors

<sup>3</sup> See Kaimowitz and Angelsen (1998) for the full report.

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