Journal of Environmental Economics and Management 75 (2016) 25–40

Contents lists available at ScienceDirect

Journal of Environmental Economics and Management

journal homepage: www.elsevier.com/locate/jeem

Impact of foot-and-mouth disease status on deforestation in Brazilian Amazon and *cerrado* municipalities between 2000 and 2010☆

Maria S. Bowman*[1]

Research Agricultural Economist, Economic Research Service, United States Department of Agriculture (Resource and Rural Economics Division), 1400 Independence Ave., SW, Mail Stop 1800, Washington, DC 20250-0002, United States

ARTICLE INFO

Article history:
Received 29 November 2013
Available online 25 September 2015

Keywords:
Deforestation
Brazil
Cattle
Foot-and-mouth disease
Beef exports

ABSTRACT

Deforestation in the Brazilian Amazon released approximately 5.7 billion tons of CO_2 to the atmosphere between 2000 and 2010, and 50–80% of this deforestation was for pasture. Most assume that increasing demand for cattle products produced in Brazil caused this deforestation, but the empirical work to-date on cattle documents only correlations between cattle herd size, pasture expansion, cattle prices, and deforestation. This paper uses panel data on deforestation and foot-and-mouth disease (FMD) status—an exogenous demand shifter—to estimate whether changes in FMD status caused new deforestation in municipalities in the Brazilian Amazon and *cerrado* biomes during the 2000–2010 period. Results suggest that, on average, becoming certified as FMD-free caused a temporary spike in deforestation in the 2 years after a municipality became FMD-free, but caused subsequent deforestation to decline relative to infected municipalities during the 2000–2010 period.

Published by Elsevier Inc.

Introduction

One-third of the world's remaining rainforests are in Brazil, and it is the world's most biodiverse country (Lewinsohn and Prado, 2005). It is also the 3rd largest exporter of global agricultural commodities by value, ranking 1st in sugar and beef exports and 2nd in exports of soybeans (Economic Research Service, 2012). Between 2000 and 2005, Brazil deforested approximately 0.4–0.6% of its Legal Amazon region every year (INPE, 2012)—an area larger than Belize—and 50–80% of these forests were replaced by pasture (Simon and Garagorry, 2005; Morton et al., 2006; Wassenaar et al., 2007; Espindola et al., 2012). Although deforestation rates have slowed since 2005, deforestation in the Brazilian Amazon released approximately 5.7 billion tons of CO_2 to the atmosphere between 2000 and 2010[2] and deforestation and land management in Brazil could contribute significantly to future greenhouse gas (GHG) emissions (Galford et al., 2010). Bustamante et al. (2009) estimate that cattle ranching accounted for more than half of Brazil's total GHG emissions for the 2003-2008 period. Beyond the effects on global climate, the local and regional consequences of deforestation

☆ The views expressed are those of the author and should not be attributed to the Economic Research Service or the U.S. Department of Agriculture.

* Tel.: +1 202 694 5542.
E-mail addresses: maria.s.bowman@gmail.com, maria.bowman@ers.usda.gov

[1] Research completed when the author was a Ph.D. candidate in the Department of Agricultural and Resource Economics at the University of California, Berkeley, and a Graduate Student Researcher at the Energy Biosciences Institute at the University of California, Berkeley.

[2] Using data from the INPE PRODES database (www.obt.inpe.br/prodes), CO_2 emissions were calculated using a conversion factor of 100 tons C committed to the atmosphere per hectare deforested, which is the (conservative) factor officially used by Brazil's Amazon Fund. The conversion factor from C to CO_2 is 3.66.

http://dx.doi.org/10.1016/j.jeem.2015.08.003
0095-0696/Published by Elsevier Inc.

in Brazil include drought, perpetuation of the fire regime, and loss of biodiversity and ecosystem services (Kirby et al., 2006; Nepstad et al., 2008; Nepstad et al., 2009; Martinelli et al., 2010; Stickler et al., 2013).

Policy makers and scientists alike have assumed that cattle ranching causes more than half of new deforestation since more than half of the forest that is cleared is converted to pasture (Comitê Interministerial Sobre Mudança do Clima, 2008; Zaks et al., 2009; Cerri et al., 2010). They cite increasing beef consumption in Brazil (Faminow, 1997; Levy-Costa et al., 2005) and the dramatic increase in exports from roughly 5% to 17% of production between 1990 and 2010 due to increasing global demand for beef (McAlpine et al., 2009; Foreign Agricultural Service, 2015) as the forces driving this expansion. Clearly regional and global demand for beef is one factor driving deforestation for pasture in Brazil, but we know relatively little about the empirical relationship from the existing literature.

There are a number of econometric studies that have looked at the drivers of deforestation and expansion of cattle ranching in Brazil.[3] One category of econometric studies, which makes up much of the economic literature on deforestation in Brazil, combines remotely sensed data on deforestation and land cover or land use change with data collected from federal censuses or surveys conducted by the Instituto Brasileiro de Geografía e Estatística (IBGE). These analyses are usually conducted at the municipality or the census tract level, and are limited by the fact that full censuses have occurred only periodically, every 5 years. IBGE collects other annual data at the municipality level through specific surveys of agriculture or animal production, but these have the disadvantage of not being based on surveys of producers or market data (i.e. they are filled out by a representative at the municipality level that reports total production and/or prices; see IBGE, 2002). Nonetheless, researchers have used these quinquennial data to run separate models for multiple time periods, structuring models such that the dependent variable (or independent variable) is the change between census periods, or pooling data. This body of literature formed the basis for our understanding of the drivers of deforestation in the Brazilian Amazon, including roads, location, and infrastructure; endogenous socioeconomic variables such as GDP, area in pasture or agriculture, and population growth; and climatic and edaphic variables (Reis and Margulis, 1991; Pfaff, 1999; Andersen et al., 2002; Chomitz and Thomas, 2003; Weinhold and Reis, 2008; Pfaff et al., 2007).

Another segment of the econometric literature has used panel data models with different fixed effects specifications to investigate similar research questions. These models have the advantage of controlling for unobserved heterogeneity at the municipality level that does not vary with time, but that may be correlated with other covariates (Wooldridge, 2005). In the case of Brazilian municipalities, such heterogeneity might result from differences in municipality size, soil quality, distance to markets, climate, average levels of infrastructure or governance, or other variables specific to the municipality that impact deforestation rates. Although these fixed effects are controlled for, the corresponding disadvantage of fixed effects models is that the disaggregated impact of each of these variables is not observed when you run a regression—they are lumped together into a fixed effect. Including year fixed effects has a similar result—it allows the researcher to combine and control for factors that vary over time but not at the municipality level, such as changing macroeconomic conditions, agricultural commodity prices or Brazil-wide initiatives.

Ferraz (2001) constructed a state-level panel to look at the determinants of cattle herd density over time, at the state level with state fixed effects. He found that the cattle price was significantly and negatively correlated with herd density, and paved and unpaved road density were positively correlated. Arima et al. (2011) use a panel fixed effects model (with year and municipality fixed effects) to look at the impact of cattle- and soy-related variables on deforestation within a selected area (to get at deforestation at the extensive margin). They conclude from their analysis that a 10% reduction in conversion from pasture to soybeans would have decreased deforestation by as much as 40% in heavily-forested municipalities between 2003 and 2008. Hargrave and Kis-Katos (2013) employ a difference-in-difference spatial panel model (with and without year fixed effects), estimated via generalized method of moments (GMM), to look at the impact of deforestation enforcement on deforestation rates at the municipality level. They find expected signs of coefficients on prices, high rainfall (−), and area under protection (−) or in smallholder settlement (+), and instrument for fining intensity (number or value of fines per area deforested) using state-level IBAMA presence. They find a negative relationship between fining intensity and deforestation.

Recent work by Assunção et al. (2013a, 2013b) and Assunção and Rocha (2014) uses panel fixed effect models to look at the impact on deforestation of several variables of interest, including whether municipalities were considered “priority municipalities” between 2008 and 2011, intensity of fining, effect of the new DETER monitoring system, and impact of environmental compliance conditions for access to credit. In Assunção et al. (2012), the authors look at the relative impacts of agricultural prices and various conservation policies implemented by the Brazilian government on curbing deforestation. They create exogenous price indices at the municipality level using prices from outside the region and weighting them by the relative contributions of different products in the pre-period to deal with endogeneity in local prices.

[3] For the purposes of this paper, I do not discuss the rich literature on the drivers of household-level decision making about deforestation and cattle ranching in Brazil, which are based on household-level survey data (see, for example: Mattos and Uhl, 1997; Arima and Uhl, 1997; Walker et al., 2000; Perz and Walker, 2002; Walker et al., 2000; Caviglia-Harris, 2004; Caviglia-Harris, 2005; Caviglia-Harris and Sills, 2005; Merry et al., 2008). Many of these studies are cross-sectional, and look at how differences in household and market characteristics at one snapshot in time (e.g. education, location, wealth, income, property rights, household composition, opportunity cost of time) affect decisions about, for example, how much land to clear or how large of a cattle herd to invest in. I also do not discuss in detail a large body of literature that takes a hybrid approach to econometric and geographic modeling (see e.g. Andersen et al., 2002; Mertens et al., 2002; Weinhold and Reis, 2008; Soares-Filho et al., 2010; Mann et al., 2014). Many of these focus on the role of cross sectional variation in soil type, precipitation, slope and other geographic variables in explaining where deforestation occurs at the pixel level, or use a combination of economic and geographic variables (both exogenous and endogenous to the process being modeled) to predict the probability of land being deforested or being in a certain land use in a given period or year. Modeling approaches include Probit or Logit regression, “random reduction” or stepwise regression, as well as non-parametric approaches.