Global Environmental Change 29 (2014) 1–9

Contents lists available at ScienceDirect

Global Environmental Change

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

Spatially complex land change: The Indirect effect of Brazil's agricultural sector on land use in Amazonia

Peter D. Richards [a,*], Robert T. Walker [b], Eugenio Y. Arima [c]

[a] Population Studies and Training Center, Institute for the Study of Environment and Society, Brown University, United States
[b] Department of Geography and Center for Latin American Studies, University of Florida, United States
[c] Department of Geography, University of Texas, United States

ARTICLE INFO

Article history:
Received 27 August 2013
Received in revised form 21 May 2014
Accepted 18 June 2014
Available online

Keywords:
Indirect land use change
Agriculture
Deforestation
Amazon
Brazil

ABSTRACT

Soybean farming has brought economic development to parts of South America, as well as environmental hopes and concerns. A substantial hope resides in the decoupling of Brazil's agricultural sector from deforestation in the Amazon region, in which case expansive agriculture need not imply forest degradation. However, concerns have also been voiced about the potential indirect effects of agriculture. This article addresses these indirect effects for the case of the Brazilian Amazon since 2002. Our work finds that as much as thirty-two percent of deforestation, or the loss of more than 30,000 km^2 of Amazon forest, is attributable, indirectly, to Brazil's soybean sector. However, we also observe that the magnitude of the indirect impact of the agriculture sector on forest loss in the Amazon has declined markedly since 2006. We also find a shift in the underlying causes of indirect land use change in the Amazon, and suggest that land appreciation in agricultural regions has supplanted farm expansions as a source of indirect land use change. Our results are broadly congruent with recent work recognizing the success of policy changes in mitigating the impact of soybean expansion on forest loss in the Amazon. However, they also caution that the soybean sector may continue to incentivize land clearings through its impact on regional land markets.

© 2014 Elsevier Ltd. All rights reserved.

1. Introduction

Over the last decade Brazil's expansive soybean sector has reshaped the nation's physical and socioeconomic landscape. While evidence indicates positive socioeconomic changes associated with soybean production (VanWey et al., 2013; Weinhold et al., 2013), researchers and policy makers have nonetheless fretted over the environmental implications of expanding soybean agriculture in the tropics (Searchinger et al., 2008). Most notably, research has tied Brazil's soybean sector to more than 5000 km^2 of deforestation in State of Mato Grosso alone (Morton et al., 2006); and, through statistical correlations, to land use change more broadly across tropical Amazonia (Barona et al., 2010; Lapola et al., 2010; Arima et al., 2011).

In this article we follow work addressing the indirect effects of the agriculture sector, which we refer to as indirect land use change (ILUC).We define ILUC as a land use change in one location that is responsive to a land use change in another, potentially distant location. We theorize that this occurs through two mechanisms: (1) through the spatial relocation of key agricultural and ranching inputs, including human and financial capital (Barona et al., 2010; Lapola et al., 2010; Arima et al., 2011); and (2) through land appreciation in frontier areas linked to high returns to soybean production.

In our models we estimate that Brazil's soybean sector has contributed, indirectly, to as much as thirty-two percent of forest loss in the Brazilian Amazon since 2002. We tie one-third of this indirect deforestation to agricultural expansion and land valuation in Brazil's distant agricultural strongholds in its southern states. We then argue that work to date on indirect land use change has largely overlooked the broader impacts of the agricultural sector on the demand for land in Brazil, and on land speculation and appreciation on the frontier. We also argue that policy makers must pay close attention to the complications that arise from spatially complex land change, which links environmental change in remote frontiers such as Amazonia to land use and land values in established agricultural regions.

We organize the paper as follows. First, we engage with the growing body of literature that considers ILUC in Brazil's Amazon

* Corresponding author. Tel.: 401-863-5862; fax: 401-863-3839.
E-mail address: peter_richards@brown.edu (P.D. Richards).

http://dx.doi.org/10.1016/j.gloenvcha.2014.06.011
0959-3780/© 2014 Elsevier Ltd. All rights reserved.

region. This then leads to our conceptualization of the indirect effect, which we argue is driven by increasing land values and the growing demand for land. We then present a statistical analysis of ILUC where we spatially distribute the indirect effects of the agricultural sector through Brazil's road network, and where we pay particular attention to temporal shifts in economic conditions and environmental policies. Finally, after a discussion of our statistical results we draw out several important policy implications.

2. Amazon deforestation and the indirect effects of agricultural change

Quantitative attempts to describe or estimate indirect land use change have been prosecuted at the international, national, and regional scales. Much of this work has focused on the impact of US and European biofuel policies, or on the impact of American corn or ethanol subsidies and trade mandates on production areas in the US, Brazil, or Indonesia (Fargione et al., 2008; Searchinger et al., 2008; Keeney and Hertel, 2009). This research has focused on estimating the carbon impacts associated with the land use changes predicted to be needed to meet new demand for biofuel or ethanol production. In this body of research ILUC hinges on the elasticities of commodity prices to decreases or increases in global production areas (Keeney and Hertel, 2009; Hertel et al., 2010b). Thus a shift in corn production in the American Midwest might come at the expense of soybeans, which, in turn, would trigger an increase in soybean prices and a subsequent expansion of soybean cultivation in distant nations (e.g., such as Brazil).

Other research focused on Brazil specifically, or on the Amazon exclusively, has suggested that ILUC stems not only from changing returns to agricultural commodities, but from the internal redistribution of rural skills and capital. This work has focused on land use displacement, and the notion that any agricultural expansion comes, in part, through the displacement and reconstitution of pastures in frontier areas (Gasparri and Polain de Waroux, 2014; Meyfroidt et al., 2014).

To assess the extent to which displacement has led to deforestation in the Amazon, researchers have implemented both spatially explicit computational models (Lapola et al., 2010) and statistical analyses (Barona et al., 2010; Arima et al., 2011; Andrade de Sá et al., 2012). In this article we build on the recent efforts of Arima et al. (2011) by modeling distal relationships in a statistical framework. However, we advance from this past research on three fronts. First, we conceptualize the indirect effect as a function of not only market phenomena (e.g., prices, supply elasticities), or of the mobility of people and capital (displacement), but as the effect of land appreciation driven by agricultural returns. Second, we expand our analytical and spatial scope to incorporate impacts associated with Brazil's southern agricultural states (Andrade de Sá et al., 2012; Richards, 2012b; Walker and Richards, 2013). Southern Brazil, we note, has traditionally served as a feeder region for capital and skills to the agricultural frontiers of central Brazil (Margolis, 1973; Jepson, 2006; Richards, 2012a). Finally, we acknowledge that ILUC may be attributable to multiple mechanisms, and that these mechanisms shift with time. Thus, we not only estimate ILUC, but test our estimates across two time periods: pre and post-2006, or before and after the decline in soybean returns, and the contemporaneous intensification of Brazil's environmental policy.

3. Theoretical considerations: indirect land use change in a location-rent context

Land use change is the result of human behavior, and of decisions made given both local considerations (land suitability, available skills, culture and experience, and access to capital) and structural context (e.g., markets, access, policies, and institutions). Place, and location with respect to other land uses, also affect land use, both on the demand side, in terms of regional or local demand for rural resources, and from the supply side, via the decreased transaction costs and increased production knowledge associated with agglomeration economies (Robalino and Pfaff, 2012; Garrett et al., 2013a). For an indirect land use to take place, which in the context of this article amounts to tying a land clearing on the frontier to changes in the agriculture sector elsewhere in Brazil, the agriculture sector must alter micro-level incentive structures in frontier regions. This can occur through a change in either the local or structural level conditions that allow such rents to come into existence. To date, work on indirect land use change has suggested that this occurs through one of two processes: (1) from the demand side, via an increase in returns to beef production; or (2) through the supply side, through the spatial relocation of ranching capital from the periphery of an agricultural frontier to forested regions (Andrade de Sá et al., 2013; Gasparri and Polain de Waroux, 2014; Meyfroidt et al., 2014). We pause to consider both of these mechanisms, before adding a third channel by which the agricultural sector is capable of reshaping production decisions on the frontier: land appreciation.

Much of the literature on ILUC has focused on the impact of US and European biofuel policies on Brazil's agricultural sector (Searchinger et al., 2008; Hertel et al., 2010a), or of the impact of Brazil's agricultural sector on returns to beef production (Walker, 2011; Walker and Richards, 2013; Walker, 2014). In this literature, if expanding agriculture encroaches on ranching, it is also acting to reduce beef supplies. This, in turn, could raise beef prices, which sparks a compensatory expansion of pastures to bring new lands into production (Walker, 2001; Angelsen, 2007; Walker and Richards, 2013; Cohn et al., 2014). While we hardly refute this effect, or the potential impact of soybean expansion on beef prices, we point out that pasture areas have actually increased far beyond the areas occupied by soybean farmers in recent years. Perhaps more importantly, at the height of the soybean boom, from 2001–2004, approximately 6000 km^2 of pasture were converted to cropland in Mato Grosso (Morton et al., 2006). If we assume that this equates to roughly 600,000 animals (with one animal per hectare), this amounts to only three percent of the state's total cattle herd, and less than 0.3 percent of Brazil's total supply. Presumably, any price effect from the supply reduction would be minimal. We thus turn our attention to the second means by which researchers have suggested that Brazil's agricultural sector has led, indirectly, to regional scale forest loss, namely land use displacement.

From a behavioral perspective, land use displacement rests on the assumption that an expanding agricultural sector displaces human and financial capital from old ranching areas to the forest. If displaced individuals re-establish their operations in forest areas, and clear the forest in order to do so, then it follows that their initial displacement by the agricultural sector is, indirectly, altering production capacities in frontier regions (Meyfroidt et al., 2010; Andrade de Sá et al., 2012; Richards, 2012a; Gasparri and Polain de Waroux, 2014; Meyfroidt et al., 2014). At the micro-level, the displacement process spatially redistributes knowledge and investment capital from capital and knowledge-rich regions in core ranching or agricultural areas to Amazonian frontier regions, which are land abundant but capital-scarce (Ozorio de Almeida and Campari, 1995). As investment capital and production knowledge migrate to new areas, lands suitable for ranching are cleared for ranching, often with a greater than a one to one displacement of old pasture for new pasture (with deforestation). This occurs because the newly arrived ranchers may sell highly appreciated properties, and buy inexpensive land on the frontier.

Download English Version:

https://daneshyari.com/en/article/7470202

Download Persian Version:

https://daneshyari.com/article/7470202

Daneshyari.com