



The impact of deforestation, urbanization, public investments, and agriculture on human welfare in the Brazilian Amazonia



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ABSTRACT

The relationship between human welfare and deforestation in the Brazilian Amazonia has traditionally been thought to follow a boom-and-bust pattern. According to this pattern, forest clearing triggers rapid increases in human welfare levels (“the boom”) due to short-term economic gains; these levels then drop to below national or regional averages (“the bust”) after the forest stocks have declined, thus causing the local populations to become deprived of ecosystem services. However, recent studies have questioned the validity of this boom-and-bust pattern. In this paper, we use panel data and simultaneous autoregressive models to evaluate the effects of deforestation, urbanization, public investments, agriculture, and state policies on temporal changes in human welfare that occurred across multiple municipalities in the Brazilian Amazonia from 2005 to 2012, a period during which governments implemented a set of strategies aimed at controlling deforestation across the region. We found that: (a) signals of a boom-and-bust pattern are weak at the regional level, and therefore this pattern cannot be generalized across the entire region; (b) human welfare is increasing more rapidly in low-development municipalities than in high-development cities, and all municipalities are converging on at least one regional average rather than on a national average; (c) urbanization does not lead to positive changes in human welfare, which indicates that the infrastructure available in regional urban centers is limited; (d) public investments are negatively associated with human welfare growth, thus signifying that if public investments are not used to leverage the potential of other sectors of the local economy, human welfare will not improve; (e) agriculture is negatively associated with positive changes in human welfare at the local level, possibly due to the dominance of cattle-ranching as the predominant economic activity of this sector; and (f) state-level policies matter, and future analyses of regional trends in the realm of development and conservation across this region should take such policies into account. Finally, we suggest that although human welfare and deforestation retain a weak statistical relationship, we cannot contend that they have been fully decoupled. Forest loss across the region is still pervasive, and institutions are too weak to sustain the transition from a frontier development model to a conservation-centered model.

1. Introduction

In tropical forest regions, traditional development usually follows the frontier model, in which forests are replaced by other types of land better suited to the production of quick economic gains. Such a model does not embrace long-term concern about environmental sustainability (Becker, 2001). In places where financial resources generated by the depletion of forest stocks are reinvested into the local community, average human welfare is likely to improve. Over time, a favorable standard of living can lead to better environmental regulations and the advent of local organizations. These factors can, in turn, lead to forest transition (i.e., a reversal from net forest loss to net forest gain)

(Mather, 1992; Rudel et al., 2005). However, if the revenues generated by forest use are exported to other places, and if local organizations are not capable of adopting actions that sustain a relatively high growth rate in human welfare levels, a different pattern can occur. Instead of forest transition, such places may exhibit a boom-and-bust pattern. This pattern is found when the short-term gains caused by forest clearing trigger a rapid growth rate in average human welfare (“the boom”) which then drops to below national or regional averages (“the bust”) after the forest stocks have declined, thus causing populations to become deprived of the ecosystem services that once sustained their economic activities (Schneider et al., 2002; Rodrigues et al., 2009). An alternative to the frontier model is the conservation-centered model, in

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which societies use knowledge and technology to design sustainable territories wherein most natural ecosystems are protected or wisely used and where human welfare improves as a consequence of the development of local economies that are diversified, efficient, inclusive, and resilient (Becker, 2004; Vieira et al., 2005; Silva, 2015; Nobre et al., 2016).

The Brazilian Amazonia is considered to be a textbook example of the modern frontier development model. Since the 1960s, the expansion of roads, dams, and large mineral projects has led to an intense process of regional occupation that has already claimed roughly 20% of the original forests and caused recurrent social conflicts (Becker, 2004; Hecht, 2011; Silva, 2015; Souza et al., 2015). From 1988–2015, 413,505 km² of forests in the region were replaced by other types of land use (INPE, 2015). In 2004, deforestation peaked at 27,772 km², which led the Brazilian government to design a long-term plan to control deforestation and move the region away from the traditional frontier model to a more conservation-centered development plan (Hecht, 2011). The Action Plan for Prevention and Control of Deforestation in the Legal Amazonia (PPCDAm) combined a set of initiatives, including those focused on the expansion of protected areas, the recognition of indigenous lands, the increased enforcement of existing environmental legislation, the development of a new forest monitoring system led by the National Institute for Spatial Research (INPE), the creation of incentives for forest production, and the reduction of subsidies and credits for economic activities that sustain illegal deforestation (Hecht, 2011; Assunção et al., 2015; Rajão and Georgiadou, 2014). Aligned to PPCDAm there were various private sector initiatives such as the soybean and beef moratoria (Gibbs et al., 2015, 2016). To date, the PPCDAm has been successful, and resulted in deforestation decline to its lowest historical rate of 4571 km² in 2012 (INPE, 2015). However, because forest conservation is a historical and political process, only a substantial increase in human welfare across the region will ensure the long-term maintenance of low deforestation rates and accelerate the transition to a conservation-centered development model (Vieira et al., 2005; Dias et al., 2016; Aguiar et al., 2016).

The relationship between human welfare and deforestation in the Brazilian Amazonia remains a controversial issue. Schneider et al. (2002) proposed that this relationship follows the boom-and-bust pattern rather than the forest transition pattern. Rodrigues et al. (2009) and Celentano et al. (2012) evaluated and supported this hypothesis by using cross-sectional data from the year 2000. However, recent efforts to analyze panel data (from 1990 to 2010) conducted by Caviglia-Harris et al. (2016) and Weinhold et al. (2015) have questioned these findings. Weinhold et al. (2015) suggested that the results of the cross-sectional data analysis are merely artifacts of spatial correlation and that municipalities with different levels of forest cover have enjoyed equal increases in human welfare over a decade, with no evidence of a boom-and-bust pattern. Caviglia-Harris et al. (2016) found that a weak but significant boom-and-bust pattern was identified only when human welfare rates during the first year of the study period were included in the regression model. Furthermore, Caviglia-Harris et al. (2016) suggested the following: (a) that human welfare in the region has become decoupled from deforestation, (b) that human welfare rates are converging on rising national averages, and (c) that this convergence is the result of an increase in public investments and the rapid urbanization process that is occurring throughout the region. In the search for factors that can explain the geographic patterns of temporal changes in human welfare across the Brazilian Amazonia, two factors have not yet been assessed: agriculture and state-level policies. The most recent wave of human occupation in the Brazilian Amazonia was based on the assumption that the promotion of monocultures and cattle ranching as a regional development strategy would lead to substantial gains in local human welfare (Becker, 2004). Supporting this assumption is the fact that, from a purely economic viewpoint, agriculture is—among the major economic sectors of Brazil—the segment with the smallest Gini coefficient (IBGE, 2014). This indicates

that the sector could have a positive social impact on local societies. However, since the 1970s, agricultural expansion in the Brazilian Amazonia has caused several social-ecological issues by exacerbating land use conflicts, undermining the rights and lifestyles of traditional people, and facilitating the spatial diffusion of homicidal violence (Becker, 2004; Arima et al., 2005; Hecht, 2011; Silva, 2015). In addition to social problems, monocultures and cattle-ranching were and continue to be the major drivers of massive regional deforestation (Gibbs et al., 2015; Hansen et al., 2013), thereby eroding important ecosystem services that are relevant to both local and global societies (Fearnside, 1997; Clement and Higuchi, 2006; Silva, 2015). Consequently, whether monocultures and cattle ranching make a genuine contribution to positive changes in human welfare across the Brazilian Amazonia remains a controversial issue (Prates and Bacha, 2011).

Most of the recent discussion about human welfare across the Brazilian Amazonia is focused on the policies and programs designed by the national government. Almost no emphasis is placed on state-level initiatives. However, Brazil is a federative republic wherein states have autonomy—and their own resources—to set policies and programs that can converge on or diverge from the national agenda. In the last decades, states have become strong protagonists of the region's socio-economic development, designing and leading the implementation of innovative public policies (Silva et al., 2005; Garda et al., 2010). However, the strategies adopted by the various states within the region are different. For instance, while some of the states in the Brazilian Amazonia (such as Amazonas, Amapá, Acre, and Pará) have embraced a conservation-centered development plan in at least a portion of their territories, other states (such as Mato Grosso, Rondônia, Roraima, Maranhão, and Tocantins) continue to base their development strategies on the traditional frontier model (Silva et al., 2005; Garda et al., 2010). These differences among the many state-level development strategies are predicted to lead to disparities between local development trajectories.

In this study, we evaluated the effects of deforestation, urbanization, public investments, agriculture, and state policies on temporal changes in human welfare across various municipalities in the Brazilian Amazonia by using panel data from 2005 to 2012, the period immediately following the implementation of the PPCDAm. To this end, we assessed the following hypotheses: (a) signals of a boom-and-bust pattern are weak across the region; (b) human welfare in the region is converging on a rising national average; (c) increased urbanization contributes positively to temporal changes in human welfare; (d) increased public investments contribute positively to temporal changes in human welfare; and (e) agriculture contributes positively to temporal changes in human welfare. Additionally, because the Brazilian Amazonia is a heterogeneous region composed of nine states, all with different policy priorities and socioeconomic contexts, we evaluated the hypothesis that the set of relationships described above also holds at the state level. Finally, we applied our results to a discussion of whether—as suggested by Caviglia-Harris et al. (2016)—the socio-economic development that occurred across the region during our study period became fully decoupled from deforestation.

2. Methods

2.1. Study area

We delimited the Brazilian Amazonia according to the boundaries of the Amazonia Biome as defined by the Brazilian Institute of Geography and Statistics (IBGE, 2004). The IBGE's proposal follows the boundaries laid out in the original extension of the tropical rainforests of northern Brazil. This region covers an area of 4.3 million km² (Fig. 1) and has a population of 21.6 million people, 72% of whom live in urban areas. The Brazilian Amazonia includes 517 municipalities in the following nine Brazilian states: Amazonas, Acre, Rondônia, Roraima, Amapá,

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