Environmental conservation program and poverty : evidence from the Brazilian Amazon

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Abstract

Nowadays, about 20% of the Brazilian Amazon is under environmental protection and 13% of its population live within these preserved areas. The role of protected areas is essential for biodiversity and environmental conservation but could also imply a cost for local populations. Thanks to a unique dataset built for the whole Brazilian Amazon, we examine how protected area implementation affects population in term of poverty for the 2000-2010 period. While Brazilian rural population tends to decrease during the decade, exposure to a protected area tends to increase the number of individuals living in rural area. However, evidence of rural population growth depends on the nature of the protected area. Strictly protected areas lead the poorest population to migrate. This makes likely that strict protection, by restricting land use and implying an increasing land scarcity, leads the poorest people to leave since they cannot exploit land anymore. On the contrary, richest people who already own their lands can keep using it.

keywords: Protected areas policy, Development, Brazilian Amazon
JEL codes: Q01, Q2, Q56

1 Introduction

mettre en avant les résultats du papier précédent en avant puis parler plus des inégalités concernant les small vs big farmers With the alarming climate change situation, policy-maker and researchers are increasingly interesting in the combined effect of environmental conservation and development policies. Although objectives of environmental conservation is climate change mitigation, it has been recognizing they can also benefit for sustainable development especially for development economies. However, we still have limited understanding on how environmental protection impact economic development.

This paper analyses one particular environmental policy on population. Specifically we explore the effect of protected area implementation on economic development outcomes. Protected area is "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (the International Union for Conservation of Nature). Protected areas play a huge role in term of biodiversity conservations but They also provide externalities in terms of human welfare. Indeed, for most rural population in developing countries, agricultural activities are an important part of revenue due to the low level of skills required by extractive activities (Rudel and Roper [1997]). Implemented protected area would then act as a land use constraint, leading to negative externalities of protected area on economic outcomes. Despite that, protected areas can also improved the utility of environmental resources through the development of Eco-tourism which in turn provides off-farm revenues and allows for poverty alleviation.

With about 400 millions hectares, Brazil has the largest part of the Amazon Forest. It is also considered as one of the most deforested with more than 750 000 square kilometers cover loss since 1970 (PRODES). Reasons of such deforestation are related to the demographic evolution, and intensive agriculture. However, in July 2000, Brazilian Government launched, through Law 9985, the creation of the National System of Protected Areas (SNUC, in Portuguese), in order to establish a robust mechanism to ensure the creation, management and consolidation of protected areas (PAs) in Brazil. The creation of the SNUC has been followed by creation of numerous conservation units (Droulers and Tourneau [2007]). Even though agricultural productivity was still important, deforestation rate has tended to radically reduced during the decade following the SNUC implementation.

Most of the time, Forest literature focuses on efficiency of environmental policies on deforestation (Assunção and Rocha [2014], Anderson et al. [2016], Burgess et al. [2012]). Indeed, empirical evaluation of land use regulation on the social and economic outcomes is extremely in literature and if so only available at small scale (Arriagada et al. [2012], Alix-Garcia et al. [2013]). It is not surprising since, "evaluation of impacts is difficult due to the vastly different spatial scales of data needed and the fact that many [areas] are located in remote or isolated areas which are costly to reach and survey" (Alix-Garcia et al. [2013]). Finally, data reliability or lack of individual data compatible with the spatial scale of the geographic one, make the empirical analysis of poverty and land use regulation challenging.

Our contribution thus consists of evaluating the impacts of environmental policies on economic outcomes using a unique data set for all the Brazilian Amazon of 5 million of square kilometers combining social data from the Brazilian demographic census and highly remote sensing data for the Legal Amazon. While many studies deal either with poverty in one state of the Brazilian Amazon or focus on deforestation outcomes, we build a dataset related on social and geographic characteristics at an aggregation level far below the municipality level. We indeed based our data on the Brazilian demographic sector census for the 2000 and 2010 years and overlapped a grid map of 10km sides. This grid level aggregation allows us to combine social data with highly remote sensing data while maintaining a proper level of aggregation for geographic characteristics. The decade of 2000 to 2010 covered by our data seems significant because during this period poverty as well as deforestation begins to recede while protected areas and environmental monitoring increase.

Our empirical strategy is a difference-in-differences method. Specifically, we exploit differences across rural sectors in the overall Brazilian Amazon for those with a protected area and without protected area on population. Our identification strategy is mainly related on the creation of the SNUC in 2000 and the bias location literature (Pfaff et al. [2015]Eric Nazindigouba et al. [2016]Veríssimo et al. [2011a]), majority of protected areas where more effective on deforestation. "[R]ecent protected areas are more efficient than older ones because they are mostly located in high deforestation pressure areas." (Eric Nazindigouba et al. [2016]). Literature agreed to say that most of conservation units created after 2000, were mainly implemented in "hotspot" area, meaning in areas where agricultural profitability was important and environmental degradation were threatening biodiversity. Bias localization literature actually demonstrates that protected area designations are largely related on environmental and biodiversity criterion. This resulting on the fact that protected area designations would not be correlated to population characteristics. Moreover, we also put several restriction hypothesis on our data to define properly a treatment and avoid endogeneity between treated grid and dependent variable (the population). Finally, we only understand Brazilian conservation unit in our treatment. Indeed, we do not include indigenous land in our study, since indigenous lands are implemented according to local communities characteristics and requested by indigenous people himself.

The contribution of this paper is double. we first address the literature gap related to the effect of natural resource management of natural resources in developing countries on poverty in developing countries. Answering this question could help targeting population's expectations more adequately and make the localization of conservation units more efficiently. Second, we also provide an original database at an under-explored aggregation data level, for the Brazilian Amazon in 2000 and 2010 combining spatial and economic data.

The rest of the paper is structure as followed. In section two, the institutional context of Brazil related to its population within the Brazilian Amazon and environmental protection is presented. In the following section step of the dataset building are presented. Next, empirical strategy and first results are detailed. Finally, conclusion is exposed.

2 Historical context of Brazil :rural population, deforestation and conservation:

In a context of climate change and global warming, countries with huge environmental degradations have rapidly been pointed out by the international scene. In the beginning of the the 21st century, focus on the environmental protection as well as poverty alleviation became two main objectives. *"Action is urgently needed to identify and quantify the links between biodiversity and ecosystem services on the one hand, and poverty reduction on the other"* [Sachs et al., 2009]. However, the relationship between environmental conservation and poverty is often subject to controversy. Indeed, several view dominate the literature. The first strand specifies that poors take part in the environmental degradation due to their extractive activities Geist and Lambin [2001]. A second and novel strand of literature argue that environmental conservation through the promotion of sustainable development could actually "increase employment opportunities, reduce regional income inequalities, prevent rural-urban migration, and ultimately reduce poverty" Guedes et al. [2009].

2.1 Population and poverty

Relationship between Brazil and deforestation is a story of long-lasting. The Amazonian forest, considered as one of the "lung of the earth", both for the huge concentration of biodiversity and ecosystem services, represents nowadays 40% of total forest cover in the world. Brazil gets most part of this forest with 75% contained in the country, being two third of whole country, called the Brazilian Amazon. The Brazilian population settlement is strongly related to its geographical characteristics such as the forest. The presence of the forest and the large size of this territory inhibited the development of infrastructure and the access of the population leading the Brazilian Amazon as a remote area. The lack of infrastructure combine with the high density of forest cover has curbed the settlement of urban population. The brazilian population is then mainly rural where economic opportunities are scarce. Finally, this ruralization combined with inequality of land tenure,lack of well defined property right are such reasons of higher poverty rate than the national average (IFAD, 2007). Verner even estimates that almost 59% of the rural population in the Brazilian Amazon lives below the poverty line. "Poverty itself, along with imperfect capital markets, may increase the discount rate and reduce the time horizon of rural Brazilian smallholders, leading them to adopt low-technological agropastoral activities which contribute to decline in soil fertility" Guedes et al. [2016].

However, poverty distribution among rural brazilian population is not uniformed. Indeed, poverty and rural population settlement are closely related to the colonization and infrastructure project initiated by both private and governmental policies in the 1970s' (Droulers and Tourneau [2007]Le Tourneau and Bursztyn [2011]) and has been accentuated with the population settlement pattern during the last decades. Population increased 10-fold in the Brazilian Amazon, from 2.5 million in 1960 to 24.3 million in 2010 (IBGE, 2010). But still, population settlement remains unequal through the overall Legal Amazon. Following the infrastructure project and thanks to climatic advantage (plateau of savannah do not share the rainforest climate, are less humid) ,states of the south and southeast of the Brazilian Amazon, have rapidly seen the development of 'latifundia' or large scale mechanized farms promoted by the cattle pasture in the beginning of the 1970s. Cattle pasture has finally been replaced by soybean crop due to its structural advantage. With the initial infrastructure project, soy crop spread around to other states along of the paved roads, the BR-364 for the western states and the BR-163 for the eastern ones. However, the western states (Amazonas and Acre) are dominated by small and medium properties while the eastern states (Parà, Maranhao, Tocantin and nothern of Mato Grosso) are mainly dominated by large properties. Poverty and inequality of income are then the consequences of the population settlement pattern.

2.2 Brazilian environmental conservation

In front of this environmental emergency, international institutions and Brazilian Government step in to create environmental conservation from anthropic action. One of the most efficient way to protect environment from human being is the implementation of protected areas. According to the International Union for Conservation of Nature, a protected area is "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values".

At the dawn of the 2000's year arises the creation of the first environmental institution in Brazil named the National Conservation Unit System (SNUC). This public institution allowed common bases and guidelines for "the creation, administration and management of the [environmental] units". Indeed, before such guidelines, protected areas already existed but without defined boundaries and included as well indigenous land as national parks, without distinction of the environmental purpose. Before the SNUC, designation process was also complex and quiet random. SNUC then provided unification and improvement of the environmental monitoring through the country. It was the first step for defining protected areas features. Brazilian Government gets its own protected area's definition based on the International Union for Conservation of Nature's definition and its own historical and cultural features. They define conservation units as "a territorial space and its environmental resources, including its jurisdictional waters, possessing important natural qualities, established in law by public authority for the purpose of conservation, with defined boundaries and subject to a special administrative regime and to appropriate guarantees of protection".

Following environmental seminars held by the Brazilian government between 1998 and 2000, creation of the SNUC also resulted on designation of priority areas within the Legal Amazon.
As said before, SNUC allowed a clear and common definition of the implementation of a PA. According to the SNUC Law No. 9.985/2000, creation and designation of a protected area must lean on technical studies made by public institution in the case of federal protected areas and private institutions in the case of state or municipal protected areas. Whatever the protected areas they must be accompanied with public consultation near local population

to advise and inform (in a non deliberative form) population of the creation of Conservation Units (Veríssimo et al. [2011b]).

Finally SNUC defines different categories of conservations units. Firstly, those with "a strict protection" named the strictly protected area (PI PA) which aimed to prohibit any anthropic action. Secondly, protected areas with "a sustainable use" (SU PA) where monitored agriculture or scientific research are allowed but with high monitoring and constraint on the way people can use the land (or sea). *The Sustainable Use Conservation Units are those destined for both biodiversity conservation and sustainable extraction of natural resources. The populations classified as traditional may remain within the areas, as long as they undertake activities under a management regime, "in such a way to guarantee the perennially renewable environmental resources and ecological processes, maintaining biodiversity and the other ecological attributes, in a socially fair and economically viable fashion" (SNUC, 2002).*

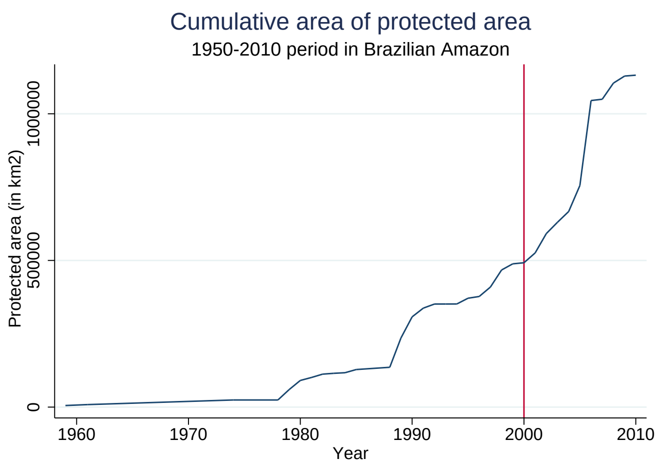

Figure 1: Conservation units area

3 Data

In order to measure the effect of protected area implementation on rural population, we build a unique database for the whole Legal Amazon allying as well economics and social data as highly remote sensing data. Here after we provide the data source for each variable and the level of aggregation. In the most recent literature on the effect of environmental conservation on deforestation level, the data used is at the pixel level of less than 1 km^2, a high spatial resolution. However, regarding the literature on deforestation and population, data used is often at the municipality level, being 756 municipalities. The main issue here is the lack of variability of social outcomes when related to geographic one. Indeed, Brazilian amazon measures 5 millions of square kilometers, which is bigger by 1 millions km^2 of the 27 Europe countries. Brazilian amazon is into the most remote area of the Brazil. Since 2000, the number and frontiers of municipalities are quiet stables. Besides, since municipalities' frontiers resulted from development policies features, colonial legacy or again heterogeneity of population settlement pattern, municipalities size in the Brazilian amazon is largely heterogeneous Théry [1997]. For example, four municipalities exceed 100 000 km^2. It then seems complicated to have a good representation of the repartition population within these municipalities, especially since most high population densities are concentrated within a narrow part of space leaving the rest of the territory with low density population.

The number of municipalities by state is also largely heterogeneous. In the eastern states, number of municipalities are numerous compared to the one in the north-west. Area and population size are also lower in these latest states. Heterogeneity of population and size of states could lead to erroneous results in estimating the effect of conservation policy on local population. For example, if we would like to know the impact of protected area on population in terms of revenues. It would means that the impact would be the same for population living near the protected areas and for them living far from 1500 km^2; results would not be relevant. In other words, satellite data have allowed researchers to significantly improve geographic data. But lack of population localization at a lower level of municipality make the study of much of environmental versus social outcomes extremely limited for the Brazilian Amazon. The aggregation level for social outcomes is then an important issue and might explain the existing research gap in the Brazilian forest literature .

In spite of this lack of reliability of both economics and geographic satellite data, Brazilian government has produced demographics census data at the sector level. While, data at municipality level account for 756 municipalities, the one at sector level account for 215 811 sectors in 2000. It then allowed a better accurate of our estimation related to the effect of protected area on population. Demographic census is produced every decades since 1970 but only include all states of the Legal Amazon since 2000. We eventually use the two last one for the 2000 and 2010 years. Brazilian government provides all the demographic census freely available in the IBGE website. Two kinds of demographic census exist : a long and a short one. "The short form contains general information about the characteristics of the dwelling and each of persons in the dwelling. The long form contains general and more specific information about the characteristics of the dwelling, families, and each of the people in the dwellings. The long form was applied to a 10% sample of the population in municipalities with estimated populations greater than 15,000 and 20% in the remaining municipalities" Ruggles et al. [2003]. What is interesting about these two kinds of census is related to the aggregation level they are available. Indeed, the long one provides micro data but only at municipality level, meaning we cannot disentangle the precise localization of individuals within the municipality. This census is the one mainly exploited in literature. The second one (short census) provide aggregated information at the sector level.

Sectors are administrative boundaries created during the census tracts. It then depends on the realization conditions while collecting the data and on population size.Sectors are created for the realization of the Demographic Census. « Sectors are defined according to the number of households. In the ubran area, each census is composed , in most cases of 250 to 350 households. In the rural area the census sector is composed , for the most part from 150 to 250 households ». It takes the huge advantage that sectors size are far below the municipalities' size . However two main issues also appeared. The first one is about boundaries of sectors would not be the same for the two periods since demographic population has been important during the decades of 2000 to 2010. The second one is due to the aggregation information at sector level.

Table 1: Conservation units per state

State	Area	FP%	SU%	Total Area in %	Total of Protected Area(km2)
Acre	152,581	10.6	23.6	34.2	52,168
Amapá	142,815	33.3	28.8	62.1	88,635
Amazonas	1,570,746	7.8	15.8	23.5	369,788
Maranhão	249,632	5.4	12.0	17.4	43,453
Mato Grosso	903,358	3.2	1.3	4.6	41,242
Pará	1,247,689	10.2	22.1	32.3	403,155
Rondônia	237,576	9.2	12.4	21.6	51,433
Roraima	224,299	4.7	7.3	11.9	26,769
Tocantins	277,621	3.7	8.5	12.3	34,009
Brazilian Amazon	5,006,317	8.0	14.2	22.2	1,110,652

**Official areas of the States according to the IBGE site, in July 2010.*
Source : Veríssimo et al. [2011b]

The state of Amazonas get the greatest area of PA with 369 778 km^2 while Roraima has the smallest area with 26 769 km^2. However if we think in relative term (relative to the total area of each state), the state with the smallest area dedictaed to PA is the Mato-Grosso with only 4.6% of PA implemented in 2010. In the same vein, Amapa is the state with the most area dedicated to PA (62%) relatively to its whole area. Moreover, excepting the Amapa, all the other states create more sustainable area than strictly protected area. This result is related to the fact that sustainable area are more easily promoted by federal for local population since sustainable PA allows for a land use (as soon as it respects biodiversity).

3.1 Compiling the data

3.1.1 Compilation step

1. **First step: Brazilian Amazon and grid:**

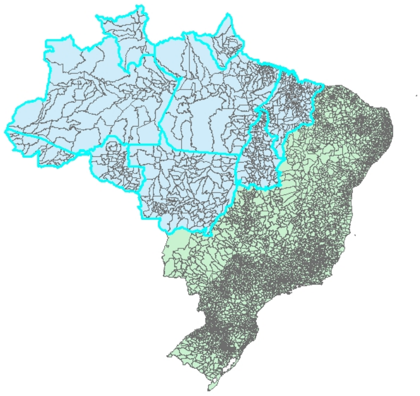

Figure 2: Brazil and Brazilian amazon with municipality boundaries

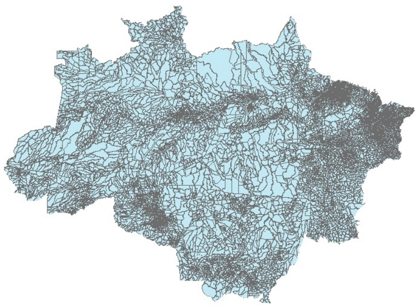

Figure 3: Brazilian Amazon and sectors

First, we show a brazilian map with municipality borders and a map for the brazilian amazon only with sectors borders. We have tried to overlay both sector map for 2000 and 2010 to see whether some rural areas where identical through time. However, all frontiers changed. To deal with this non homogeneity through time, we decided to follow the Tritsch and Le Tourneau [2016] strategy and overlay a grid of 100 km^2.

2. **Second step : Overlay of grid**

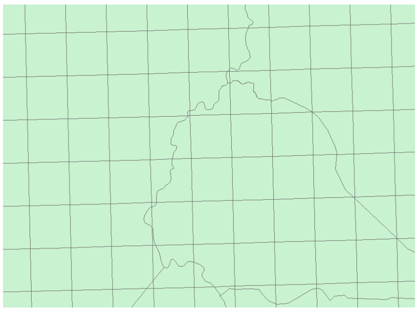

Figure 4: Grid and repartition of population

In order to divide sector population into grid we first compute demographic density per sector. In the following map, we have represented three sectors with the grid layer overlaid. Lets suppose that for the sector one (on the right) the demographic density is 15 individuals per kilometer for the sector two (on the left) there is 6 individuals per kilometer. For full grids, meaning for grids within only one sector, we uniformly divide population. In other words, we multiply categorical variables by demographic density times the area of grids being 100km^2.

3. **Third Step:**

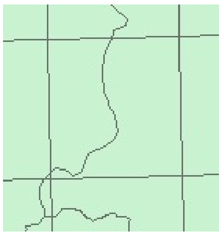

Figure 5: Grid and repartition of population

Here we show how we divide population for intersected grids, meaning grids belonging to two sectors. We actually repeat the same computation as before with adding two results for the sector one and sector two. Let's get an example with the intersected grid below. Let's suppose that this grid contains about 35%, being 35km^2, of its area of the sector one and about 65% (65 km^2) of its area of the sector two. So we multiply categorical variables by demographic density of sector one times 35km^2 plus categorical variables times demographic density of sector two times the area remaining, 65km^2.

3.1.2 Variables description

Social and economics variables

The first data used, the sector demographic census data, comes from the IBGE. IBGE provides as well economic data, meaning individuals variables or dwelling variables as spatial data. Economics data is represented by multiple tables with 3200 variables. All variables are actually more statistics variables aggregated at the sector level. For most of them they are categorical variables accounting for the number of individual per category per sector. These statistics variables ensue from the total number of population per sector. We select around thirty of these statistics variables to compose our data relatively to households assets like individuals living in house, apartment, with water access (etc...). Poverty estimates are computed from these statistics variables. We use the ones related to repartition of population across categorical revenues. We get the number of individuals who have less than one half of the minimum wage, the one who win more than one half and less than one fold the minimum wage and this, until the one with five fold the minimum wage. We finally divide each revenues categorical variables by the total number of population per sector.In our sample, poverty rate looks like to a quantile poverty rate, with the first part of population with a revenue less than one half of the minimum wage being the poorer and the one with more than five fold of the minimum wage being the richer .

With regard to spatial data, it takes the form of a shape file. This shape file describes boundaries of each sector and attributes an identification code to each sector and their partnership to each municipality which allow us to link spatial data to the economic one. However, as said above, sectors do not share the same frontiers through time. We decided to overlay another layer composed of 100 km^2 grids to deal with heterogeneity of frontiers through time. In the next subsection will be describes how economic data was distributed into each grid.

Protected areas

The second kind of data we are using, is a shape file for protected areas. This data is also freely available on the SNUC website. As for the previous shape file, the coordinate system used is the SIRGASS 2000. Using the same coordinate system facilitates the overlay of layers. This data provides the area, the creation date, the responsible administration, and the type of protected area. We eventually have the overall protected area for the span time of 1957 to 2014

Forest Cover

The third data source is related to forest cover and takes raster form. We actually use two different sources to get forest cover for 2000 and 2010 years. For 2000 period, we use the forest cover from Hansen's data. This raster provides pixel information at 5 meters under the WGS 1989 coordinate system. We first increase pixel size to 1 km^2 in order to reduce number of observations and improve the overlay of grid and forest cover. We finally transform the raster into polygon for easing computation of forest cover per grid. We then have the forest cover in square kilometers per grid. For 2010, we use deforestation data from INPE PRODES, which is with pixel size of 200 meters and SIRGASS 2000 coordinate system. We do the same as before concerning the increasing of pixel size to 1 km^2 and polygon shape. We get deforestation (forest loss between 2000 and 2010) in square kilometers in 2010. To get forest cover in 2010 we then make difference in forest cover in 2000 and deforestation cover in 2010.

Rainfall

This data concerns rainfall. We use raster rainfall data from CHIRPS for both years. To get rainfall per grid we use krigging methods. We actually use a linear interpolation from rainfall point to associate it to the closest center point in the grid data. We then obtain the average rainfall per grid. This variable is used as a covariate.

Travel time to cities

This data defines the "accessibility to high-density urban centers at a resolution of 1×1 kilometer for 2015, as measured by travel time" Weiss et al. [2018]. We do the same strategy as rainfall data. We use spatial interpolation in order to estimate the average time distance to each grid. The main benefit of using this data, in spite of the high quality of the raster, is that this data take into account the road, quality of road,topography of place.

Table 2: Data source

Variables	type	Source	year
Individuals' characteristics	Economic	IBGE	2000/2010
Protected area	Shp file	SNUC	2000 to 2010
Deforestation	Raster	INPE-Prodes	2010
Forest cover	Raster	Hansen Geospatial	2000
Rainfall	Raster	CHIRPS	2000/2010
Travel time	Raster		2015

Table 3: Statistic summary

Variables	Mean	St. Dev.	N. of Obs.
Geographic characteristics			
Total area of Protected area (PA)	62.84149	38.91557	728
Area of strictly protected PA	55.56606	39.29103	89
Area of sustainable use PA	64.0485	38.70481	639
Year of creation of PA	2005		728
Grid area	70.57036	34.36935	19598
Forest cover	60.62457	24.99908	19598
Rainfall	2135.131	460.6878	19598
Travel time to cities	397.0301	392.5755	19598
Total number of inhabitants	162.9781	234.5038	19598
Number of poorest ind.	4.140583	10.56556	19598
Number of richest ind.	1.941385	4.412253	19598

4 Differential analysis of protected area on poverty

All of these assumptions have been set up thanks to the previous paper which help us to understand how PA can affect settlement of population. This previous paper was essentially to get the right identification strategy on our data.

4.1 Hypothesis on data

All along of our study we only focus on rural area. So we drop all grids stipulated as "Urban". As long as this analysis, we only focus on rural population and then drop all grid with urban population. The main reason of that is related to the fact the PA are implemented in the aim at reducing deforestation. Forest area is localized only in rural areas around cities. Then, population directly affected by PA implementation is the rural population.
Literature indicates that population in the Brazilian Amazon known a huge increase. However the increase of population was in benefit of the urban one. During the same period, the rural population instead, decreases. However in a previous paper we observe that rural population increases when a PA is implemented. We have two waves of population estimation thanks to Brazilian demographic census for 2000 and 2010 year. Regarding protected area we remind that we have yearly satellite data from 1957 to 2010 for the overall Brazilian amazon.

We drop all grids without population for both years. This hypothesis allows us to get sort of homogeneity in population and to get better accurate for a comparison between controlled grids and treated grids.

4.2 Protected area designation

With regards to the effect of the implementation of a protected areas on population, we need to establish a treated group which is only impacted by the creation of the protected area with no confounding variable. We then need to highlight two point.

The first point is related to the designation process of a protected area. Indeed, a huge strand of literature highlight the ' bias localization ' of PA. This bias is related to the fact that PA are placed far from land of human pressure, meaning where benefits from land are less important **citer article**. In other words, PA tends to be placed in remote areas where deforestation is less likely to happen. To deal with this, we decide to include grids with a PA implemented after 2000. Firstly, the year 2000 has been selected for two reasons. The first but not the least one is due to data availability. The second one is due to historical context of the designation process. Indeed, as said in the section 2, the law 2000 allow a better monitoring and localization of PA. Besides, after several seminars in 1999 to create the SNUC, 900 priority areas has been defined for the country. These priority areas were defined according to their degree of endemic species and the diversity of ecosystems. In other words, if a PA is implemented within a priority area, we can say that this PA would be efficiently localized whatever it takes on population in terms of economics regulation.

The second point we need to care about is related to a confounding variable : distance to cities. We show that population in the Brazilian Amazon tends to be in a rural-urban organization. Most of remote areas remain empty while some non remote area with low density of population (10-50 inhabitants of population per km^2) know a growth of population (Tritsch and Le Tourneau [2016]. We include in our analysis the network time variable from each grid to the closest city. We keep only grid with less than 2000 minutes of transports to go to the closest city.

The number of grids with PA decrease of almost one half (from about 4500 to 2600) but population size remain similar which leads to the idea developed by Letourneau and Tritch in their paper. Beyond a distance threshold, the remote and low densely populated grid keep decreasing while non remote and low densely populated grid gets a 'villagelization' process. Besides, controlling for the distance to cities allow us to also control for the existing bias of PA localization.

4.3 Empirical implementation

We investigate the effect of the implementation of a protected area after 2000 on poverty. We use a difference and difference analysis over the 2000 and 2010 period. We have two waves of population estimation thanks to Brazilian demographic census for 2000 and 2010 year. Regarding protected area we remind that we have yearly satellite data from 1957 to 2010 for the overall Brazilian amazon. To investigate the impact of protected area on poverty, I get several sets of estimates, each focusing on the effect of protected area on various outcomes, like overall population size or population size per class of revenues. I begin by estimating the relationship between the overall protected area on population size. I then consider the impact of protected area on population where population is categorized by class of revenue. The population will be considered in term of absolute value of population but also in relative term depending on the whole population. Finally, I examine more closely the underlying mechanism by focusing on the type of protected area, meaning the effect of sustainable use protected area and the effect of strictly protected area on categories of population.

We address a dummy variable for the treated grid. In other words, grids with a protected area characterized our treated group. The ones without a protected area compose the controlled group and get a 0 assigned.

Our regression take the following form :

$$Y_{ijt} = Treated_{ijt} + Post + [Treatment_{ijt}] + X_{ijt}\beta + \epsilon_{ijt} \tag{1}$$

where Y_{ijt} is population size for grid i in the sector j at time $t = (2000, 2010)$. Treated variable takes the value 1 for the grid i, sector j and time $t = (2000, 2010)$ for grid with a protected area and 0 otherwise. Post is a dummy variable addressing the second wave of the program, meaning 2010 year. Variable $Post$ takes the value 1 if $year = 2010$ and 0 otherwise. $Treatment_{ijt} * Post$ is the interaction term of the difference in difference method. It takes the value 1 when the grid has a protected area implemented in the second wave, 2010, and 0 if in 2010 the grid has not a protected area. We also includes $X_{ijt}\beta$ as covariates variables, like rainfall or forest cover, for time $t = (2000, 2010)$, grid i and sector j.

5 Results

5.1 Decrease of poverty ?

We provide two different specifications per class of revenue whatever the PA implemented. One is in relative[1] term and the second is in absolute term. These two different computations allow us to get deeper explanations of results. Here after, we report the poorest class and the richest one. Previously, in the first part paper, we found that population size increases up to almost 16 inhabitants per grid when a PA is implemented. However these results were only significant when PA implemented is a Sustainable PA.

Now computing the effect of the creation of PA on population by class of revenues allows us to determine which population is going to be affected by this environmental conservation policy. Surprisingly, implementation of protected area decreases the number of poorest individuals. Besides, the poverty rate (relative term) also decreases of about 0.0000962%. Hence in concordance with our poverty variable, the interaction term actually means that the part of individuals living with less than one half of the minimum wage decreases with the creation of protected area. With regard to the last column, accounting for population in the highest class of revenue, interaction term tells us that creation of protected area increases population size in that category. However, the number of individuals increase of about 1,6% when a protected area is implemented. We cannot explicitly explain if the decrease of number of poor individual is related to migration or to a real wealth effect - meaning if poorest are going to become wealthier and then going up to the second category. We think that, to the view of the population settlement pattern described in the previous paper, these results should be interpreted in term of migration. Indeed, literature related to rural population in the Brazilian Amazon stipulates that Rural Brazilian Amazon know a "villagelization process", where poorest or smaller farmers tends to be closer to city while big farmers tends to be beyond the arc of deforestation where lands are "free".

Table 4: Effect of PA on population by class of revenues

	Number of individual (poorest)	**Share of individual (poorest)**	**Number of individual (richest)**	**Share of individual (richest)**
Post period	4.797499***	0205175***	-1.499271***	-.0096328 ***
	(.3953236)	(.0011967)	(.1502754)	(.0007422)
Treated	-1.832342***	-.0018776	-1.499876***	-.0005761
	(.5149157)	(.0016291)	(.272059)	(.0024764)
Treatement	-1.546443**	-.0000962**	1.165226***	.0000776***
	(.6952823)	(.0032772)	(.169309)	(.000011)
State FE	yes	yes	Yes	Yes
Control Variable	yes	yes	Yes	Yes
Number of observations	19606	19606	19606	19606
Cluster	Municipality	Municipality	Municipality	Municipality
Rsquared	0.1301	0.1301	0.1685	0.1682
lla				

Standard error are in parentheses and clusters at municipality level . ***p<0,01, **p<0,05, * p<0,1

We will explore this intuition on migration with the inequality analysis right after the

[1] relative to the whole population

analysis of the implementation of PA per type on population. Indeed, As we say before, sustainable PA has been favored by federal and state, since their is less constraint on economics outcomes for population. Sustainable PA could then be without effect on poorest population and the overall negative effect discussed before could then be dominated by the strictly PA.

5.2 Intensity depends on the objective followed by Protected Area

We now report results of the difference-in-difference by class of revenues and by type of PA.

The implementation of strictly protected area is going to decrease population size of class one by 3,5 inhabitants. For the richest individuals however, we still observe a slight positive effect on population size. To the view of that result but also to the feature of the economic development of the Brazilian Amazon, we suspect that these opposite effects are also related to migration from poorest individual. Indeed,nowadays the lack of property right is well known to be one of the main cause of land inequality also favoring the deforestation. Poorest individuals could then suffered more of the land use constraint, while richest still keep using land. Poorest individual have then no other choice to leave. These explanations are reinforced by the rural-urban linkages largely explained in the literature for small properties. This result suggests that richest individuals can afford to remain. "Although there is still no public survey detailing the land situation in each Conservation Unit, it is known that conflict over this issue is generalized. According to ICMBio, three out of ten hectares of federal Conservation Units in Brazil are private lands, and of the 251 federal Conservation Units required to have their territory public, 188 still contained private properties inside their boundaries" (Veríssimo et al. [2011b]). In other words, richest population, the one which own land within a Strictly PA remains because it is going to keep extracting land or woods. However, pressure on land through settlement of PA, let's individual without any land property right, with no other choice than leaving. Eventually, this effect can also be reinforced by the weak environmental monitoring well known in the Brazilian Amazon (Veríssimo et al. [2011b]).

Table 5: Effect of Strictly and sustainable PA on population by class of revenues

	Number of individual (poorest)	Number of individual (richest)	Number of individual (poorest)	Share of individual (richest)
	Strictly PA		Sustainable PA	
Post period	4.797499***	-1.499271***	4.799958***	-1.500174***
	(.394723)	(.1502836)	(.3948318)	(.1502536)
Treated	-2.216366***	-2.715728***	-2.014342***	-1.300421***
	(1.004322)	(.9572896)	(.5993896)	(.1855572)
Treatement	-3.529379***	1.615133***	-1.245389	1.233711***
	(.7005037)	(.5467191)	(.7886709)	(.1858988)
State FE	yes	yes	Yes	Yes
Control Variable	yes	yes	Yes	Yes
Number of observations	18328	18328	19416	19416
Cluster	Municipality	Municipality	Municipality	Municipality
Rsquared	0.1323	0.1669	0.1302	0.1704

Standard error are in parentheses and clusters at municipality level . ***p<0,01, **p<0,05, * p<0,1

5.3 Inequality

Finally, we would like to estimate the effect of the implementation of a PA on the inequality. Here, we measure inequality as the difference of individuals in the first class of revenues and the last class of revenues, being the same strategy as the difference in quantile. All specifications are highly significatives and slightly positive in the treatment according the overall, the strictly PA and the Sustainable PA. The overall effect being the average of both effect tends to the sustainable treatment coefficients since the number of treated grid with sustainable PA is two third bigger than grids with strictly PA. What we observe is that coefficient associated with the treatment for the strictly PA are higher than for the sustainable PA. In other words, inequality increases much more between class when a strictly PA is implemented. These results corroborate the one previously presented. Indeed, we have seen that poorest individual were not affected by the creation of a sustainable PA (see table 3 above), which leads to the idea that sustainable PA are may be more accepted and more efficient according economics development than the strictly PA.

Table 6: Effect of PA by type on inequality

Variables	**Inequality overall**	**Inequality Strictly PA**	**Inequality Sustainable PA**
Treated group	.0000164	-.0000695	.0000293
	(.0000324)	(.00006)	(-.000033)
Post period	-.0003848***	-.0003847***	-.0003848***
	(.0000282)	(.0000282)	(.0000282)
Treatment	.0001738***	.0003165***	.0001539***
	(.0000481)	(.00005)	(.0000529)
Covariables	Yes	Yes	Yes
State FE	Yes	Yes	Yes
Number of obs	19594	18320	19416
R^2	0.1396	0.1431	0.1400

Standard error are in parentheses and clusters at municipality level . ***p<0,01, **p<0,05, * p<0,1

6 Conclusion

Brazilian Amazon with its about 5 millions of square kilometers, population settlement pattern and deforestation make challenging study of as well geographic as socio economic. The first main contribution of our paper is the building of a unique database relating high spatial resolution and economic data for the overall Brazilian Amazon. We manage a data far under-explored which allow us to answer a research gap about environment development dilemma. Eventually, using a quasi experimental method under panel data, we show that protected area creation impacts differently population according to wage but also according to type of PA. We only deal with strictly and sustainable PA. The first one aims at having a better environmental conservation and the second one combine population and environmental conservation in order to promote economic development. We find that the overall effect of the implementation of PA is differentiated according to the class of revenues. Poorest individuals are going to migrate (decrease of their number) while richest individuals is going to remain within the PA. Besides, the intensity related to PA type on population is also important. We show that strictly protected area have differentiated effect on poorest individual. Strictly PA are going to force poorer individual to migrate while sustainable PA has no effect on poorest individual. On the contrary, richest are equally affected by both type, meaning they remain into the grid when a PA is implemented. These results demonstrate the lack of means that would allows Brazilian Government to perform correct environmental protection. We also pursue our analysis with the PA effect on inequality. Inequality is the most important when a strictly PA is implemented which respect that sustainable PA are less restrictive for population.What should be next is to increase the quality of the data. The use of real micro data both for economic and gegraphic data could allow us to go further in the poverty and inequality definition. Indeed, we have been constraint on the poverty defnition due to lack of reliable and available data for the Brazilian Amazon.

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