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Version of Record: https://www.sciencedirect.com/science/article/pii/S0928765521000622
Manuscript_a91a5fac73a954c89bdefcecf000a999

Revisiting the location bias and additionality of REDD+ projects: the role of project proponents status and certification

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ARTICLE INFO

Keywords:
Additionality
Conservation policy
Deforestation
Impact evaluation
REDD+
Spatial analysis

ABSTRACT

Since the establishment of REDD+, hundreds of projects have emerged around the globe. Much attention has been given to REDD+ projects in the literature, but the conditions under which they are likely to be effective are still not well known. In particular, the location bias concept states that projects are more likely to be implemented in remote areas, where development pressure is low, hence questioning the additionality of these projects. In this article, we examine this concept, assessing how the status of REDD+ project proponents and the project certification influence the choice of location and the project's additionality. Using a sample of six REDD+ projects in Brazil, we show that these two dimensions can impact location choice toward areas with higher or lower opportunity costs and that this choice can impact additionality. We also show that the selection of an areas with low opportunity costs, which is frequently presented as a location bias, does not necessarily preclude additionality.

1. Introduction

REDD+ is an international umbrella encompassing a wide variety of initiatives aimed at compensating developing countries for their participation in the global effort to mitigate climate change through the reduction of deforestation and forest degradation, as well as through the conservation and enhancement of their forest carbon stocks. Although REDD+ was initially proposed as a national mechanism, pilot activities were encouraged during COP 13 in Bali (Pistorius, 2012). As of September 2018, over 400 REDD+ projects were being implemented across the tropics (Simonet, Agrawal, Bénédet, Cromberg, de Perthuis, Haggard, Jansen, Karsenty, Liang, Newton et al., 2018a). Some of these projects are financed through the sale of carbon credits, which are assumed to remunerate project proponents based on project effectiveness.

Effectiveness of REDD+ projects is generally assessed through the concept of additionality, which can be defined as the avoided deforestation attributable to the project (Engel, Pagiola and Wunder, 2008; Wunder, 2015). Additionality is estimated here based on a comparison between the actual deforestation in the area under conservation and a baseline level of deforestation that corresponds to a counter-factual situation without project implementation which is determined using an accepted business-as-usual scenario. If the baseline scenario is accurately estimated, it is possible to compute the additionality of the projects which is the area kept under forest cover, that otherwise (without the project) would have been deforested.

The literature underlines that the effectiveness of conservation instruments, including REDD+ projects, is strongly heterogeneous (Baylis, Honey-Rosés, Börner, Corbera, Ezzine-de Blas, Ferraro, Lapeyre, Persson, Pfaff and Wunder, 2016; Börner, Marinho and Wunder, 2015). On the one hand, a strong body of empirical literature assesses that avoided deforestation projects and other policies are affected by location bias[1] (Joppa and Pfaff, 2009; Pfaff, Robalino, Herrera and Sandoval, 2015; Pfaff and Robalino, 2012; Sims, 2014): they tend to be implemented in remote areas characterized by low development pressures, where forests are not threatened. Such biases generally result in low additionality, as the baseline deforestation is low. On the other hand, in areas where development pressures are too high and monitoring is imperfect, conservation projects may also fail to be additional because of economic pressures. This suggests a complex relationship between opportunity costs and additionality where low additionality can be associated with locations characterized by opportunity costs that are either too low or too high

In the context of REDD+ projects, the choice of location is made by the project proponent. This choice is then likely to be influenced both by its type and its own objectives. First, the vast majority of REDD+ projects is implemented by the private sector, either by not-for-profit organizations such as Non-Governmental Organisations (NGOs) that see

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[1] Some authors use the term location bias as a synonym for the term selection bias used in econometrics to explain why it is difficult to find a relevant counter-factual situation for conservation instruments. Here, we understand the location bias as a bias in the location choice that leads to enroll non-threatened forests in the program, which may reduce their effectiveness.

REDD+ projects as a new source of financing for forest conservation projects; or by for-profit carbon companies that seek to start capital-generating projects focused on carbon[2].

Second, projects may differ in terms of objectives: some of them only focus on forest conservation while others also pursue development objectives. The choice of certification can reflect this diversity. Data provided by Simonet et al. (2018a) indicates that 40 percent of REDD+ projects certified or in the process of certification are using the Verified Carbon Standard (VCS), which is the most commonly used voluntary market standards (Hamrick and Goldstein, 2016). The VCS validates carbon monitoring methodologies proposed by project proponents and strictly focuses on environmental effectiveness. To address buyers' concerns regarding the potential negative impacts of REDD+ projects on biodiversity or the local population, project proponents often combine VCS certification with a certification awarded by the Climate, Community and Biodiversity (CCB) Alliance standard, which focuses on the non-carbon benefits of the project. Therefore, the choice of single carbon (VCS) or double (VCS + CCB) certification can be understood as an indicator of the project proponent's objectives.

In this article, we contribute to the literature in two areas: we first question which factors determine the location choices of REDD+ projects, and second, how those choices influence the project's additionality. For that manner, we distinguish what we call "potential additionality", which can be approximated by a high deforestation baseline or reference level; and "effective additionality", which is the difference between this reference level and actual deforestation. Using an original database, we empirically study the characteristics of six REDD+ projects located in Brazil, and estimate their additionality in the short-run using impact evaluation methodologies as recommended in the literature on forest conservation policy instruments (Miteva, Pattanayak and Ferraro, 2012; Baylis et al., 2016). The six projects studied are heterogeneous in terms of the type of project proponent and the choice of certification schemes. We consider two types of actors: NGOs and private-for-profit organizations, along with the two types of certification standards mentioned above. Our results suggest that the choice of project location and the project additionality are likely to be influenced by both the type of project proponent and the choice of certification scheme. Moreover, we show that proponents who choose to target areas that are structurally threatened by deforestation may fail to achieve additionality, while those who focus less on endangered forests may implement more additional projects.

Section 2 discusses the link between location choices, opportunity costs and additionality in light of existing evidence. Section 3 introduces the methods used in our empirical analysis and Section 4 presents the results. Section 5 concludes and proposes recommendations for the implementation of future REDD+ projects.

2. Location bias and additionality

Fifteen years ago, Ferraro and Pattanayak (2006) published an article pointing out the lack of rigorous impact evaluation of conservation instruments. Since 2006, a vast body of literature has emerged to fill this evidence gap which includes articles focusing on protected areas (Pfaff, Robalino, Sanchez-Azofeifa, Andam and Ferraro, 2009; Sims, 2014), payments for environmental services (PES) (Arriagada, Ferraro, Sills, Pattanayak and S.Cordero-Sancho, 2012; Alix-Garcia, Shapiro and Sims, 2012; Jayachandran, 2013; Chervier and Costedoat, 2017), certification (Blackman, 2013; Tritsch, Le Velly, Mertens, Meyfroidt, Sannier, Makak and Houngbedji, 2020) or REDD+ projects (Simonet, Subervie, Ezzine-de Blas, Cromberg and Duchelle, 2018b) among others. As the literature grows, other authors take stock of existing evidence, highlight current patterns in conservation policy and attempt to understand the theoretical mechanisms leading to additionality. In the early reviews, Miteva et al. (2012) and Samii, Lisiecki, Kulkarni, Paler, Chavis, Snilstveit, Vojtkova and Gallagher (2014) highlighted the inefficiencies of many PES to reduce deforestation.

One of the main factors affecting additionality is not directly related to the design of the instruments but rather to the location of the projects. As later emphasized by Börner, Baylis, Corbera, Ezzine-de Blas, Ferraro, Honey-Rosés, Lapeyre, Persson and Wunder (2016) and Börner, Schulz, Wunder and Pfaff (2020), this inefficiency can be explained by location bias. Conservation policies tend to be located in remote areas (Joppa and Pfaff, 2009) characterized by very low, if not null, opportunity costs. These areas are unlikely to be deforested which explains the low additionality of the programs. However, focusing on areas characterized by high opportunity costs may also lead to low additionality if the development pressures are too high and the monitoring is imperfect (Keles, 2021). In such cases, the efficiency of the funds dedicated to conservation is low because they fail to compensate for the high opportunity costs. In other words, one could make the distinction between potential and effective additionality: potential additionality is greater in areas

[2] Public sector and research institutes represent less than 20 percent of the proponents (Simonet, Karsenty, de Perthuis, Newton and Schaap, 2015).

where opportunity costs are high, but effective additionality may be lower because protection of the forests located in these areas is more difficult to achieve.

Some authors have already highlighted the link between the national REDD+ strategy, the type of REDD+ projects implemented in a country, and the country's position on the forest transition curve (Angelsen and Rudel, 2013; Simonet and Wolfersberger, 2013). Others have shown that the location of REDD+ projects can be explained by the presence of protected areas (Lin, Pattanayak, Sills and Sunderlin, 2012), as well as by the baseline CO2 emissions, the forest carbon stock, the number of threatened species, the quality of governance and the region, with a bias toward Latin America (Cerbu, Swallow and Thompson, 2011).

However, Pirard, Wunder, Duchelle, Puri, Asfaw, Bulusu, Petit and Vedoveto (2019) recently noted that REDD+ projects have received less attention than other conservation instruments in the impact evaluation literature. Under the umbrella of REDD+ projects, a vast heterogeneity of projects can be found, notably in terms of project type, location, proponents and funding sources (Simonet et al., 2015). Given this heterogeneity among projects, it seems crucial when questioning the additionality of REDD+ projects to wonder, not only whether REDD+ projects generate additionality, but also which types of projects do.

Our intuition is that the objectives of project proponents are crucial to understanding the links between location and additionality. As explained by Delacote, Palmer, Bakkegaard and Thorsen (2014), the objectives of the project proponent strongly influence both the way REDD+ projects are implemented and their additionality. For this reason, we explore, using 6 different projects, how the type of project proponents influences the choice of location which in turns impacts the project's additionality.

First, we use certification as an indicator of the proponent's objectives. Indeed, we assume that projects that only certify carbon credits have avoided deforestation as their main objective. In contrast, projects certifying both carbon credits and livelihood credits are expected to give more importance to local development. We can expect that projects with double certification put less effort into forest conservation than projects with only carbon certification, implying smaller additionality. Second, we also consider NGOs vs for-profit organizations. Indeed, it is likely that these two types of organizations implement REDD+ projects in a different manner, and with different objectives, which would tend to influence both their location and additionality. For instance, as we'll demonstrate below, private-for-profit firms are likely to rely more financially on voluntary carbon markets.

3. Data and methods

3.1. Sample of REDD Projects in Brazil

Brazil is a key player in the field of deforestation, with deforestation generating 44 percent of the total greenhouse gases emissions (GHG) of the country (in 2012, according to data from the World Resource Institute) and because of the significant shift observed in its deforestation since 2004. Indeed, the annual deforestation rate in Brazil fell by 70 percent between 2005 and 2013 due to the implementation of command-and-control measures, the expansion of protected areas, and interventions in the soy and beef supply chains, such as the Soy Moratorium established in 2006 (Nepstad, McGrath, Stickler, Alencar, Azevedo, Swette, Bezerra, DiGiano, Shimada, Seroa da Motta, Armijo, Castello, Brando, Hansen, McGrath-Horn, Carvalho and Hess, 2014). In 2009, Brazil received about one billion of USD to implement REDD+ projects, mainly from Norway, through the Amazon Fund. This fund made Brazil the main recipient of REDD+ funding (Silva-Chavez, Schaap and Breitfeller, 2015). However, recent evidence suggests that, because of radical changes in the Brazilian Forest Code, deforestation has drastically increased in recent years (Junior, Pessôa, Carvalho, Reis, Anderson and Aragão, 2021).

Simonet et al. (2018a) have built an international database of REDD+ projects around the world. This database is available online [3] and contains 454 projects located in 56 countries. As of August 2018, the database included information about 59 projects in Brazil, 30 of which are ongoing projects of avoided deforestation (REDD+). However, the vast majority of these projects were not certified. Given the scope of this article and the fact that we approximate objectives through certification choices, we focus on projects that have relied, or will soon rely, on funding from the voluntary carbon markets. Therefore, we choose to focus on projects that have already obtained the VCS and/or CCB certifications.

Moreover, we choose to focus on conservation projects rather than reforestation projects for two reasons. First, it is easier to monitor deforestation than reforestation with the use of satellite images. Second, reforestation projects

[3] http://www.reddprojectsdatabase.org/

Table 1
List of projects

Certification	CCB and VCS	VCS	CCB and VCS
Actors	Private for-profit	Private for-profit	NGO's
Variable	$CCB^{Pri} = 1$	$VCS^{Pri} = 1$	$CCB^{Ngos} = 1$
Number of projects	2	2	2
Expected priority	Development	Avoided deforestation	Development
Size Project 1 (Hectares)	135,105	27,435	248,000
PES-like component Project 1	No	No	Yes
Size Project 2 (Hectares)	94,695	71,714	940,000
PES-like component Project 2	Yes	No	No

are smaller, making georeferencing complicated if not impossible. As a matter, since projects are smaller, the maps contained in the projects documents do not always exhibit shapes that can be easily identified as precise tracts of roads, rivers or administrative boundaries. Moreover, if an approximate location can be identified, without precise scales in the maps, we are unlikely to correctly locate the projects. Note that projects of avoided deforestation, represent around half of REDD+ projects worldwide (Simonet et al., 2015). Eventually, we exclude projects that partially overlap with protected areas in order not to bias the estimates of additionality. A recent article by Simonet et al. (2018b) studies the impact of a REDD+ project in Brazil using similar techniques. Note that this project is not included in our sample but we improve on the author's work by studying six projects and providing explanations for the underlying mechanisms that lead to heterogeneous results.

Table 1 presents our sample composed of 6 REDD+ projects that cover around 1.5 million hectares of forest. Average project size is 216,000 hectares and varies between 71,000 and 940,000 hectares. We hypothesize that the projects that are promoted by private-for-profit organizations tend to rely financially more on the voluntary market and that the potential income from the projects is a stronger objective for these actors than for NGOs. Qualitative evidence collected during the construction of the ID-RECCO database (Simonet et al., 2018a) showed us that NGOs rely only partially on the carbon market. As a matter of fact, most NGOs already existed and relied on other sources of funding before they began selling carbon credits, while many private-for-profit organizations emerged for the sole purpose of selling carbon credits. Our hypothesis is supported by the fact that, according to the database, selling carbon credits appears as an objective of the project in around 50% of the REDD+ projects implemented by private-for-profit organizations, compared to only 36% of those implemented by NGOs. This insight also helps us to link our projects to the proponent's alleged objectives, as shown in Table 1.

The six projects are representative of a sub-sample of Brazilian REDD+ projects that are focused on reducing emissions from deforestation (or REDD+) opposed to projects focused on afforestation/reforestation (or AR) certified by at least one standard of the voluntary carbon market, and not located in a protected area under the governance of federal, regional or indigenous entities according to the database by UNEP-WCMC (2018). For comparison purposes, out of the 57 REDD+ projects identified in Brazil in 2018, 36 were oriented toward REDD versus 21 oriented toward AR; 38 were certified or in the process of certification, the others did not seek to sell carbon credits but rather relied on other funding sources (notably, in Brazil, the Amazon Fund) and only 12 were located in protected areas. Moreover, 14 had a component of direct conditional cash payments (PES-like) and two of these projects are in our sample.[4] Our sample thus shows a small over-representation of projects that include a PES component compared to the whole sample of Brazilian REDD+ projects.

We assume that the objectives of the project proponents are reflected through their choice of certification. Looking at REDD+ projects in Brazil using the ID-RECCO database, development mostly appears as a primary or secondary objective for the projects with double certification while it is a third objective for most projects that only obtained VCS certification. Our sample of projects is composed of three groups, detailed in Table 1. All the projects have obtained VCS certification but only four of them have obtained CCB certification. The two projects that did not obtain CCB certification are implemented by private-for-profit proponents. Two projects are implemented by NGOs and both

[4]Note that the other projects may also include wages for local populations for patrolling or the adoption of alternative activities but no direct payments for conservation.

obtained both CCB and VCS certifications. We assume that the projects with both certifications aim more at providing social benefits and livelihood improvements given that they obtained a premium for development outcomes due to the CCB certification. In contrast, projects only relying on the VCS certification are assumed to focus more on the environmental objective.

3.2. Data

Project proponents seeking VCS certification must submit a Project Design Document (PDD) that describes the methodology used to estimate the emissions reductions or carbon sequestration to be generated by the project. We georeferenced each project using these PDDs. The PDDs include a map of the projects in PDF format that can be projected using GIS software but there are no geographic coordinates. In order to correctly locate each project, we use shape files that map waters, urban areas, protected areas and roads provided on-line by the *Instituto Brasileiro de Geografia e Estatistica* (IBGE), ESRI's Digital Chart of the World, and the shape file of protected areas provided by the International Union for Conservation of Nature (UNEP-WCMC, 2018). We overlap each image extracted from the PDD with some of these geographic features to locate the six projects. Once they are located, we draw the polygons that correspond to each of the six REDD+ projects. The polygons measure, on average, 103% of the project areas declared by the project proponents in the PDDs. This ratio is heterogeneous but for all six projects, the difference between the computed and declared areas is lower than 15%. For this reason, we are confident that we have successfully georeferenced the six REDD+ projects.

In order to build a database, we use a similar procedure as Le Velly, Sauquet and Cortina-Villar (2017), combining conservation policies, gridding and forest cover. We use a gridding of 5 km x 5 km so that each cell measures 2,500 hectares. Given the size of REDD+ projects in Brazil, it seems relevant to consider that the decisions made by project proponents involve large forested areas. Therefore, we choose to build grids of 5km x 5km as it both seems relevant as a unit of decision for the project proponent and allows us to capture heterogeneity within the project boundaries.

We intersect this grid with all of the REDD+ project boundaries. Therefore, each forested cell is either entirely within or outside a REDD+ project. Regarding forest cover and deforestation, we use data provided by PRODES[5]. PRODES is a national program that provides geographic data about deforestation and forest cover in the Legal Amazon between 2000 and 2014, based on LandSat images of 20 to 30 meter resolution. The georeferenced projects all started during this period of analysis which allows us to compute deforestation before and after implementation of the project. This procedure allows us to compute yearly deforestation rates within each cell. We drop cells of less than 1000 hectares as they mainly result from polygons overlapping and may bias our results.

3.3. Analyzing the choice of location

In the first stage of our analysis, we study the choice of a location by project proponents according to the certification and the type of proponents. Note that in this analysis, we do not study if the areas under REDD+ are different from non REDD+ areas but rather if, within a sample of REDD+ areas, there are differences correlated with the type of proponent. In Section 3.1, we define three groups of projects. In order to study the difference in the location choice for each type of REDD+ project, we restrict our sample to the cells included in one of the six projects. We obtain a sample of 566 observations.

In order to study the heterogeneity between the different types of projects, we run two analyses. First, we provide descriptive statistics of our sample of grid cells i in order to study the distribution of a vector X_i of six variables including geographic characteristics that are structural determinants of deforestation (Kaimowitz and Angelsen, 1998; Pfaff, 1999; Robalino and Pfaff, 2013) such as distances to the closest waters, main roads[6] and localities in hundreds of kilometers, as well as slope in percent rise. We also include two measures of deforestation before the implementation of the REDD+ projects. The first is the average yearly deforestation rate between 2006 and the first year of implementation of the project within the cell i. The second variable measures the average yearly deforestation rate for this same period before the implementation of the project in the direct neighboring cells. Details on the sources of the data can be found in Appendix 5.

For all measures of deforestation, we compute the average yearly ex-ante deforestation rates in grid cells i according to the following equation where t is the first year of implementation of the project:

$$Deforestation_i = 1 - (Cover_{i,t-1}/Cover_{i,2006})^{\frac{1}{t-1-2006}} \quad (1)$$

[5]http://www.dpi.inpe.br/prodesdigital/prodes.php
[6]Note that the data we use do not include secondary roads and tracks into the forests.

For each variable in X_i, we provide the median, the minimum and maximum values and the first and last decile. These statistics allow us to analyze the heterogeneity of the grid cells for each type of projects. As a matter of fact, for distances or deforestation measures, the median values may be of lesser interest than the first and last decile, as these measures can allow us to assess if those areas are likely to be deforested.

Second, we run a multinomial logit in order to estimate how each of the variables included in X_i influences the probability that the grid cell i is located within the boundary of a project of a given type as presented in Table 1. Based on the results of our estimation, we derive the marginal effect of each variable at the mean values of other variables.

3.4. Estimating additionality

In the second stage of the analysis, we estimate the additionality of each of the six projects separately. Remember that there are two projects per proponent type. The additionality is here defined as the avoided deforestation that can be directly attributed to the project. It cannot be estimated only by comparing enrolled and non-enrolled areas. As a matter of fact, there are factors, called confounding variables, that influence both deforestation and the enrollment in a REDD+ project, making simple comparisons biased. To estimate the additionality, we rely on impact evaluation methodologies, and more specifically matching methods, in order to estimate the Average Treatment Effect on the Treated (ATT). In line with the literature, we define the areas enrolled in the REDD+ projects as treated areas and build a counterfactual using a control group of non-enrolled areas.

In order to build a relevant counterfactual, we use difference-in-difference (DID) matching (Chabé-Ferret and Subervie, 2013; Chabé-Ferret, 2015). Contrary to simple matching, DID-matching introduces a control on time-unvarying unobservable confounding factors. The objective of this procedure is to select a group of observations that are as similar as possible to the treated areas and only differ regarding the treatment. For each REDD+ project we consider as treated the cells that are located within the polygon of the project area and build a control group of observations that are outside the boundary of a REDD+ project.

We use covariate matching based on the Mahalanobis distance using Abadie and Imbens (2011)'s correction. In order to check the robustness of our results, we display for each project the results of the matching procedure using the three and five nearest neighbors. We use the weights generated by the matching procedure in order to compute the impact of the program on the difference in average yearly deforestation rates before and after the project's implementation. Thus, we examine if deforestation rates decreased or increased more in areas within the boundary of the REDD+ projects using the matched control group as a counterfactual situation. For deforestation rates before the project, we consider the difference between 2006 and the first year of of the project in order to average deforestation rates over three years at least. Our outcome variable is defined as:

$$DID_i = (1 - (Cover_{i,2015}/Cover_{i,t})^{\frac{1}{2015-t}}) - (1 - (Cover_{i,t-1}/Cover_{i,2006})^{\frac{1}{t-1-2006}}) \quad (2)$$

We define our control group as all the cells located within a distance of 15 to 100km around each project. In order to obtain a valid estimation of the impact, the Stable Unit of Treatment Value Assumption (SUTVA) must hold. This hypothesis requires that the outcome of an observation, here deforestation, is only influenced by its own status in terms of the treatment. In our case, it means that the project must not impact deforestation in the control group. For this reason, we consider that the direct buffer of 15km around the projects (approximately the three cells closest to the project) is likely to be influenced by the project through leakage for instance (Alix-Garcia et al., 2012) so we exclude this buffer from our control group. This is similar to Arriagada et al. (2012)'s analysis of Costa Rica's PES in which the areas that were contiguous from the PES farms were excluded from the control group. If we did not exclude the neighboring cells, the SUTVA hypothesis would not hold and the estimation might be biased. However, in order to identify the impact of the projects, the choice of the control and treated groups must also take into account unobservable confounding factors that affect both deforestation and the location of the REDD+ projects. By restricting our control group to the cells that are located no farther than 100km from the REDD+ project, we hope to balance unobservable covariates such as agro-ecological conditions. We also exclude protected areas and/or other REDD+ projects from the control group since they can influence deforestation.

We introduce seven variables into the matching procedure: the six variables from X_i described above and the area forested in 2006 in hundreds of hectares. This procedure allows us to build a relevant control group for each of the six REDD+ projects.

One of the key assumptions of DID-matching is the conditional parallel trend. This assumption states that, once controlled for observable confounding factors through the matching procedure, there are no significant differences between the two groups in terms of deforestation rates before the implementation of the program. In order to test for the validity of our matching procedure, we run placebo tests for each estimation using as an outcome variable the difference in average yearly deforestation rates between 2006 and the beginning of the project compared with average yearly deforestation rates between 2003 and 2005. Here again, we choose 2003 in order to average deforestation rates over three years. Our outcome variable for placebo tests is defined as:

$$DID_i = (1 - (Cover_{i,t}/Cover_{i,2006})^{\frac{1}{t-2006}}) - (1 - (Cover_{i,2005}/Cover_{i,2003})^{\frac{1}{3}}) \quad (3)$$

Therefore, we estimate the impact of the REDD+ projects on the increase of deforestation rates in the few years before their implementation compared to the period between 2003 and 2005. If the conditional parallel trend assumption holds, there should be no statistically significant differences between the treated and control groups after weighting.

4. Results

4.1. Choice of location

Tables 6 to 11 in the Appendix present the descriptive statistics as explained in Section 3.3. Figure 1 also plots the kernel density estimates for each six variables. Kernel densities estimate using a non-parametric method the probability density function of each variable. For all three samples and for each variable, it represents the probability (left-axis) that this variable is equal to a given value (right-axis). However, the distribution of deforestation rates is highly skewed toward zero making difficult the interpretation of panel (d) and (e) in Figure 1.

[INSERT FIGURE 1 ABOUT HERE]

According to these statistics, NGOs and private-for-profit organizations with both VCS and CCB certification seem to focus on more threatened forests than do private-for-profit organizations with single VCS certification. As a matter of fact, looking at Tables 9 and 10, the most threatened forests targeted by the private-for-profit organizations projects with single VCS certification have experienced lower levels of deforestation in the past than the others.

Moreover, according to Table 6 and 7 and panel (a) and (b) in Figure 1, these projects are located further away from roads and urban areas than the projects led by private-for-profit organizations with both certifications. We assumed that the proponents with only one certification would focus more on the environmental objective, carbon, than the other proponents who pursue multiple objectives. Therefore, our results show that the proponents with a lesser social objective and a greater environmental objective tend to be located in areas where deforestation pressures related to development opportunities are lower.

These indications can be interpreted in the light of the location bias frequently identified in the literature. Both private-for-profit organizations with both certifications and NGOs tend to implement projects closer to roads and where deforestation rates are higher. These areas characterized by higher opportunity costs and possibly higher potential additionality. Yet, because of high opportunity costs, effective additionality may be more difficult to achieve because of high economic pressure. In contrast, private-for-profit with only VCS certifications tend to choose locations farther from roads where deforestation rates are lower, which can be interpreted as location bias. Projects take place in areas with lower development pressure and opportunity costs. Our results regarding additionality of the six projects give us some insights regarding how the choice of location can influence the impact of a project.

Results of the multinomial logit are displayed in Table 2. In our estimation, the cells located in a project led by an NGO were used as a baseline category. For each variable, Table 2 displays the marginal effect of a variation equals to one on the probability that a cell is part of one sub-sample or another. For each variable, the sum of the marginal effects is equal to zero because, if following a variation in variable X an observation is more likely to be part of sub-samples 1 or 2, it automatically decreases the probability that it is part of sub-sample 3.

Here, we do not find statistically significant results regarding the location choice made by the project proponents with single VCS certification. This is probably due to the fact that there are fewer grid cells for those projects. However, comparing Column (1) and (3) confirms that the location choices are made differently depending on the type of project proponent. NGOs tend to enroll areas in REDD+ projects where neighboring deforestation is higher. However, these areas are more remote from the roads and waters than the areas enrolled by private-for-profit organizations with double certification.

[INSERT TABLE 2 ABOUT HERE]

Nevertheless, these results should be interpreted cautiously. Despite the high number of cells, our sample is only composed of two projects per proponent type. Therefore, the external validity of our results regarding the location choice according to the proponent type remain questionable and definitive conclusions on this matter cannot be drawn. However, the evidence we provide here by comparing six project proponents with very different incentives and heterogeneous objectives still represents a notable addition to the existing literature.

4.2. Additionality

Tables 3 and 4 display the results regarding the additionality of the projects estimated using the methodology presented in Section 3.4. Remember that there are two projects per proponent type. Each table displays the number of treated observations for each project and the results before and after matching for the impact estimation and placebo tests. As a comparison, using yearly deforestation data from FAO Stat, average yearly deforestation rates in Brazil were around 0.7% between 2003 and 2006, 0.6% between 2007 and 2011 and 0.3% between 2012 and 2015.

We do not find much evidence of additionality for our set of projects. Our results tend to show that only projects implemented by private-for-profit proponents with single VCS certification decrease deforestation. These results remain stable and statistically significant using the three and five nearest neighbors matching for one project and the five nearest neighbors matching for the other. According to our placebo tests, the conditional parallel trend assumption is not always verified but when it is not, the difference between the treated and matched samples remains very small. However, as will be explained below, the results regarding Columns (7) and (8) should be interpreted with caution as the estimates are likely to be biased.

In contrast to our results regarding the additionality of projects implemented by private for-profit proponents with single VCS certification, we do not find any impact for the other projects. Projects with double certification do not appear to reduce deforestation. Our results in Table 4 suggest that the projects implemented by an NGO could even increase deforestation but this impact is very small and only significant in one estimation. These results can be explained by the fact that projects with double certification, because they have livelihood objectives, tend to choose locations in areas with potential livelihood improvement, which makes additionality harder to achieve. Note that the fact that some projects include a PES-like component (see Table 1) does not seem to influence their impact according to our results.

[INSERT TABLES 3 and 4 ABOUT HERE]

In order to test whether the matching procedure succeeded in balancing confounding factors between the treated and control groups, we use balancing tests for each estimation. Results for each matching procedure (Table 12 to 23) are available in the Appendix. Despite some remaining imbalances, the bias has been largely reduced for most estimations, which does not reject the validity of our results, with the notable exception of the second project implemented by a private-for-profit organization with single VCS certification (Columns 7 and 8 in Tables 3 and 4). In particular, one should be cautious about the biases regarding ex-ante deforestation rates highlighted in Tables 15 and 21; these are consistent with the bias identified in the placebo estimates. Therefore, the results regarding this project must be interpreted with a great deal of caution.

Moreover, as a robustness test, we increase the size of the buffer around each project that is excluded from the control group. The results, which are available upon request, do not allow us to reject our findings but, in most cases, we are not able to validate the conditional parallel trend assumption with a larger buffer. This is probably due to the fact that, with a lower number of control observations, the procedure fails to find appropriate matches.

Eventually, since all treated observations are part of the same project, our estimates of standard errors could be biased by a correlation in the unobserved component of the outcome variable (Abadie, Athey, Imbens and Wooldridge, 2017). In order to check for the robustness of our results to this potential bias, we use a pre-matching procedure and cluster standard-errors at the project level in our estimations of additionality. First, for each type of proponent, we run a matching procedure for both projects that are implemented by this type of proponent in order to select a control group for each project. As previously, we use covariate matching based on the Mahalanobis distance using Abadie and Imbens (2011)'s correction with three and five nearest neighbour matching. Second, we merge the samples of treated and matched observations for both projects implemented by the same type of proponent and estimate the impact of the REDD+ projects using Ordinary Least Squares. Our outcome variable is the variation in average yearly deforestation rates as defined in Equation 2 and standard errors are clustered at the project level in these estimates. Results are displayed in Table 24 and 25 in the Appendix. The robustness test does not reject the additionality of the projects implemented by private-for-profit organizations with single VCS certification. Moreover, the results in Table 24 does not reject that the impact of the other two types of projects is very close to zero but this result is not statistically significant in Table 25.

4.3. Discussion

Our results show that the type of proponents influence the location choice of a project. NGOs tend to select locations farther away from roads and water. Similarly, private-for-profit firms with single carbon certification tend to target areas that are less threatened by deforestation. Two kinds of explanations can be made on this result. First, if baseline scenarios are not correctly set, selecting areas with low deforestation may be related to the creation of "hot air" carbon credits (Seyller, Desbureaux, Ongolo, Karsenty, Simonet, Faure and Brimont, 2016) that are not supported by actual additionality. A second explanation, as described in Delacote, LeVelly and Simonet (2021), is that project proponents select areas where forests are less threatened, but may nevertheless achieve additionality, because the implementation of the project is less complicated to implement than in high opportunity costs areas.

In contrast, private-for-profit organizations with double certification select areas nearer roads and waters. According to the location bias concept, one would expect projects led by NGOs and private-for-profit firms with single certification to have lower additionality, and projects led by private-for-profit organizations with double certification to have higher additionality. Yet, our results on additionality differ from that prediction.

Indeed, according to our additionality analysis, none of the projects with double certification (either led by NGOs or private firms) did achieve any avoided deforestation. This result provides evidence that the location bias concept should be considered more carefully in future work: locating a project in areas with higher development pressure does not mean that the project will be more effective in terms of avoided deforestation. In other words, effective additionality does not necessarily correspond to potential additionality.

The only projects for which we find additionality only obtained an environmental certification. Moreover, projects with double certification failed to avoid deforestation, whatever their location choice. This result suggests that environment/development trade-offs are strong, and that projects with double certification are likely to put their emphasis on the development objective, which can be detrimental to avoided deforestation.

Note that our results do not allow to conclude that only private-for-profit organizations can effectively tackle deforestation. For instance, the project studied by Simonet et al. (2018b) was implemented by an NGO and led to a decrease in deforestation rates of about 50%. In this paper, we only focus on six case studies which is a sample statistically too small to draw general conclusions regarding the relative effectiveness of the different types of proponents. Moreover, and perhaps more important, our results do not tell us if, in the long-run, pursuing both objectives can lead to better trade-offs between development and conservation. However, our results do highlight the complex relationship between opportunity costs, efficiency of conservation funds and additionality.

Finally, our results using DID-matching can not reject that the impact of the REDD+ projects is rather small if not null. With the notable exception of Simonet et al. (2018b) that we've already mentioned, this result is in line with other findings using quasi-experimental methods published in the literature. Using a sample of 23 sub-national REDD+ projects in Latin America, Africa or South-East Asia, Bos, Duchelle, Angelsen, Avitabile, De Sy, Herold, Joseph, De Sassi, Sills, Sunderlin et al. (2017) find small impacts of these projects. More recently, West, Börner, Sills and Kontoleon (2020) also finds in the Brazilian Amazon, that once controlled for relevant confounding factors using synthetic control, most of the twelve projects studied display a very low level of additionality which questions the credibility of the crediting baseline. More recently, Chabé-Ferret and Voia (2021) provide an updated meta-analysis of the effectiveness of forest conservation programs. They test for the existence of publication bias and build cost/benefit estimates. They provide evidence of the existence of publication bias: studies that do not find evidence of additionality may experience difficulty in getting published, which artificially increase the estimated impacts. The authors find a relatively low additionality of forest conservation programs, in line with Samii et al. (2014). Finally, they estimate the cost-benefit ratio of forest conservation programs to be below one at current carbon prices.

5. Conclusion

In this article, we empirically study how the type and objectives of project proponents influence the location choice and additionality of the REDD+ projects. Doing so, we revisit the concept of location bias. According to our results, project proponents that rely more on carbon funding tend to target areas with lower opportunity costs. They also tend to be more additional in the short-run, which we explain by the fact that lower opportunity costs are more easily compensated making the projects more efficient. On the contrary, proponents with multiple objectives target areas with higher development pressures and opportunity costs but this focus on areas with higher opportunity costs may come at the expense of additionality.

Our work therefore provides evidence that location biases, often identified in the literature, are not independent of the REDD+ project manager type. Furthermore, the existence of location bias toward areas with lower opportunity costs does not necessarily imply a lack of additionality. By contrast, choosing a location with high opportunity costs may lead to low (if any) levels of additionality.

Our analysis provides innovative empirical evidence regarding the mechanisms that lead to additionality and contributes to filling the evidence gap regarding REDD+ projects (Pirard et al., 2019). We show how the incentives behind the REDD+ mechanism can lead to target areas with lower development potential. Following recent calls by Baylis et al. (2016), among others, we do not question whether REDD+ projects are effective instruments for forest conservation but, instead, how and under what conditions they deliver the expected results. Moreover, given the publication bias identified by Chabé-Ferret and Voia (2021), by studying six projects and reporting non-significant results for four of them, we also participate in increasing the available information regarding the potential effectiveness of conservation instruments. We believe that this focus on the mechanisms is a crucial issue that needs to be tackled by academics in order to improve our understanding of conservation policies.

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Figure 1: Characteristics of the locations according to the types of proponents

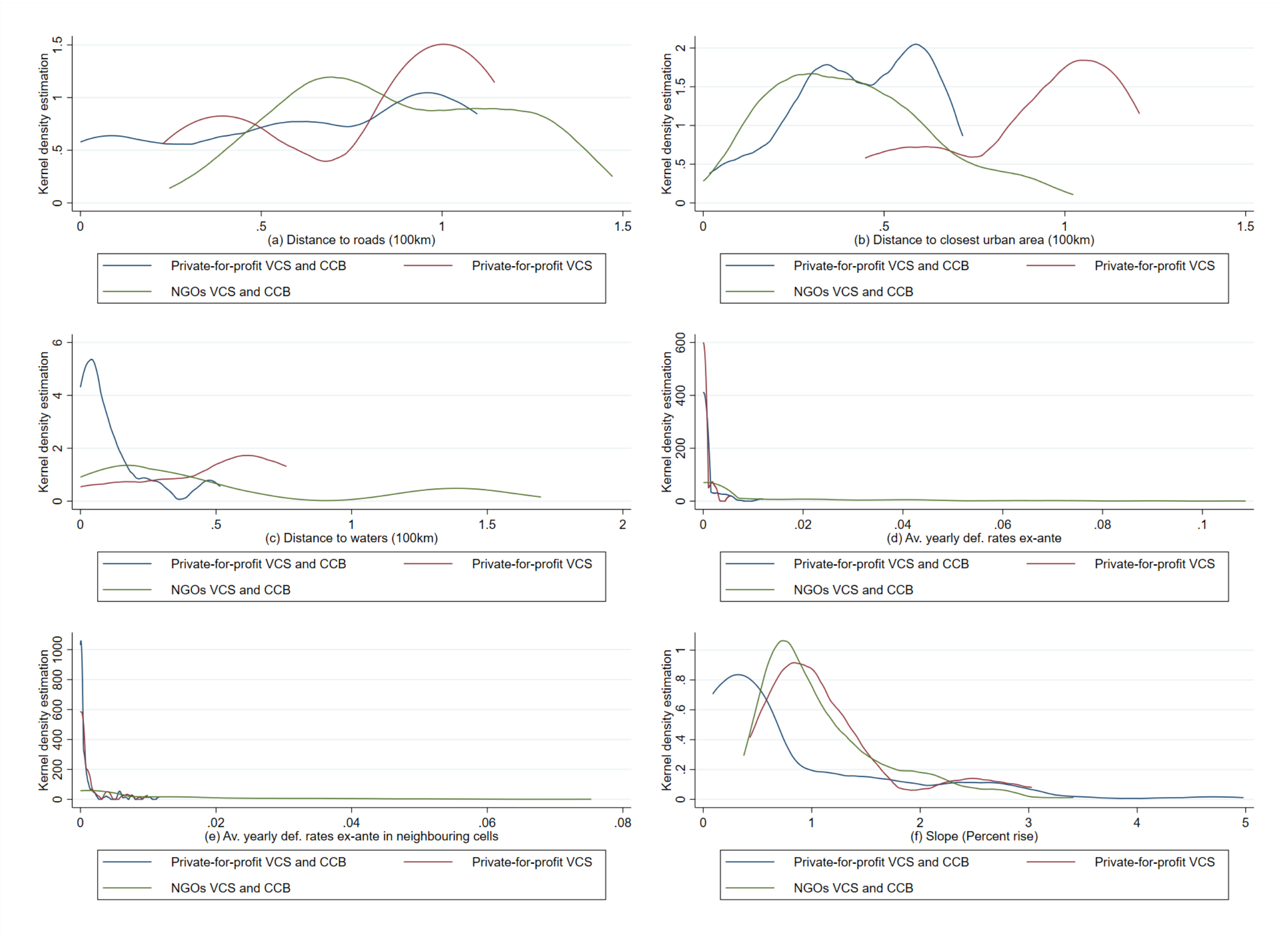

Table 2
Impact of location characteristics on the type of REDD+ proponents (marginal effects)

Proponent type Certification	Private-for-profit VCS + CCB	Private-for-profit VCS	NGO VCS + CCB
Distance to waters	-0.1526***	0.0001	0.1525***
	(0.0541)	(0.0006)	(0.0541)
Distance to roads	-0.1583***	-0.0021	0.1603***
	(0.0590)	(0.0030)	(0.0591)
Distance to closest urban area	-0.0305	0.0083	0.0222
	(0.0340)	(0.0119)	(0.0353)
Slope	-0.0396**	0.0002	0.0394***
	(0.0166)	(0.0004)	(0.0166)
Ex-ante deforestation in	-6.6696***	-0.1081	6.7777***
neighbouring cells	(2.4001)	(0.1861)	(2.4061)
Ex-ante deforestation	-0.5079	-0.1193	0.6272
	(1.7533)	(0.1165)	(1.7570)
Number of observations	566		
Pseudo-R^2	0.4758		

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3
Additionality of the projects using three nearest neighbor matching

	(1)	(2)	(3)	(4)	(5)	(6)
Proponent type	Private-for-profit		Private-for-profit		Private-for-profit	
Certification	VCS + CCB		VCS + CCB		VCS	
Treated observations	72		47		13	
	Unmatched	Matched	Unmatched	Matched	Unmatched	Matched
Treated group	-0.0018	0.0001	**-0.0005**	-0.0005	0.0001	0.0001
Control group	0.0000	-0.0000	**-0.0059**	-0.0011	-0.0070	0.0040
Difference	-0.0019	0.0001	**0.0054****	0.0005	0.0071	-0.0039
Standard-Error	0.0019	0.0003	**0.0023**	0.0005	0.0074	0.0030
p-value	0.321	0.772	**0.022**	0.352	0.341	0.189
Placebo treated group	**0.0004**	0.0005	**-0.0006**	-0.0006	-0.0004	-0.0004
Placebo control group	**0.0064**	0.0006	**0.0078**	0.0005	0.1111	-0.0010
Placebo difference	**-0.0060*****	-0.0001	**-0.0085*****	-0.0012	-0.0115	0.0006
Standard-Error	**0.0020**	0.0002	**0.0024**	0.0007	0.0078	0.0006
p-value	**0.002**	0.534	**0.000**	0.111	0.140	0.291
	(7)	(8)	(9)	(10)	(11)	(12)
Proponent type	Private-for-profit		NGO		NGO	
Certification	VCS		VCS + CCB		VCS + CCB	
Treated observations	24		100		310	
	Unmatched	Matched	Unmatched	Matched	Unmatched	Matched
Treated group	-0.0005	**-0.0005**	**0.0001**	0.0001	-0.0053	-0.0053
Control group	-0.0005	**0.0035**	**-0.0011**	0.0008	-0.0052	-0.0063
Difference	-0.0001	**-0.0040*****	**-0.0013***	-0.0006	-0.0001	0.0010
Standard-Error	0.0031	**0.0015**	**0.0075**	0.0006	0.0012	0.0013
p-value	0.9852	**0.007**	**0.088**	0.259	0.923	0.437
Placebo treated group	-0.0001	**-0.0001**	0.0004	**0.0004**	0.0016	0.0016
Placebo control group	0.0010	**-0.0134**	0.0002	**-0.0009**	0.0013	0.0009
Placebo difference	-0.0009	**0.0133*****	0.0003	**0.0013*****	-0.0003	0.0007
Standard-Error	0.0023	**0.0027**	0.0008	**0.0003**	0.0011	0.0012
p-value	0.652	**0.000**	0.770	**0.000**	0.798	0.536

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4
Additionality of the projects using five nearest neighbour matching

	(1)	(2)	(3)	(4)	(5)	(6)
Proponent type	Private-for-profit		Private-for-profit		Private-for-profit	
Certification	VCS + CCB		VCS + CCB certification		VCS	
Treated observations	72		47		13	
	Unmatched	Matched	Unmatched	Matched	Unmatched	Matched
Treated group	-0.0018	0.0001	-0.0005	-0.0005	0.0001	0.0001
Control group	0.0000	-0.0002	-0.0059	-0.0008	-0.0070	0.0054
Difference	-0.0019	0.0002	0.0054**	0.0003	0.0071	-0.0053**
Standard-Error	0.0019	0.0003	0.0023	0.0006	0.0074	0.0022
p-value	0.321	0.432	0.022	0.661	0.341	0.013
Placebo treated group	0.0004	0.0005	-0.0006	-0.0006	-0.0004	-0.0004
Placebo control group	0.0064	0.0005	0.0078	0.0005	0.1111	-0.0009
Placebo difference	-0.0060***	0.0000	-0..0085***	-0.0012*	-0.0115	0.0005
Standard-Error	0.0020	0.0001	0.0024	0.0007	0.0078	0.0005
p-value	0.002	0.988	0.000	0.089	0.140	0.261
	(7)	(8)	(9)	(10)	(11)	(12)
Proponent type	Private-for-profit		NGO		NGO	
Certification	VCS		VCS + CCB		VCS + CCB	
Treated observations	24		100		310	
	Unmatched	Matched	Unmatched	Matched	Unmatched	Matched
Treated group	-0.0005	-0.0005	0.0001	0.0001	-0.0053	-0.0053
Control group	-0.0005	0.0043	-0.0011	-0.0011	-0.0052	-0.0058
Difference	-0.0001	-0.0047***	-0.0013*	0.0012*	-0.0001	0.0005
Standard-Error	0.0031	0.0014	0.0075	0.0007	0.0012	0.0012
p-value	0.9852	0.000	0.088	0.073	0.923	0.649
Placebo treated group	-0.0001	-0.0001	0.0004	0.0004	0.0016	0.0016
Placebo control group	0.0010	0.0148	0.0002	0.0002	0.0013	0.0010
Placebo difference	-0.0009	0.0147***	0.0003	0.0002	-0.0003	0.0006
Standard-Error	0.0023	0.0029	0.0008	0.0003	0.0011	0.0011
p-value	0.652	0.000	0.770	0.305	0.798	0.594

*** p<0.01, ** p<0.05, * p<0.1

Table 5
Data sources

Variable	Source
Distance to waters (100km)	ESRI - Digital Chart of the World
Distance to roads in 1993 (100km)	ESRI - Digital Chart of the World
Distance to the closest urban area (100km)	IBGE
Slope (Percentage rise)	SRTM
Total deforestation in neighbouring cells before the implementation (100ha)	PRODES
Total deforestation before the implementation (100ha)	PRODES
REDD+ projects	Simonet et al. (2018a)
Federal, regional and indigenous protected areas	UNEP-WCMC (2018)

Table 6
Descriptive statistics: Distance to roads (100km)

	Minimum	1st decile	Median	9th decile	Maximum
Private-for-profit with VCS and CCB certification	0.0000	0.0498	0.5944	1.0531	1.0971
Private-for-profit with single VCS certification	0.2277	0.3639	0.9430	1.0893	1.1454
NGOs with VCS and CCB certification	0.2454	0.4950	0.8449	1.3004	1.4715

Table 7
Descriptive statistics: Distance to closest urban area (100km)

	Minimum	1st decile	Median	9th decile	Maximum
Private-for-profit with VCS and CCB certification	0.0169	0.1277	0.4204	0.6546	0.7180
Private-for-profit with single VCS certification	0.4477	0.5386	0.9953	1.1930	1.2067
NGOs with VCS and CCB certification	0.0000	0.1450	0.3842	0.7254	1.0237

Table 8
Descriptive statistics: Distance to waters (100km)

	Minimum	1st decile	Median	9th decile	Maximum
Private-for-profit with VCS and CCB certification	0.0000	0.0000	0.0626	0.3088	0.5160
Private-for-profit with single VCS certification	0.0000	0.0887	0.5099	0.7103	0.7597
NGOs with VCS and CCB certification	0.0000	0.0139	0.3134	1.4240	1.6984

Table 9
Descriptive statistics: Av. yearly def. rates ex-ante

	Minimum	1st decile	Median	9th decile	Maximum
Private-for-profit with VCS and CCB certification	0.0000	0.0000	0.0000	0.0030	0.0120
Private-for-profit with single VCS certification	0.0000	0.0000	0.0000	0.0021	0.0054
NGOs with VCS and CCB certification	0.0000	0.0000	0.0000	0.0430	0.1087

Table 10
Descriptive statistics: Av. yearly def. rates in neighbouring cells ex-ante

	Minimum	1st decile	Median	9th decile	Maximum
Private-for-profit with VCS and CCB certification	0.0000	0.0000	0.0000	0.0040	0.0116
Private-for-profit with single VCS certification	0.0000	0.0000	0.0000	0.0041	0.0099
NGOs with VCS and CCB certification	0.0000	0.0000	0.0027	0.0354	0.0753

Table 11
Descriptive statistics: Slope (Percent rise)

	Minimum	1st decile	Median	9th decile	Maximum
private-for-profit with VCS and CCB certification	0.087	0.172	0.364	2.458	4.981
private-for-profit with single VCS certification	0.430	0.637	1.008	2.357	3.030
NGOs with VCS and CCB certification	0.373	0.574	0.929	1.990	3.413

Table 12
Balancing test using three nearest neighbour matching: First private-for-profit project with both certification

Variable		Treated	Control	% Biais	%Reduction Bias	t-stat	p-value
Distance to waters (100km)	Unmatched	0.1129	0.4087	-103.3		-7.09	0.000***
	Matched	0.1129	0.1139	-0.4	99.7	-0.04	0.966
Distance to road (100km)	Unmatched	0.8581	10.0629	-26.9		-1.72	0.085*
	Matched	0.8581	0.8002	7.6	71.7	1.83	0.069*
Distance to the closest urban area (100km)	Unmatched	0.5453	0.7144	-43.6		-2.80	0.005***
	Matched	0.5453	0.5222	6.0	86.3	0.94	0.349
Slope (Percent rise)	Unmatched	0.3661	0.9677	-71.5		-4.75	0.000***
	Matched	0.3413	0.3740	-3.9	94.6	-0.77	0.440
Area of the cell	Unmatched	1633.4000	1961.5000	-52.2		-4.56	0.000***
	Matched	1633.4000	1719.0000	-13.6	73.9	-0.85	0.398
Av. yearly def. rates in	Unmatched	0.0006	0.0053	-45.8		-2.98	0.003***
neigbouring cells ex-ante	Matched	0.0005	0.0005	0.4	99.0	0.27	0.788
Av. yearly def. rates ex-ante	Unmatched	0.0006	0.0059	-34.8		-2.20	0.028**
	Matched	0.0006	0.0002	2.2	93.7	1.44	0.152

Table 13
Balancing test using three nearest neighbour matching: Second private-for-profit project with both certification

Variable		Treated	Control	% Biais	%Reduction Bias	t-stat	p-value
Distance to waters (100km)	Unmatched	0.1073	0.4086	-112.4		-5.57	0.000***
	Matched	0.1073	0.1187	-4.2	96.2	-0.68	0.501
Distance to road (100km)	Unmatched	0.2414	10.0631	-107.5		-5.33	0.000***
	Matched	0.2414	0.2793	-5.0	95.4	-0.88	0.381
Distance to the closest urban area (100km)	Unmatched	0.2591	0.7145	-117.3		-5.83	0.000***
	Matched	0.2591	0.2630	-1.0	99.2	-0.17	0.867
Slope (Percent rise)	Unmatched	1.6610	0.9669	61.7		4.12	0.000***
	Matched	1.6610	1.5289	11.7	81.0	0.58	0.566
Area of the cell	Unmatched	1619.6000	1961.4000	-52.0		-3.66	0.000***
	Matched	1619.6000	1623.4000	-0.6	98.9	-0.03	0.977
Av. yearly def. rates in	Unmatched	0.0021	0.0042	-26.3		-1.32	0.186
neigbouring cells ex-ante	Matched	0.0021	0.0019	2.6	90.2	0.32	0.752
Av. yearly def. rates ex-ante	Unmatched	0.0014	0.0046	-30.0		-1.47	0.140
	Matched	0.0014	0.001	3.6	88.0	0.73	0.467

Table 14
Balancing test using three nearest neighbour matching: First private-for-profit project with single VCS certification

Variable		Treated	Control	% Biais	%Reduction Bias	t-stat	p-value
Distance to waters (100km)	Unmatched	0.1903	0.4085	-77.5		-2.12	0.034**
	Matched	0.1903	0.2572	-23.7	69.4	-1.13	0.269
Distance to road (100km)	Unmatched	0.3919	1.0628	-89.6		-2.29	0.022**
	Matched	0.3919	0.3669	3.3	96.3	0.41	0.688
Distance to the closest urban area (100km)	Unmatched	0.6332	0.7143	-20.7		-0.55	0.585
	Matched	0.6332	0.6394	-1.6	92.3	-0.10	0.919
Slope (Percent rise)	Unmatched	1.0783	0.9672	13.3		0.35	0.729
	Matched	1.0783	1.1734	-11.4	14.4	-0.68	0.501
Area of the cell	Unmatched	1509.9000	1961.3000	-73.8		-2.54	0.011**
	Matched	1509.9000	1534.8000	-4.1	94.5	-0.11	0.912
Av. yearly def. rates in	Unmatched	0.0002	0.0053	-49.2		-1.26	0.209
neigbouring cells ex-ante	Matched	0.0002	0.0012	-9.1	81.4	-1.50	0.146
Av. yearly def. rates ex-ante	Unmatched	0.0000	0.0059	-38.8		-0.99	0.323
	Matched	0.0000	0.0004	-3.1	92.0	-1.03	0.314

Table 15
Balancing test using three nearest neighbour matching: Second private-for-profit project with single VCS certification

Variable		Treated	Control	% Bias	%Reduction Bias	t-stat	p-value
Distance to waters (100km)	Unmatched	0.6279	0.4084	80.7		2.90	0.004***
	Matched	0.6279	0.7290	-37.2	53.9	-1.97	0.055*
Distance to road (100km)	Unmatched	1.0036	1.0627	-7.9		-0.27	0.784
	Matched	1.0036	1.3121	-41.2	-421.7	-4.80	0.000***
Distance to the closest urban area (100km)	Unmatched	1.0723	0.7142	93.3		3.27	0.001***
	Matched	1.0723	0.9097	42.4	54.6	2.03	0.048**
Slope (Percent rise)	Unmatched	1.2217	0.9672	25.8		1.08	0.280
	Matched	1.2217	1.2249	-0.3	98.7	-0.01	0.989
Area of the cell	Unmatched	1517.1	1961.3	-70.1		-3.40	0.001***
	Matched	1517.1	1718.6	-31.8	54.6	-1.19	0.239
Av. yearly def. rates in	Unmatched	0.0012	0.0047	-37.8		-1.33	0.184
neigbouring cells ex-ante	Matched	0.0012	0.0049	-39.6	-4.6	-3.09	0.003***
Av. yearly def. rates ex-ante	Unmatched	0.0004	0.0052	-36.8		-1.28	0.201
	Matched	0.0004	0.0069	-50.1	-36.1	-3.26	0.002***

Table 16
Balancing test using three nearest neighbour matching: First NGO project with both certification

Variable		Treated	Control	% Biais	%Reduction Bias	t-stat	p-value
Distance to waters (100km)	Unmatched	1.3900	0.4075	347.9		26.56	0.000***
	Matched	1.3900	1.4088	-6.6	98.1	-0.85	0.395
Distance to road (100km)	Unmatched	0.5535	1.0632	-67.5		-4.82	0.000***
	Matched	0.5535	0.4692	11.2	83.4	3.16	0.002***
Distance to the closest urban area (100km)	Unmatched	0.3721	0.7146	-87.5		-6.39	0.000***
	Matched	0.3721	0.4184	-11.8	86.5	-2.25	0.025**
Slope (Percent rise)	Unmatched	1.3060	0.9669	36.9		2.94	0.003***
	Matched	1.3060	1.3331	-2.9	92.0	-0.31	0.756
Area of the cell	Unmatched	2240.6	1960.9	51.8		4.37	0.000***
	Matched	2240.6	2248.6	-1.5	97.1	-0.13	0.897
Av. yearly def. rates in	Unmatched	0.0005	0.0047	-47.0		-3.33	0.001***
neigbouring cells ex-ante	Matched	0.0005	0.0009	-4.3	90.9	-2.73	0.007***
Av. yearly def. rates ex-ante	Unmatched	0.0006	0.0052	-34.9		-2.49	0.013**
	Matched	0.0006	0.0006	0.5	98.7	0.20	0.838

Table 17
Balancing test using three nearest neighbour matching: Second NGO project with both certification

Variable		Treated	Control	% Biais	%Reduction Bias	t-stat	p-value
Distance to waters (100km)	Unmatched	0.2429	0.409	-56.5		-7.87	0.000***
	Matched	0.2429	0.3066	-21.7	61.6	-3.99	0.000***
Distance to road (100km)	Unmatched	0.9800	1.063	-10.8		-1.38	0.167
	Matched	0.9800	0.9845	-0.6	94.5	-0.18	0.861
Distance to the closest urban area (100km)	Unmatched	0.4226	0.7152	-70.3		-9.60	0.000***
	Matched	0.4226	0.3943	6.8	90.3	1.51	0.132
Slope (Percent rise)	Unmatched	1.0475	0.967	8.9		1.23	0.220
	Matched	1.0475	1.0313	1.8	79.8	0.40	0.693
Area of the cell	Unmatched	1879.5	1961.5	-13.1		-2.25	0.024**
	Matched	1879.5	1875.6	0.6	95.3	0.08	0.936
Av. yearly def. rates in	Unmatched	0.0122	0.0047	55.6		10.43	0.000***
neigbouring cells ex-ante	Matched	0.0122	0.0117	3.7	93.3	0.45	0.654
Av. yearly def. rates ex-ante	Unmatched	0.0134	0.0052	41.9		7.88	0.000***
	Matched	0.0134	0.0126	4.1	90.2	0.49	0.627

Table 18
Balancing test using five nearest neighbour matching: First private-for-profit project with both certification

Variable		Treated	Control	% Biais	%Reduction Bias	t-stat	p-value
Distance to waters (100km)	Unmatched	0.1129	0.4087	-103.3		-7.09	0.000***
	Matched	0.1129	0.1159	-1.0	99.0	-0.12	0.902
Distance to road (100km)	Unmatched	0.8581	1.0629	-26.9		-1.72	0.085*
	Matched	0.8581	0.8005	7.6	71.9	1.80	0.073*
Distance to the closest urban area (100km)	Unmatched	0.5453	0.7144	-43.6		-2.80	0.005***
	Matched	0.5453	0.5257	5.1	88.4	0.78	0.437
Slope (Percent rise)	Unmatched	0.3661	0.9677	-71.5		-4.75	0.000***
	Matched	0.3413	0.3670	-3.1	95.7	-0.62	0.536
Area of the cell	Unmatched	1633.4000	1961.5000	-52.2		-4.56	0.000***
	Matched	1633.4000	1742.4000	-17.3	66.8	-1.08	0.280
Av. yearly def. rates in	Unmatched	0.0006	0.0053	-45.8		-2.98	0.003***
neigbouring cells ex-ante	Matched	0.0005	0.0005	0.9	98.1	0.51	0.608
Av. yearly def. rates ex-ante	Unmatched	0.0006	0.0059	-34.8		-2.20	0.028**
	Matched	0.0006	0.0002	2.1	93.9	1.40	0.163

Table 19
Balancing test using five nearest neighbour matching: Second private-for-profit project with both certification

Variable		Treated	Control	% Biais	%Reduction Bias	t-stat	p-value
Distance to waters (100km)	Unmatched	0.1073	0.4086	-112.4		-5.57	0.000***
	Matched	0.1073	0.1204	-4.9	95.6	-0.76	0.447
Distance to road (100km)	Unmatched	0.2414	1.0631	-107.5		-5.33	0.000***
	Matched	0.2414	0.2881	-6.1	94.3	-1.07	0.287
Distance to the closest urban area (100km)	Unmatched	0.2591	0.7145	-117.3		-5.83	0.000***
	Matched	0.2591	0.2703	-2.9	97.5	-0.48	0.631
Slope (Percent rise)	Unmatched	1.6610	0.9669	61.7		4.12	0.000***
	Matched	1.6610	1.5165	12.8	79.2	0.62	0.540
Area of the cell	Unmatched	1619.6000	1961.4000	-52.0		-3.66	0.000***
	Matched	1619.6000	1625.6000	-0.9	98.2	-0.05	0.964
Av. yearly def. rates in	Unmatched	0.0021	0.0042	-26.3		-1.32	0.186
neigbouring cells ex-ante	Matched	0.0021	0.0017	4.7	82.0	0.61	0.545
Av. yearly def. rates ex-ante	Unmatched	0.0014	0.0046	-30.0		-1.47	0.140
	Matched	0.0014	0.0010	3.7	87.8	0.75	0.453

Table 20
Balancing test using five nearest neighbour matching: First private-for-profit project with single VCS certification

Variable		Treated	Control	% Biais	%Reduction Bias	t-stat	p-value
Distance to waters (100km)	Unmatched	0.1903	0.4085	-77.5		-2.12	0.034**
	Matched	0.1903	0.2351	-15.9	79.5	-0.76	0.456
Distance to road (100km)	Unmatched	0.3919	1.0628	-89.6		-2.29	0.022**
	Matched	0.3919	0.3431	6.5	92.7	0.75	0.461
Distance to the closest urban area (100km)	Unmatched	0.6332	0.7143	-20.7		-0.55	0.585
	Matched	0.6332	0.6286	1.2	94.4	0.08	0.940
Slope (Percent rise)	Unmatched	1.0783	0.9672	13.3		0.35	0.729
	Matched	1.0783	1.0841	-0.7	94.8	-0.04	0.968
Area of the cell	Unmatched	1509.9000	1961.3000	-73.8		-2.54	0.011**
	Matched	1509.9000	1563.1000	-8.7	88.2	-0.24	0.813
Av. yearly def. rates in	Unmatched	0.0002	0.0053	-49.2		-1.26	0.209
neigbouring cells ex-ante	Matched	0.0002	0.0017	-14.5	70.6	-1.70	0.103
Av. yearly def. rates ex-ante	Unmatched	0.0000	0.0059	-38.8		-0.99	0.323
	Matched	0.0000	0.0011	-7.2	81.3	-1.03	0.312

Table 21
Balancing test using five nearest neighbour matching: Second private-for-profit project with single VCS certification

Variable		Treated	Control	% Biais	%Reduction Bias	t-stat	p-value
Distance to waters (100km)	Unmatched	0.6279	0.4084	80.7		2.90	0.004***
	Matched	0.6279	0.7400	-41.2	48.9	-2.22	0.031**
Distance to road (100km)	Unmatched	1.0036	1.0627	-7.9		-0.27	0.784
	Matched	1.0036	1.3554	-47.0	-494.9	-5.14	0.000***
Distance to the closest urban area (100km)	Unmatched	1.0723	0.7142	93.3		3.27	0.001***
	Matched	1.0723	0.8344	62.0	33.6	2.94	0.005***
Slope (Percent rise)	Unmatched	1.2217	0.9672	25.8		1.08	0.280
	Matched	1.2217	1.2469	-2.5	90.1	-0.12	0.908
Area of the cell	Unmatched	1517.1	1961.3	-70.1		-3.40	0.001***
	Matched	1517.1	1689.8	-27.3	61.1	-1.02	0.312
Av. yearly def. rates in	Unmatched	0.0012	0.0047	-37.8		-1.33	0.184
neigbouring cells ex-ante	Matched	0.0012	0.0046	-36.9	2.4	-2.96	0.005***
Av. yearly def. rates ex-ante	Unmatched	0.0004	0.0052	-36.8		-1.28	0.201
	Matched	0.0004	0.0063	-45.7	-24.0	-3.08	0.003***

Table 22
Balancing test using five nearest neighbour matching: First NGO project with both certification

Variable		Treated	Control	% Biais	%Reduction Bias	t-stat	p-value
Distance to waters (100km)	Unmatched	1.3900	0.4075	347.9		26.56	0.000***
	Matched	1.3900	1.4016	-4.1	98.8	-0.51	0.611
Distance to road (100km)	Unmatched	0.5535	1.0632	-67.5		-4.82	0.000***
	Matched	0.5535	0.4786	9.9	85.3	2.74	0.007***
Distance to the closest urban area (100km)	Unmatched	0.3721	0.7146	-87.5		-6.39	0.000***
	Matched	0.3721	0.425	-13.5	84.5	-2.52	0.012**
Slope (Percent rise)	Unmatched	1.3060	0.9669	36.9		2.94	0.003***
	Matched	1.3060	1.3368	-3.4	90.9	-0.35	0.726
Area of the cell	Unmatched	2240.6	1960.9	51.8		4.37	0.000***
	Matched	2240.6	2252.2	-2.2	95.8	-0.19	0.849
Av. yearly def. rates in	Unmatched	0.0005	0.0047	-47.0		-3.33	0.001***
neigbouring cells ex-ante	Matched	0.0005	0.0009	-4.5	90.3	-2.93	0.004***
Av. yearly def. rates ex-ante	Unmatched	0.0006	0.0052	-34.9		-2.49	0.013**
	Matched	0.0006	0.0006	0.1	99.6	0.06	0.951

Table 23
Balancing test using five nearest neighbour matching: Second NGO project with both certification

Variable		Treated	Control	% Biais	%Reduction Bias	t-stat	p-value
Distance to waters (100km)	Unmatched	0.2429	0.409	-56.5		-7.87	0.000***
	Matched	0.2429	0.309	-22.5	60.2	-4.15	0.000***
Distance to road (100km)	Unmatched	0.9800	1.063	-10.8		-1.38	0.167
	Matched	0.9800	0.9908	-1.4	86.9	-0.41	0.682
Distance to the closest urban area (100km)	Unmatched	0.4226	0.7152	-70.3		-9.60	0.000***
	Matched	0.4226	0.3941	6.8	90.3	1.52	0.129
Slope (Percent rise)	Unmatched	1.0475	0.967	8.9		1.23	0.220
	Matched	1.0475	1.041	0.7	92.0	0.16	0.876
Area of the cell	Unmatched	1879.5	1961.5	-13.1		-2.25	0.024**
	Matched	1879.5	1877.4	0.3	97.5	0.04	0.965
Av. yearly def. rates in	Unmatched	0.0122	0.0047	55.6		10.43	0.000***
neigbouring cells ex-ante	Matched	0.0122	0.0115	5.4	90.3	0.65	0.513
Av. yearly def. rates ex-ante	Unmatched	0.0134	0.0052	41.9		7.88	0.000***
	Matched	0.0134	0.012	6.8	83.7	0.82	0.413

Table 24
Additionality of the projects: OLS after pre-matching using three nearest neighbour matching

VARIABLES	(1) Variation in average yearly deforestation rates	(2) Variation average yearly deforestation rates	(3) Variation in average yearly deforestation rates
Priv. for profit with both certif.	0.0005**		
	(0.0001)		
Priv. for profit with single VCS certif.		-0.0056**	
		(0.0013)	
NGOs with both certif.			0.0013*
			(0.0005)
Distance to waters (100km)	-0.0005	-0.0011	0.0010
	(0.0005)	(0.0078)	(0.0018)
Distance to road (100km)	0.0012**	-0.0070	-0.0007
	(0.0004)	(0.0035)	(0.0064)
Distance to the closest urban area (100km)	-0.0016	0.0044	0.0079
	(0.0008)	(0.0040)	(0.0038)
Slope (Percent rise)	-0.0000	0.0006	-0.0003
	(0.0000)	(0.0007)	(0.0014)
Av. yearly def. rates in neigbouring cells ex-ante	0.1566*	0.3114*	0.4386*
	(0.0645)	(0.1323)	(0.1656)
Av. yearly def. rates ex-ante	-0.7882***	-0.3403**	-0.7427***
	(0.0730)	(0.0873)	(0.0435)
Area of the cell	-0.0000	-0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
Constant	0.0005	0.0124	-0.0050
	(0.0007)	(0.0056)	(0.0026)
Observations	274	93	767
R-squared	0.4438	0.0937	0.5795

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 25
Additionality of the projects: OLS after pre-matching using five nearest neighbour matching

VARIABLES	(1) Variation in average yearly deforestation rates	(2) Variation average yearly deforestation rates	(3) Variation in average yearly deforestation rates
Priv. for profit with both certif.	0.0001		
	(0.0002)		
Priv. for profit with single VCS certif.		-0.0032**	
		(0.0009)	
NGOs with both certif.			0.0010
			(0.0007)
Distance to waters (100km)	-0.0030*	-0.0045	0.0014
	(0.0009)	(0.0068)	(0.0015)
Distance to road (100km)	0.0002	-0.0027	0.0004
	(0.0004)	(0.0037)	(0.0051)
Distance to the closest urban area (100km)	0.0006	0.0023	0.0080**
	(0.0010)	(0.0018)	(0.0021)
Slope (Percent rise)	-0.0002**	0.0006**	-0.0007
	(0.0000)	(0.0001)	(0.0012)
Av. yearly def. rates in	0.3367*	0.4863*	0.4071*
neigbouring cells ex-ante	(0.1417)	(0.1534)	(0.1484)
Av. yearly def. rates ex-ante	-0.7102***	-0.2482**	-0.7277***
	(0.0708)	(0.0778)	(0.0312)
Area of the cell	-0.0000**	-0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
Constant	0.0009	0.0083*	-0.0053
	(0.0005)	(0.0033)	(0.0025)
Observations	341	125	888
R-squared	0.2066	0.0696	0.5628

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1