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INSTITUTIONS AND CONSERVATION: THE CASE OF PROTECTED AREAS

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Abstract

We study the link between institutions and the establishment of protected areas for natural resources conservation. Using difference-in-differences we estimate the impacts of democratization on the share of countries' area under protected areas in a panel of 144 countries over 1992-2018. We find that countries that democratized devote higher shares of their land to protected areas, but only in the medium- and long-run. Our preferred estimates indicate that, fifteen years after democratization, the share of the countries' area under PAs increases on average by one percentage point more than what would have been implemented without democratization. We also find evidence that democratization leads countries to implement the different types of protected areas in a non-homogeneous way. Our results are robust to several estimators and treatment definitions, confirming the critical role of institutions for natural resources conservation.

Keywords: Biodiversity; Democracy; Difference-in-Differences; Natural Parks; Natural Reserves.

JEL Codes: P16, Q56, Q57.

1 Introduction

While an increasing literature addresses the links between institutions and the environment, both theoretically (Fredriksson and Svensson, 2003; Harstad and Mideksa, 2017) and empirically (Bohn and Deacon, 2000; Farzin and Bond, 2006; Burgess et al., 2012), the relationship between institutions and the establishment of protected areas (PAs) has received little attention so far (Hu et al., 2020). This constitutes an important issue since PAs cover about 15% of terrestrial surface and are recognized as a key tool for natural resources conservation (Maxwell et al., 2020).

In this paper, we use difference-in-differences to estimate how institutions, proxied by a dichotomous index of democracy, impact the establishment of terrestrial PAs. We unfold two main results related to the size and strictness of established PAs. First, we find that democratizers devote higher shares of land to PAs. Our preferred estimates indicate that, fifteen years after democratization, the share of the countries’ area under PAs increases on average by one percentage point (p.p.) more than what would have been established without democratization. Second, we find that democratizers implement the different types of PAs in a non-homogeneous way. Some democratization events are for example associated to a double of the initial share of the countries’ area under “wilderness areas” (i.e. large natural reserves), one of the most stringent types of PAs. Others have only significant impacts on the least stringent PA types. Crucially, most of those results are only statistically significant eight to twenty years after democratization, suggesting that institutions affect natural resources conservation mainly in the medium- and long-run.

To reach these results, we build a panel dataset of 144 countries over the 1992-2018 period, which covers the establishment of 68% of all terrestrial PAs. Our primary data source is the World Database on Protected Areas (WDPA) that provides exhaustive information on PAs worldwide. We measure institutional quality across countries with a democracy index combining Polity5 and Freedom House scores (Papaioannou and Siourounis, 2008; Acemoglu et al., 2019). We then estimate the treatment effects of first democratization event on the size and strictness of PAs using the DID_l estimator proposed by De Chaisemartin and D’Haultfoeuille (2022a). In addition to be robust to heterogeneous and dynamic treatment effects, the DID_l estimator is particularly adapted to our “unstaggered” setting where countries can switch “in” and “out” democracy. Importantly, we show that our results are robust to alternative estimators, specifications and treatment definitions.

Our analysis contributes to the literature by being the first global-level analysis with an identification strategy that isolates the effect of institutions on PA establishment. Indeed, existing works rely on cross-section regressions (Midlarsky, 1998; Neumayer, 2002; Van, 2003; Wurster,

2013; Kashwan, 2017), where several biases prevent causal identification.¹ By comparison, we are using the latest developments in difference-in-differences literature to ensure unbiased measures of the impacts of institutions on PA establishment. Specifically, we are among the first to apply the De Chaisemartin and D’Haultfoeuille (2022a)’s estimator to an applied research question. Given that our estimates are robust to several empirical choices, we believe that they plausibly represent causal impacts of institutions on PA establishment. Our work is also related to a large literature focusing on PA effectiveness (e.g., Joppa et al., 2008), particularly regarding the role of institutions (Abman, 2018; Bonilla-Mejía and Higuera-Mendieta, 2019). We view our analysis as complementary to those as we focus on establishment rather than effectiveness. Finally, we contribute to the larger literature on institutions and natural resources conservation where policy implementation has been overlooked (Dasgupta and De Cian, 2018).

The paper is structured as follows. Section 2 presents the data and the econometric strategy. Section 3 presents the results. Section 4 concludes.

2 Data and methods

2.1 Data description and definitions

Protected Areas. Denoting by $A_{i,t}$ the area under terrestrial PAs in country i and year t and S_i the country i ’s terrestrial size, we define the outcome of interest as the share of a country’s area under PAs and write it as $a_{i,t} = A_{i,t}/S_i$. We measure $A_{i,t}$ using the WDPA. This database compiles information on all areas that meet the International Union for the Conservation of Nature (IUCN) definition of a PA, that is “a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-run conservation of nature with associated ecosystem services and cultural values” (Dudley, 2008). Fed by PA managers, the WDPA is updated every month to provide the latest overview on active PAs (Bingham et al., 2019).² We use the December 2020 update of the WDPA, which includes 261,004 active PAs. Each observation contains PA localization, establishment date and IUCN classification (within seven categories). This classification categorizes PAs according to their objectives (UNEP-WCMC et al.,

¹One exception may be Fouqueray and Papyrakis (2019) using panel data on marine PAs. However, 93.5% of PAs are terrestrial (UNEP-WCMC et al., 2018).

²The database is available for download at www.protectedplanet.net. Each WDPA update introduces newly designed PAs and removes the recent degazetted sites. These degazetted events could bias our estimates if some of the established PAs after 1992 has been degazetted since. Fortunately, the PADDTracker.org Version 2.0 database (available at <http://paddtracker.org/>) indicates that there have been only 85 degazetted PAs and 104 downsized PAs globally between 1992 and 2018, i.e. less than 0.1% of all established PAs. Degazettements are thus unlikely to threaten our identification strategy.

2018), from “strict natural reserve” (category Ia) to “PA with sustainable use of natural resources” (category VI). The numbered categories indicate decreasingly stringent constraints on human and economic activities. We call $A_{i,j,t}$ the area under PAs of IUCN category j in country i and year t and $a_{i,j,t} = A_{i,j,t}/S_i$ the corresponding share of the country’s area under PAs of IUCN category j .

Institutions. Our treatment variable is an indicator measuring democracy. Following the literature (e.g. Acemoglu et al., 2019), we create a dichotomous variable integrating the Revised Combined Polity Score (*Polity2*) from the Polity5 project (Marshall and Gurr, 2020) with the Freedom House’s score (Repucci, 2020). The former is a widely used index ranging countries from extreme autocracy (-10) to perfect democracy (+10). It offers the advantage of a yearly categorical variable, available over long time-periods for almost all countries worldwide. The latter categorizes countries in “not free”, “partially free” and “free”. Specifically, we define a country i in year t as a democracy if Freedom House designates i as “free” or “partially free” and Polity5 assigns a *Polity2* score $p_{i,t}$ above $\bar{p} = k$. The choice of \bar{p} is not straightforward. Some authors choose $\bar{p} = 0$ (e.g. Acemoglu et al., 2019), while others test greater thresholds (e.g. Papaioannou and Siourounis, 2008; Caselli and Tesei, 2016). Rather than choosing between these alternatives, we systematically define country i as a democracy in year t ($D_{i,t}^k = 1$) if $p_{i,t} \geq k$, with $k \in \{0, 2, 4, 6, 8\}$. We code the country as $D_{i,t}^k = 0$ otherwise. We thus consider five levels of treatment D^k in our study ($k \in \{0, 2, 4, 6, 8\}$), $D_{i,t}^k$ being its dichotomous measure for each country-year unit. These measures allow us to test whether the impact of democratization on PA establishment depends on the countries’ democratization level.

Panel construction. Both the WDPA and Polity5 database start in 1800 and cover a large – though different – set of countries. Freedom House’s score is however only available since 1973. Also, countries and institutions have largely changed since the USSR dissolution. To focus on the contemporary global institutional landscape, we restrict our panel to the 1992-2018 period. About 68% of active terrestrial PAs have been set in this period (see Figure ?? in Appendix). Aggregating information at the country level, we obtain a panel of 144 countries over 27 years. We add measures of countries’ land area (km²) and GDP per capita (2017 constant \$US) from World Development Indicators database (World Bank, 2020).

Summary statistics. Table 1 provides some summary statistics of our panel. The area under PAs is 60,511.5 km² per country on average over 1992-2018. In 2018, PAs covered 13.1% of countries’ terrestrial area (8.3% in 1992). Figure A2 in Appendix shows the location of PAs worldwide at

these dates. PAs increased everywhere, including in the Southern hemisphere where the bulk of the remaining primary forests is located. Table 1 further indicates that the most common PAs are National Parks (IUCN category II), which occupy about 31.6% of all PAs. The least frequent PAs are “natural monuments” (IUCN category III), which occupy 1.5% of all PAs.

Table 1: Summary statistics (N=3,662)

VARIABLES	MEAN	S.D.	MIN	MAX
Cumulative terrestrial area under PAs (km^2)	60,511.5	154,028.4	0.3	1,250,856.4
IUCN category Ia (km^2)	4,532.7	23,543.6	0.0	228,033.2
IUCN category Ib (km^2)	6,270.0	39,229.8	0.0	390,237.9
IUCN category II (km^2)	15,763.8	40,806.5	0.0	353,470.2
IUCN category III (km^2)	1,088.3	6,148.5	0.0	63,656.46
IUCN category IV (km^2)	11,390.6	51,846.9	0.0	426,102.2
IUCN category V (km^2)	6,008.3	25,308.0	0.0	251,233.0
IUCN category VI (km^2)	12,451.8	47,755.7	0.0	365,396.5
Non-attributed IUCN category (km^2)	3,005.8	9,604.1	0.0	105,982.4
Additional area under PAs per year (km^2)	438.0	1,643.0	0.0	32,014.2
Country terrestrial size (km^2)	832,572.2	2,083,846.0	670.3	16,389,950.1
Revised Combined Polity Score (<i>Polity2</i>)	3.6	6.4	-10.0	10.0
GDP per capita (1,000 constant 2017\$)	12.1	17.9	0.2	112.0

Regarding institutions, Table 1 indicates that the average *Polity2* score is 3.6 over 1992-2018, underlying that most countries are democracies. Precisely, the average *Polity2* score increased from 2.2 in 1992 to 4.2 in 2018, with a peak at 4.4 in 2015. Appendix B provides elements on the diversity of democratization events in our panel for each treatment definition D^k ($k \in \{0, 2, 4, 6, 8\}$). Specifically, Figure A3 shows the *Polity2* score in 1992 and 2018 across countries, suggesting that democratizations mostly occurred in Africa. Table A1 indicates the number of democratizations and reversals per decade. It shows that, in our panel, there have been on average about two democratizations per year for treatments D^0 to D^6 but only one D^8 democratization per year. It also indicates that democratizations have been more frequent in the nineties. Table A2 displays the number of countries switching respectively to democracies and non-democracies according to treatment definitions. It indicates that about 25% of the countries experienced democratization during the 1992-2018 period (except for treatment D^8), and that about 17% of the countries experienced democracy reversals. These “back and forth” events between democracy and non-democracy result in a complex “unstaggered” setting where the “control” and “treated” groups change over time. We explain in the following how we exploit these differential switches “in” and “out” democracy across countries over time to assess the impacts of institutions on PA establishment.

2.2 Econometric strategy

To estimate the impacts of institutions on PA establishment, we rely on a difference-in-differences strategy exploiting differential changes in countries’ democratic status (the dichotomous treatment variable $D_{i,t}^k$) and their share of area under PAs (the outcome variable $a_{i,t}$) across countries. We consider two alternative estimation strategies to proceed.

Two-way fixed effects. A first strategy is to compare the share of the countries’ area under PAs of democratic and non-democratic countries using OLS with two-way fixed effects (TWFE) to control for country-specific and year-specific shocks. The typical TWFE specification to estimate is:

$$a_{i,t} = \alpha^k D_{i,t}^k + \gamma_i + \lambda_t + \epsilon_{i,t} \quad (1)$$

where $a_{i,t}$ is the share of country i ’s area under PAs in year t , $D_{i,t}^k$ is the dichotomous measure of democratic status, α^k is the impact per unit of treatment D^k on the share of countries’ area under PAs, γ_i and λ_t are country and year fixed effects respectively and $\epsilon_{i,t}$ is the remaining error term.

The TWFE estimate $\hat{\alpha}^k$ has been interpreted for long as the average treatment effect (ATE) of a positive value of the dichotomous treatment variable on the outcome variable. While this interpretation is accurate in a simple setting with two groups (control and treated groups) and two periods (pre- and post-treatment periods),³ its validity in more complex designs involving multiple groups and periods is questioned by the recent literature on difference-in-differences (see De Chaisemartin and D’Haultfoeuille, 2022b, for a recent survey). This literature shows that, to interpret $\hat{\alpha}^k$ as an ATE, the setting needs to verify both (i) common trends between control and treated countries and (ii) constant treatment effects across countries and periods (De Chaisemartin and D’Haultfoeuille, 2020; Goodman-Bacon, 2021).⁴ While the former has good chances to be valid

³This interpretation of TWFE estimates is valid since the two groups would have evolved in parallel without the treatment, i.e. under the verification of the “parallel trends” assumption.

⁴There are two main possible source of heterogeneity in the treatment effects: across countries and across periods. Regarding the former, equation (1) implicitly assumes that the treatment effects are identical across countries within a similar group (control or treated). However, this assumption is problematic as the control group in equation (1) includes both the never- and always-treated countries. De Chaisemartin and D’Haultfoeuille (2020) show that, given TWFE estimates are weighted sums of treatment effects in each country-year unit, some outcome variable changes can be attributed negative weights for always-treated countries. In case of heterogeneous treatment effects, negative weights lead to biased TWFE estimates (De Chaisemartin and D’Haultfoeuille, 2020).

Regarding the latter, equation (1) assumes that countries’ potential outcomes only depend on their contemporaneous treatment, not on their past treatments (Goodman-Bacon, 2021). The shape of the impacts of the treatment can be very heterogeneous over time yet: cumulative, concentrated in the years following the first treatment change or, instead, appearing after a sufficiently long period. They can even be positive in the short run but negative in the long run (or *vice versa*). The usual solution to estimate such dynamic effects in a TWFE setting is to add lagged

(and can be formally tested), the latter has been often considered as implausible (Goodman-Bacon, 2021; De Chaisemartin and D’Haultfoeuille, 2022a,b). For this reason, we only estimate equation (1) using OLS in robustness checks (for the five treatment definitions D^k with $k \in \{0, 2, 4, 6, 8\}$) and prefer alternative difference-in-differences estimators for our main analyses.

Difference-in-differences. Given the limits of TWFE to recover treatment effects in complex settings, a second strategy to estimate the impacts of institutions on PA establishment is to turn towards difference-in-differences estimation procedures that are robust to heterogeneous treatment effects. The recent difference-in-differences literature proposes several estimators that are robust to such effects in a multi-period setting (Callaway and Sant’Anna, 2021; Goodman-Bacon, 2021; Sun and Abraham, 2021; De Chaisemartin and D’Haultfoeuille, 2022a). Most of these estimators are however only valid in the context of staggered designs, where the countries received the treatment once and for all (De Chaisemartin and D’Haultfoeuille, 2022b). Only the De Chaisemartin and D’Haultfoeuille (2022a)’s DID_t estimator is robust to heterogeneous treatment effects when the design is not staggered. Given our complex setting (see Appendix B), we adopt this approach.

Specifically, we aim to measure the dynamic treatment effects of turning in democracy for the first time in year t ($D_{i,t-1}^k = 0$ and $D_{i,t}^k = 1$) on the share of countries’ area under PAs over time $a_{i,t+s}$. We note $\beta^{k,s}$ the average treatment effects on the treated (ATT) of a first democratization on PA establishment s years after this event. The idea of De Chaisemartin and D’Haultfoeuille (2022a) to obtain $\hat{\beta}^{k,s}$ is to estimate separately the dynamic treatment effects for countries switching “in” and for those switching “out” of treatment for each couple $t \times s$ (year of first switch \times period after first switch) and to aggregate them afterwards. In the first step, De Chaisemartin and D’Haultfoeuille (2022a) define a difference-in-differences estimator comparing the evolution of the potential outcomes between $t - 1$ and $t + s$ in (i) countries switching of treatment for the first time in t (the “switchers”) and (ii) in countries remaining untreated until t (the control groups, including the “never-treated” and “not-yet-switchers”). Under validity of the common trends assumption,⁵ De Chaisemartin and D’Haultfoeuille (2022a) note that this estimator is an unbiased measure of the effect of the first treatment switch s periods after it took place in t . In the second step, De Chaisemartin and D’Haultfoeuille (2022a) aggregate these estimators into single coefficients

treatment values (e.g. Acemoglu et al., 2019). In this specification, the coefficient of the contemporaneous treatment is interpreted as the “instantaneous” effect, while the coefficients of the lagged treatments are interpreted as the “dynamic” effects (De Chaisemartin and D’Haultfoeuille, 2022a). However, Sun and Abraham (2021) showed that this specification leads to biased estimates as each period estimate gets contaminated by effects from other periods.

⁵De Chaisemartin and D’Haultfoeuille (2022a) propose a procedure to test the parallel trends assumption, relying on the computation of pre-treatment estimates and their joint comparison between switchers and non-switchers before the switchers switch.

$\beta^{k,s}$ by weighting them according to the number of switchers and non-switchers in each couple $t \times s$, multiplying by minus one the estimators associated to switchers “out”. De Chaisemartin and D’Haultfoeuille (2022a) show that $\hat{\beta}^{k,s}$ is unbiasedly measured since at least some countries are never treated and others are always treated (as in our case, see Appendix B).⁶

In addition to estimate dynamic treatment effects, De Chaisemartin and D’Haultfoeuille (2022a) propose an additional estimation procedure that provides weights to aggregate all the previous $\beta^{k,s}$ into a single coefficient β^k reflecting the average “total effect” per unit of treatment. Given that the “total effect” refers to the sum of all the instantaneous and dynamic treatment effects, the interpretation of $\hat{\beta}^k$ is a close approximation to the usual interpretation of $\hat{\alpha}^k$. More crucially, $\hat{\beta}^k$ is robust to dynamic and heterogeneous effects. In the following we estimate the $\beta^{k,s}$ and β^k for the five treatment definitions D^k ($k \in \{0, 2, 4, 6, 8\}$).

3 Results

3.1 Size effects

This section presents our results on the impacts of democratization on the share of the country’s area under PAs. We first detail the results for the median treatment D^4 – our preferred analysis – before showing the results with the other treatments and alternative estimators.

Preferred analysis. Figure 1 presents the estimates $\hat{\beta}^{4,s}$ for $s = -13, -12, \dots, 19, 20$ using the DID_t estimator of De Chaisemartin and D’Haultfoeuille (2022a). The solid black line depicts the ATT over time. The black and grey dashed lines plot respectively the 90% and 95% confidence intervals, which are obtained using 100 bootstrap samples with clusters at the country level. The estimates in Figure 1 call for several comments.

First, none of the estimates from $t - 13$ to $t - 1$ shows a statistically significant difference between the treated and non-treated countries. This suggests that there is no differential trend in PA establishment before democratization and that, by consequence, the parallel trends assumption holds. This is confirmed by the result of the joint significance test that all the thirteen pre-treatment estimates are null ($p = 0.831$).

Second, we do not identify any significant impact of the treatment D^4 in the short-run. Indeed, the estimates remain close to zero until four years. While the estimates indicate that democratization starts to positively affect PA establishment after four years, they remain non-significantly

⁶We determine the number of pre- and post-treatment periods accordingly (13 and 20 respectively).

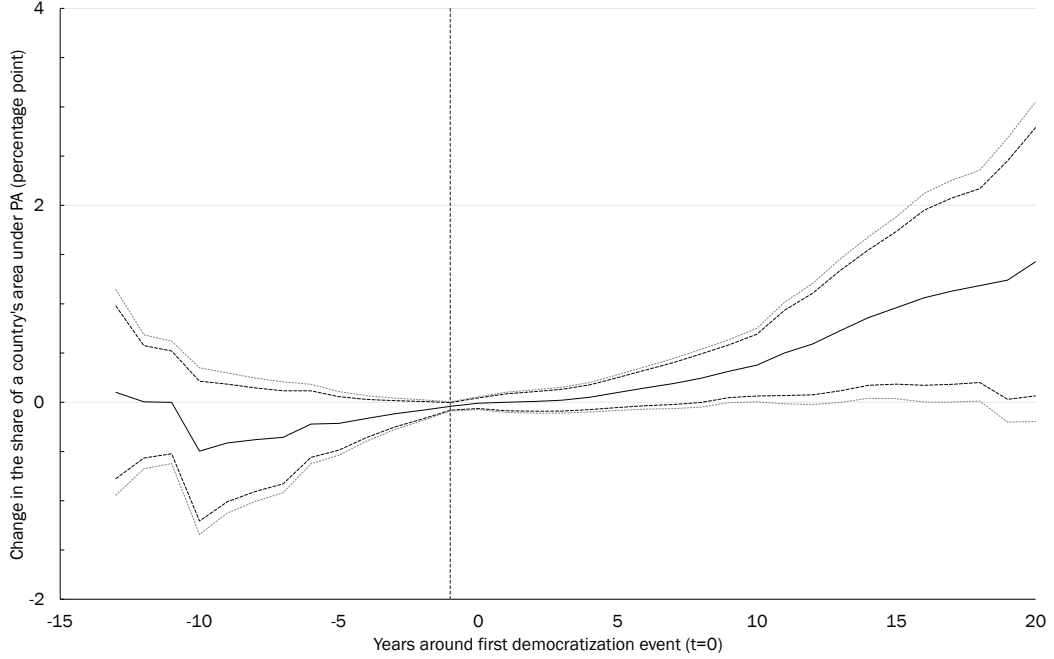


Figure 1: Estimates of the effects of democratization on the share of the country’s area under PAs. This figure plots the dynamic treatment effects of the first observed democratization event on the share of the country’s area under PAs (in percentage point). Democracy is defined as a country coded as “free” or “partially free” in Freedom House with a *Polity2* score greater than 4 in *Polity5*. The x-axis represents the time (in years) relative to the year of first switch ($t = 0$). The vertical dashed line represent the last year before the first switch ($t = -1$). The solid black line plots the ATT using the De Chaisemartin and D’Haultfoeuille (2022a)’s DID_t estimator, which is robust to heterogeneous treatment effects. The black and grey dashed lines represent respectively the 90 and 95 percent confidence interval, obtained by a cluster bootstrapping procedure of 100 random sampling with replacement. The p-value of the joint significance test for the pre-treatment estimates is 0.831, which fails to reject the null hypothesis of no pre-treatment trends.

different from zero at the 10% level. It is only eight years after democratization that democratizers allocate additional 0.3 p.p. of land to PAs compared to what they would have allocated without democratization (significant at the 10% level). Since the share of countries’ area under PAs before democratization is on average 11.0 p.p. among the treated countries, the increase of 0.3 p.p. corresponds to an increase by 3% *relatively to the pre-treatment period*. The positive impacts of democratization on PA establishment become even greater afterwards. Indeed, Figure 1 indicates that, fifteen years after democratization, democratizers implement on average 1.0 p.p. more PAs than what they would have implemented without democratization (significant at the 5% level). The impact of democratization on PA establishment increases up to 1.5 p.p. after twenty years (significant at the 10% level).

The long-run nature of the relationship between democratization and PA establishment is not surprising. Indeed, the creation of new PAs itself might take years between the identification phase

to the actual establishment. For example, the establishment of the Masoala National Park (Madagascar) took seven years between the identification of the area of interest in 1990, the beginning of the design study in 1993 and its official gazettelement in 1997 (Kremen et al., 1999). Moreover, such a long-term process is likely to be exacerbated by the turmoil that often characterizes institutional changes. For example, Madagascar officially democratized in 1991 after socialist regime’s dissolution. In 2003, twelve years after democratization, the Malagasy government committed to triple the area under PAs in the country by 2008 (Gardner et al., 2018). Similar long-term patterns have been identified in the 1980s in Portugal and Guatemala, where the establishment of first PAs took place five to ten years after the first elections (Sundberg, 2003; Pinto and Partidário, 2012).

Democratization score. The impacts of democratization on PA establishment may depend on its definition. Table 2 displays the dynamic treatment effects obtained with the DID_i estimator for the five treatment definitions and aggregated on successive periods of five years.

Table 2: Estimates of the dynamic treatment effects of first democratization event on the share of the countries’ area under PAs depending on the threshold on *Polity2* score

	AVERAGE EFFECTS FROM							Joint test for Parallel trends Assumption
	-13 to -10 Years (1)	-9 to -5 Years (2)	-4 to 0 Years (3)	1 to 5 Years (4)	6 to 10 Years (5)	11 to 15 Years (6)	16 to 20 Years (7)	
	A. TREATMENT D^0 (“FREE” OR “PARTIALLY FREE” AND $Polity2 \geq 0$)							
Avg. Effect on share of PAs	-0.176 (0.447)	-0.427 ** (0.206)	-0.097 (0.069)	0.354 (0.226)	0.734 ** (0.391)	1.018 ** (0.479)	0.978 ** (0.480)	Valid [$p=0.554$]
	B. TREATMENT D^2 (“FREE” OR “PARTIALLY FREE” AND $Polity2 \geq 2$)							
Avg. Effect on share of PAs	-0.196 (0.469)	-0.471 ** (0.225)	-0.111 (0.074)	0.364 (0.222)	0.731 * (0.412)	1.000 ** (0.510)	0.806 * (0.488)	Valid [$p=0.350$]
	C. TREATMENT D^4 (“FREE” OR “PARTIALLY FREE” AND $Polity2 \geq 4$)							
Avg. Effect on share of PAs	-0.098 (0.407)	-0.317 (0.268)	-0.083 (0.062)	0.036 (0.070)	0.255 * (0.149)	0.728 ** (0.367)	1.209 * (0.655)	Valid [$p=0.831$]
	D. TREATMENT D^6 (“FREE” OR “PARTIALLY FREE” AND $Polity2 \geq 6$)							
Avg. Effect on share of PAs	-0.465 (0.404)	-0.285 (0.172)	-0.042 (0.055)	0.025 (0.082)	0.102 (0.194)	0.270 (0.484)	0.809 (1.055)	Valid [$p=0.746$]
	E. TREATMENT D^8 (“FREE” OR “PARTIALLY FREE” AND $Polity2 \geq 8$)							
Avg. Effect on share of PAs	0.016 (0.786)	-0.205 (0.269)	-0.061 (0.054)	0.196 ** (0.082)	0.598 *** (0.280)	1.071 ** (0.510)	1.794 * (0.971)	Valid [$p=0.789$]

NOTE. This table indicates estimates of the effect of a democratization on the share of the country’s area under PAs over 5-years time horizons, indicated in the column labels. Democracy is defined as a country coded as “free” or “partially free” in Freedom House with a *Polity2* score greater than k ($k \in \{0, 2, 4, 6, 8\}$) in *Polity5*. We report estimates of the ATT using the De Chaisemartin and D’Haultfoeuille (2022a)’s DID_i estimator. Below each estimate we report standard errors (clustered at the country level) obtained via bootstrapping. *, **, *** indicate a p-value lower than 0.1, 0.05 and 0.01 respectively. We report the p-value of the join significance tests on the pre-treatment estimates between hooks.

The estimates confirm overall our main results.⁷ Indeed, none of the estimates obtained with the different treatments indicates that democracies significantly reduce PAs in the short- or long-run. Rather, these estimates confirm that democratizers increase by about 1.0 p.p the area under PAs fifteen years after democratization (significantly non-null at the 5% level for all treatments except D^6). The long-run effects are only robust at the 10% level (except for D^6). Moreover, Table 2 suggests an interesting pattern regarding the effects of democratization as the treatment definition becomes stricter. From D^0 to D^8 , we find that the long-run impacts are more pronounced over time. The effects at twenty years are for example two times larger for D^8 than D^0 . We also find that the significant positive impacts of democratization appear earlier in time as the democratization level threshold increases. While significant positive effects only appear after six, seven and eight years for treatments D^0 , D^2 and D^4 ,⁸ they become instantaneously positive for D^8 ($\hat{\beta}^{8,0} = 0.059$, with an estimated S.D. of 0.020).

TWFE vs. Difference-in-Differences. As a first – naive – robustness check, we turn to the TWFE estimation of α^k in equation (1) with OLS for the five treatments D^k ($k \in \{0, 2, 4, 6, 8\}$) and compare them with the estimated total effect β^k obtained with the DID_l estimator. Table A3 in Appendix presents the obtained estimates. These estimates call for several comments. First, the TWFE estimates are imprecisely measured. Only $\hat{\alpha}^8$ is significantly positive at the 10% risk level. By comparison, only $\hat{\beta}^6$ is imprecisely estimated with the DID_l estimator. Second, the TWFE estimates are very unstable across treatments, ranging from -0.485 to 2.115. By comparison, the DID_l estimates are very stable, ranging from 0.362 to 0.780 (and even 0.588 to 0.780 if we only account for the significant estimates). The imprecise and unstable nature of the TWFE estimates is explained by the presence of numerous negative weights for the five treatments (Table A3). While the single significantly non-null TWFE estimate $\hat{\alpha}^8$ is positive (and would confirm our main result), the presence of negative weights call for its cautious interpretation as negative weights are likely to lead to biased estimates (De Chaisemartin and D’Haultfoeuille, 2020).

Additional robustness checks. To further test the robustness of our results, we estimate the impact of democratization using alternative difference-in-differences estimators. Specifically, we follow the doubly robust estimation procedure proposed in Acemoglu et al. (2019) to estimate the

⁷Despite some pre-treatment estimates are significantly non-null in treatments D^0 and D^2 (see column (2) in Table 2), the joint significance tests proposed in De Chaisemartin and D’Haultfoeuille (2022a) fail to reject the null hypothesis of no pre-treatment trends for all the five treatments D^k ($k \in \{0, 2, 4, 6, 8\}$). This suggests the validity of the parallel trends assumption and the unbiased estimation of the $\hat{\beta}^{k,s}$.

⁸These heterogeneous impacts between treatments do not appear in Table 2 as average treatment effects are aggregated over time horizons of five years.

treatment effects of first democratizations (taking place in t) on the share of the countries’ area under PAs in $t + s$ ($s = -13, \dots, 20$).⁹

The doubly robust estimation procedure only compares information on democratizers (switchers “in”) with information on not-yet and never treated countries. The doubly robust estimator thus do not fully exploit the complex “unstaggered” setting of our panel and, by consequence, the obtained estimates cannot be quantitatively compared to the DID_l estimates. The doubly robust estimator has however the advantage to allow the inclusion of time-invariant covariates (Acemoglu et al., 2019), which the DID_l estimator cannot (De Chaisemartin and D’Haultfoeuille, 2022a). Such additional information is particularly useful to control for unobserved heterogeneity. Specifically, a possible omitted variable that could affect our estimates is the level of economic development as it may be correlated to both institutions (Acemoglu et al., 2019) and PAs (Van, 2003). For the five levels of treatments D^k ($k \in \{0, 2, 4, 6, 8\}$), we use the doubly robust estimator to estimate the dynamic treatment effects of democratization on the share of treated countries’ area under PAs for two models: one including only the lagged outcome variable $a_{i,t-1}$ and year fixed effects (in the spirit of Acemoglu et al., 2019), the other additionally including the lagged GDP per capita (i.e. *before* the country democratized).¹⁰

Tables A4 and A5 in Appendix present the estimated ATT for these two models. We find qualitatively similar results to our preferred analysis. Indeed, none of the doubly robust estimates obtained with the different treatments indicates that democratizers significantly reduce PAs in the short- or long-run. The two set of estimates show a similar picture to those in Table 2 using the DID_l estimator: greater democratization events are associated with both earlier appearance of significant positive effects and larger long-run effects.¹¹ In particular, the positive impacts of

⁹As explained in Acemoglu et al. (2019), such a semi-parametric approach uses additional covariates to build a doubly robust estimator that combines (i) linear estimates of the potential outcomes of the democratizers (in the spirit of a regression adjustment approach à la Kline, 2011) *reweighted* by (ii) the scores obtained from a probit model explaining the likelihood to democratize (in the spirit of a propensity score reweighting approach à la Angrist et al., 2018). The procedure then measures the effect of a first democratization in t on PA establishment in $t + s$ as the difference between (i) the evolution of the reweighted estimated potential outcomes of democratizers between t and $t + s$ and (ii) the evolution of the potential outcomes for the not-yet and never treated countries on a similar period. The doubly robust estimator has the advantage to be consistent if either the regression adjustment or propensity score reweighting approaches is valid (Imbens and Wooldridge, 2009). As the doubly robust estimation procedure is independently implemented for each s ($s = -13, \dots, 20$), the obtained estimates are robust to heterogeneous effects.

¹⁰Indeed, the contemporaneous GDP per capita cannot be used directly to condition our estimations as it presents “bad control” properties that could bias the estimation of the dynamic treatment effects.

¹¹The magnitude of the impacts are larger in Tables A4 and A5 than those identified in Table 2. This is not surprising as the doubly robust estimation procedure presented in Acemoglu et al. (2019) does not exploit the diversity of democratizations. It only exploits information related to first democratization events, ignoring additional information from democratization reversals (and information from countries that remained always in democracy).

democratization on PA establishment are conserved even after controlling for the countries' level of development (Table A5).¹²

3.2 Strictness effects

In addition to the estimation of the impacts of democratization on the share of the country's area under PAs, we also seek to identify potential democratization effects on the types of established PAs (i.e. the different IUCN categories). We thus estimate the impacts of a first democratization D^k ($k \in \{0, 2, 4, 6, 8\}$) occurring in t on the share of the countries' area under PAs in category IUCN j ($a_{i,j,t}$ (with $j \in \{\text{Ia, Ib, II, III, IV, V, VI}\}$) using the DID _{l} estimator. Table 3 reports the estimated total effect when the joint significance test on pre-treatment estimates supports the common trends assumption, as well as the average shares of PAs under different IUCN categories the year before the countries democratized ($a_{i,j,t-1}$).

Table 3 shows that no democratization is associated with any decrease in PAs of a particular IUCN category. When precisely estimated, the total effects rather indicate positive impacts of democratization on the shares of PAs under the different IUCN categories. As for the size effects, all these effects grow over time with the largest effects in the long run (see Table A6 in Appendix for an illustration of the dynamic treatment effects for treatment D^0).

The effects of similar democratizations are however different for the different IUCN categories (Table 3). For example, the average total effects of an additional unit of treatment D^0 ranges from 0.011 for the IUCN III category ("Natural monument or feature") to 0.073 for the IUCN V category ("Protected Landscape"). However, the initial shares of PAs under the different categories were different before democratization. When reported to the initial shares, the highest total effect of democratization D^0 actually relates to IUCN category Ib ("Wilderness Area"), one of the strictest category of PAs.¹³ The smallest impacts relate to the IUCN category II ("Natural Parks"). Interestingly, the positive impacts on the strictest PAs disappear for stricter democratization definitions. On the contrary, the largest impacts – both in absolute and relative terms – for D^8 relates to IUCN category VI ("PA with sustainable use of natural resources"), which represents the least stringent PAs.

¹²The additional condition on the development level actually removes some pre-trends between treated and non-treated countries, improving the validity of the conditional parallel trends assumption.

¹³IUCN defines PAs of category Ib as an "area generally larger and protected in a slightly less stringent manner than that of strict nature reserves".

Table 3: Estimates of the average total effect of democratization on the share of the countries' area under PAs of different IUCN categories depending on the threshold on *Polity2* score

	AVERAGE TOTAL EFFECT FOR						
	IUCN Ia (1)	IUCN Ib (2)	IUCN II (3)	IUCN III (4)	IUCN IV (5)	IUCN V (6)	IUCN VI (7)
	A. TREATMENT D^0 ("FREE" OR "PARTIALLY FREE" AND $Polity2 \geq 0$)						
Avg. Effect on share of PAs	0.013 ** (0.006)	0.024 ** (0.010)	0.072 * (0.042)	0.011 ** (0.005)	0.037 * (0.022)	0.073 ** (0.037)	0.047 * (0.024)
	B. TREATMENT D^2 ("FREE" OR "PARTIALLY FREE" AND $Polity2 \geq 2$)						
Avg. Effect on share of PAs	0.020 ** (0.009)	0.021 ** (0.009)	0.064 (0.040)	0.010 ** (0.004)	-	0.062 (0.044)	0.053 ** (0.025)
	C. TREATMENT D^4 ("FREE" OR "PARTIALLY FREE" AND $Polity2 \geq 4$)						
Avg. Effect on share of PAs	0.013 (0.010)	0.031 (0.022)	0.069 (0.052)	0.005 (0.010)	-0.057 (0.041)	0.097 (0.059)	0.027 (0.033)
	D. TREATMENT D^6 ("FREE" OR "PARTIALLY FREE" AND $Polity2 \geq 6$)						
Avg. Effect on share of PAs	0.018 (0.018)	0.019 (0.029)	0.022 (0.056)	-	-	0.019 (0.048)	-
	E. TREATMENT D^8 ("FREE" OR "PARTIALLY FREE" AND $Polity2 \geq 8$)						
Avg. Effect on share of PAs	-	0.017 (0.010)	-	0.020 ** (0.010)	0.060 (0.038)	0.070 (0.044)	0.052 * (0.030)
	AVERAGE INITIAL SHARE FOR						
	IUCN Ia	IUCN Ib	IUCN II	IUCN III	IUCN IV	IUCN V	IUCN VI
First switch "in" D^0	0.342	0.019	3.059	0.249	1.467	0.179	1.701
First switch "in" D^2	0.390	0.017	2.827	0.248	1.342	0.188	1.460
First switch "in" D^4	0.533	0.310	2.886	0.278	1.375	0.179	1.386
First switch "in" D^6	0.531	0.617	2.952	0.124	1.732	0.103	0.613
First switch "in" D^8	0.417	0.674	1.991	0.282	0.905	0.136	0.649

NOTE. The first part of the table indicates estimates of the total effect of a democratization on the share of the country's area under PA of different IUCN categories, indicated in the column labels. Democracy is defined as a country coded as "free" or "partially free" in Freedom House with a *Polity2* score greater than k ($k \in \{0, 2, 4, 6, 8\}$) in *Polity5*. We report average total estimates of the ATT using the De Chaisemartin and D'Haultfoeuille (2022a)'s DID_t average estimator. Below each estimate we report standard errors (clustered at the country level) obtained via bootstrapping. * and ** indicate a p-value lower than 0.1 and 0.05 respectively. The reported estimates are those for which the joint significance test fails to reject the null hypothesis of no-pre-treatment trends. The symbol "-" indicates the rejection of the parallel trends assumption. The second part of the table indicates the initial share of PAs in the different IUCN categories before countries switch for the first time the treatment D^k ($k \in \{0, 2, 4, 6, 8\}$).

4 Conclusion

In this paper, we investigate how institutions affect natural resources conservation by looking at terrestrial PA establishment. For this purpose, we built a panel dataset over 27 years and 144 countries (covering 68% of active terrestrial PAs) and exploited the occurrence of democratization events across countries to run difference-in-differences analyses with estimators that are robust to

heterogeneous and dynamic treatment effects. We identified two main results. First, we found that democratizers allocate significantly larger share of their land area to PAs. Second, we found that democratizers implement the different types of PAs in a non-homogeneous way. Importantly, these effects mainly appear in the medium- and long-run, i.e. eight to twenty years after democratization. These results are consistent with historical examples worldwide. Eventually, we also found that higher democratization scores are associated to (i) earlier positive impacts of institutions on PA establishment over time, (ii) larger long-run impacts but (iii) slightly less stringent established PAs.

Because these results are robust to several estimators, specifications and treatment definitions, we believe that they represent plausibly causal impacts of institutions, as measured by democratization, on PA establishment. The question of the mechanisms that conduct democracies to implement larger and more stringent PAs was left out of our analysis. There could be several reasons that explain such changes, such as elections' outcomes, the presence of NGOs in a country or the signature of bilateral or international agreement (Groom et al., 2022). We believe that the identification of the role of these underlying mechanisms constitutes an interesting avenue to pursue in future research.

References

- Abman, R. (2018). Rule of law and avoided deforestation from protected areas. *Ecological Economics*, 146:282–289. 1
- Acemoglu, D., Naidu, S., Restrepo, P., and Robinson, J. A. (2019). Democracy does cause growth. *Journal of Political Economy*, 127(1):47–100. 1, 2.1, 4, 3.1, 9, 11, D, A4, A5
- Angrist, J. D., Jordà, Ò., and Kuersteiner, G. M. (2018). Semiparametric estimates of monetary policy effects: string theory revisited. *Journal of Business & Economic Statistics*, 36(3):371–387. 9
- Bingham, H. C., Bignoli, D. J., Lewis, E., MacSharry, B., Burgess, N. D., Visconti, P., Deguignet, M., Misrachi, M., Walpole, M., Stewart, J. L., et al. (2019). Sixty years of tracking conservation progress using the world database on protected areas. *Nature ecology & evolution*, 3(5):737–743. 2.1
- Bohn, H. and Deacon, R. T. (2000). Ownership risk, investment, and the use of natural resources. *American Economic Review*, 90(3):526–549. 1
- Bonilla-Mejía, L. and Higuera-Mendieta, I. (2019). Protected areas under weak institutions: Evidence from colombia. *World Development*, 122:585–596. 1
- Burgess, R., Hansen, M., Olken, B. A., Potapov, P., and Sieber, S. (2012). The political economy of deforestation in the tropics. *The Quarterly journal of economics*, 127(4):1707–1754. 1
- Callaway, B. and Sant’Anna, P. H. (2021). Difference-in-differences with multiple time periods. *Journal of Econometrics*, 225(2):200–230. 2.2
- Caselli, F. and Tesei, A. (2016). Resource windfalls, political regimes, and political stability. *Review of Economics and Statistics*, 98(3):573–590. 2.1
- Dasgupta, S. and De Cian, E. (2018). The influence of institutions, governance, and public opinion on the environment: Synthesized findings from applied econometrics studies. *Energy Research & Social Science*, 43:77–95. 1
- De Chaisemartin, C. and D’Haultfoeuille, X. (2020). Two-way fixed effects estimators with heterogeneous treatment effects. *American Economic Review*, 110(9):2964–96. 2.2, 4, 3.1, A3

- De Chaisemartin, C. and D’Haultfoeuille, X. (2022a). Difference-in-differences estimators of intertemporal treatment effects. Technical report, National Bureau of Economic Research. 1, 2.2, 4, 5, 3.1, 1, 2, 7, 3.1, 3, A6
- De Chaisemartin, C. and D’Haultfoeuille, X. (2022b). Two-way fixed effects and differences-in-differences with heterogeneous treatment effects: a survey. *The Econometrics Journal*, Forthcoming. 2.2
- Dudley, N. (2008). *Guidelines for applying protected area management categories*. Iucn. 2.1
- Farzin, Y. H. and Bond, C. A. (2006). Democracy and environmental quality. *Journal of Development Economics*, 81(1):213–235. 1
- Fouqueray, M. and Papyrakis, E. (2019). An empirical analysis of the cross-national determinants of marine protected areas. *Marine Policy*, 99:87–93. 1
- Fredriksson, P. G. and Svensson, J. (2003). Political instability, corruption and policy formation: the case of environmental policy. *Journal of Public Economics*, 87(7):1383–1405. 1
- Gardner, C. J., Nicoll, M. E., Birkinshaw, C., Harris, A., Lewis, R. E., Rakotomalala, D., and Ratsifandrihamanana, A. N. (2018). The rapid expansion of madagascar’s protected area system. *Biological Conservation*, 220:29–36. 3.1
- Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, 225(2):254–277. 2.2, 4
- Groom, B., Palmer, C., and Sileci, L. (2022). Carbon emissions reductions from indonesia’s moratorium on forest concessions are cost-effective yet contribute little to paris pledges. *Proceedings of the National Academy of Sciences*, 119(5). 4
- Harstad, B. and Mideksa, T. K. (2017). Conservation contracts and political regimes. *The Review of Economic Studies*, 84(4):1708–1734. 1
- Hu, H., Chen, D., Chang, C.-P., and Chu, Y. (2020). The political economy of environmental consequences: A review of the empirical literature. *Journal of Economic Surveys*. 1
- Imbens, G. W. and Wooldridge, J. M. (2009). Recent developments in the econometrics of program evaluation. *Journal of economic literature*, 47(1):5–86. 9

- Joppa, L. N., Loarie, S. R., and Pimm, S. L. (2008). On the protection of protected areas. *Proceedings of the National Academy of Sciences*, 105(18):6673–6678. 1
- Kashwan, P. (2017). Inequality, democracy, and the environment: A cross-national analysis. *Ecological Economics*, 131:139–151. 1
- Kline, P. (2011). Oaxaca-blinder as a reweighting estimator. *American Economic Review*, 101(3):532–37. 9
- Kremen, C., Razafimahatratra, V., Guillery, R. P., Rakotomalala, J., Weiss, A., and Ratsisompatarivo, J.-S. (1999). Designing the masoala national park in madagascar based on biological and socioeconomic data. *Conservation Biology*, 13(5):1055–1068. 3.1
- Marshall, M. G. and Gurr, T. R. (2020). Polity 5: Political regime characteristics and transitions, 1800-2018. *Center for Systemic Peace*. 2.1
- Maxwell, S. L., Cazalis, V., Dudley, N., Hoffmann, M., Rodrigues, A. S., Stolton, S., Visconti, P., Woodley, S., Kingston, N., Lewis, E., Maron, M., Strassburg, B. B. N., Wenger, A., Jonas, H. D., Venter, O., and Watson, J. E. (2020). Area-based conservation in the twenty-first century. *Nature*, 586(7828):217–227. 1
- Midlarsky, M. I. (1998). Democracy and the environment: an empirical assessment. *Journal of Peace Research*, 35(3):341–361. 1
- Neumayer, E. (2002). Do democracies exhibit stronger international environmental commitment? a cross-country analysis. *Journal of Peace Research*, 39(2):139–164. 1
- Papaioannou, E. and Siourounis, G. (2008). Democratisation and growth. *The Economic Journal*, 118(532):1520–1551. 1, 2.1
- Pinto, B. and Partidário, M. (2012). The history of the establishment and management philosophies of the portuguese protected areas: combining written records and oral history. *Environmental management*, 49(4):788–801. 3.1
- Repucci, S. (2020). Freedom in the world 2020. Technical report, Freedom House. 2.1
- Sun, L. and Abraham, S. (2021). Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. *Journal of Econometrics*, 225(2):175–199. 2.2, 4

- Sundberg, J. (2003). Conservation and democratization: constituting citizenship in the maya biosphere reserve, guatemala. *Political Geography*, 22(7):715–740. 3.1
- UNEP-WCMC, IUCN, and NGS (2018). Protected planet report 2018. Technical report, UNEP-WCMC, IUCN and NGS: Cambridge UK; Gland, Switzerland; and Washington, D.C., USA. 2.1, 1
- Van, P. N. (2003). A semiparametric analysis of determinants of a protected area. *Applied Economics Letters*, 10(10):661–665. 1, 3.1
- World Bank, T. (2020). World development indicators 2019. Technical report, Washington, D.C.: The World Bank. 2.1
- Wurster, S. (2013). Comparing ecological sustainability in autocracies and democracies. *Contemporary Politics*, 19(1):76–93. 1

Appendices

A Protected Areas over time worldwide

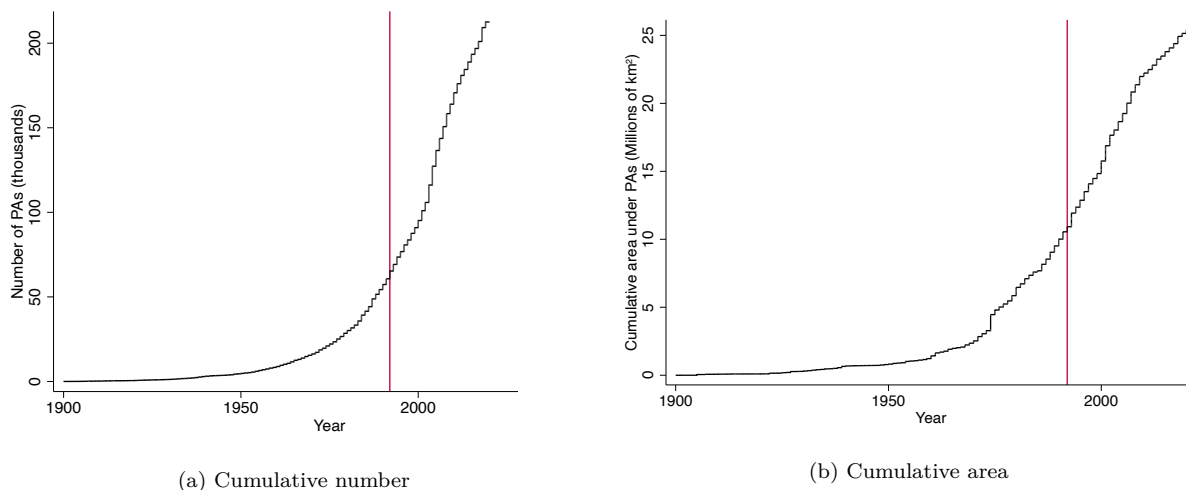


Figure A1: Cumulative number and area under protected areas in time worldwide (Source: WDPA and authors' computations). The black lines indicate the evolution of the number and cumulative area under PAs from 1900 to 2018. The vertical red lines indicate the beginning of our panel, in 1992.

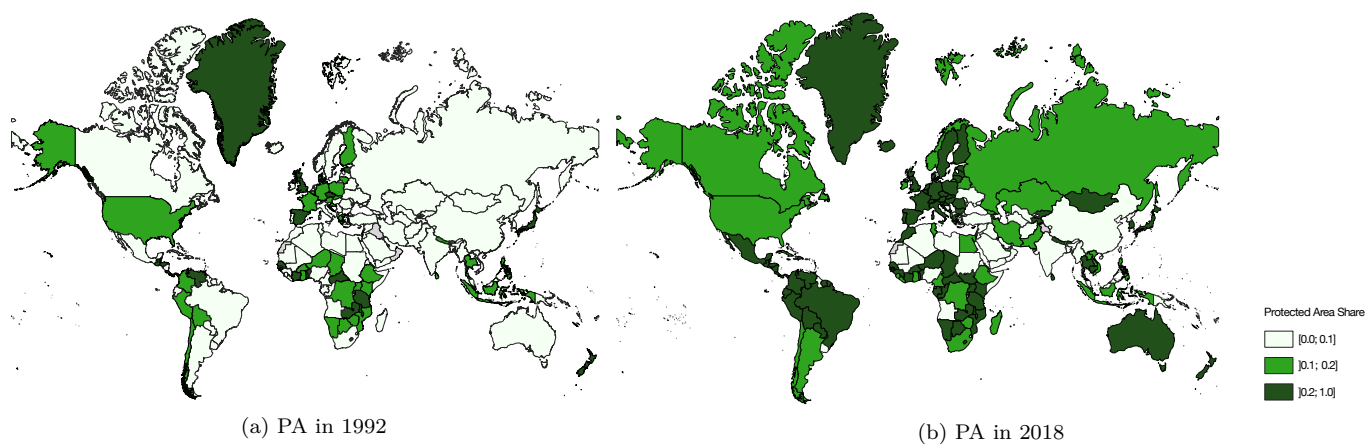


Figure A2: Evolution of the share of countries' area under PAs worldwide between 1992 and 2018 (Source: WPDA Project)

B Democratization events over time

Democratization events are not similar to each others. First, democratization events can differ in their amplitudes. For example, Ethiopia switched in democracy in 1993 according to treatment definition D^0 but remained in non-democracy according to other treatment definitions. Second, democratization events can occur at different periods. For example, Ghana democratized in 1996 and Tanzania democratized in 2015 (using definition D^0). Third, democracy can be reversed. On the one hand for example, Burundi democratized in 2003 after a period of eleven years in non-democracy (using definition D^0), but experienced a reversal towards non-democracy in 2014. On the other hand, Burkina Faso democratized in 2001 and has remained a democracy ever since (using definition D^0). Tables A1 and A2 summarize this diversity of the democratization events in our panel for the five treatment definitions D^k ($k \in \{0, 2, 4, 6, 8\}$), depending on whether countries switch “in” or “out” democracy.

Regarding Table A1, countries turn more often to democracies than to non-democracies for all treatment definitions. Both democratization and autocratization events are more frequent in the beginning of the panel. They are also about two times more frequent for D^0 , D^2 , D^4 and D^6 than for D^8 in each decade.

Table A1: Annual average of the number of democratization and autocratization events per decades (Source: authors’ own computations based on Polity5 and Freedom House databases)

	YEAR OF EVENTS (ANNUAL AVERAGE PER DECADES)									
	SWITCHING “IN”					SWITCHING “OUT”				
	D^0	D^2	D^4	D^6	D^8	D^0	D^2	D^4	D^6	D^8
90’s	2.43	2.29	2.14	1.86	1.14	1.71	1.57	1.86	1.00	1.00
00’s	1.82	1.91	2.09	2.00	1.36	1.40	1.30	1.30	1.30	0.60
10’s	1.44	1.67	1.67	1.56	0.56	1.22	1.22	1.22	1.11	0.44
Average	1.81	1.92	2.00	1.85	1.04	1.42	1.35	1.42	1.15	0.65

NOTE. The Table indicates the average number of democratization events ($D_{i,t-1}^k = 0$ and $D_{i,t}^k = 1$) and autocratization events ($D_{i,t-1}^k = 1$ and $D_{i,t}^k = 0$) per year for each decade of our panel and each treatment definition.

Overall, out of the 144 countries that constitute our panel, 26 to 41 countries turned to democracies and 16 to 30 reversed, depending on the treatment definition (Table A2). Looking for example to countries switching “in” treatment D^0 ($D_{i,t-1}^0 = 0$ and $D_{i,t}^0 = 1$), 39 countries democratized between 1992 and 2018, 64 remained always democracies and 41 never experienced democratization. This last category includes 31 countries that remained always non-democracies and 10 others

that definitely reversed to non-democracies between 1992 and 2018. From the opposite perspective, looking at countries switching “out” D^0 ($D_{i,t-1}^0 = 1$ and $D_{i,t}^0 = 0$), 30 countries experienced democracy reversals (including the 10 countries mentioned above), while 31 countries remained always non-democracies, and 83 countries never experienced democracy reversals (including the 64 mentioned countries remaining democratic between 1992 and 2018).

Table A2: Number of switchers “in” and “out” per treatment during the 1992-2018 period (Source: authors’ own computations based on Polity5 and Freedom House databases)

	GROUP SIZE PER TREATMENT									
	SWITCHING “IN”					SWITCHING “OUT”				
	D^0	D^2	D^4	D^6	D^8	D^0	D^2	D^4	D^6	D^8
Never-treated	41	44	46	54	79	83	69	79	77	60
Treated	39	40	41	39	26	30	26	28	24	16
Always-treated	64	60	57	51	39	31	35	37	43	68
Total	144	144	144	144	144	144	144	144	144	144

NOTE. The table displays the number of countries that get never-, always- or sometimes treated according to treatment definitions D^k ($k \in \{0, 2, 4, 6, 8\}$). Table displays in separated columns the countries switching “in” democracy ($D_{i,t-1}^k = 0$ and $D_{i,t}^k = 1$) and those switching “out” democracy ($D_{i,t-1}^k = 1$ and $D_{i,t}^k = 0$).

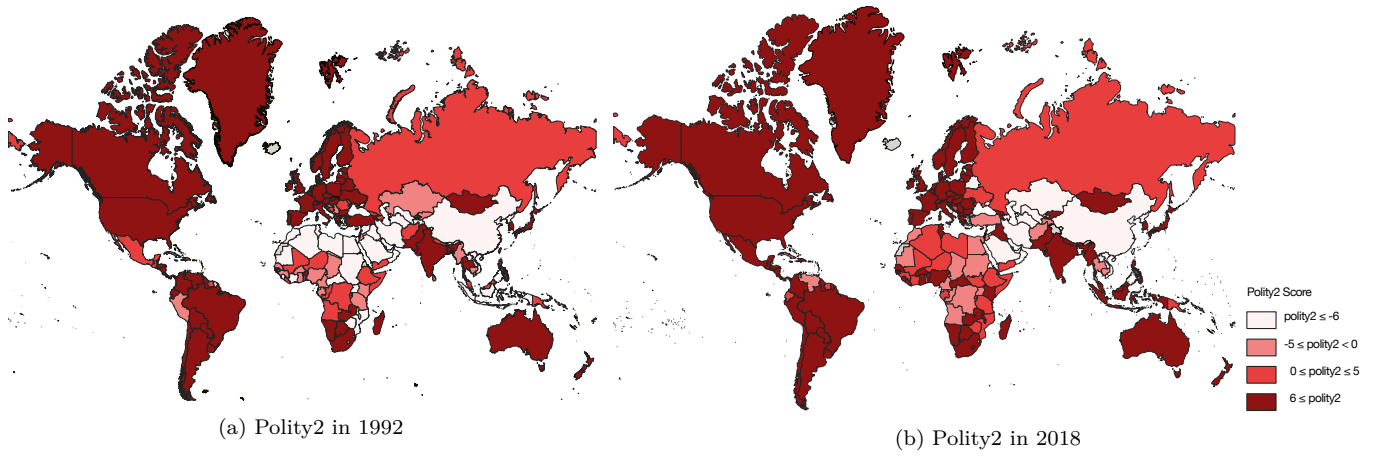


Figure A3: Evolution of Polity2 scores worldwide between 1992 and 2018 (Source: Polity5 Project)

C Two-Way Fixed Effects vs. Difference-in-Differences DID_l estimator

Table A3: Average estimate of the effect of democratization on the share of PAs using TWFE (OLS) and DID_l

	AVERAGE EFFECT	
	Two-Way Fixed Effects	Difference-in-differences (DID _l)
A. Treatment D^0 ("free" or "partially free" and $Polity2 \geq 0$)		
Avg. Effect on share of PAs	-0.491 (0.449)	0.780 ** (0.378)
ATTs with neg. weights	983/2462	
B. Treatment D^2 ("free" or "partially free" and $Polity2 \geq 2$)		
Avg. Effect on share of PAs	-0.427 (0.465)	0.742 * (0.379)
ATTs with neg. weights	869/2392	
C. Treatment D^4 ("free" or "partially free" and $Polity2 \geq 4$)		
Avg. Effect on share of PAs	-0.485 (0.451)	0.588 * (0.306)
ATTs with neg. weights	934/2316	
D. Treatment D^6 ("free" or "partially free" and $Polity2 \geq 6$)		
Avg. Effect on share of PAs	0.386 (0.591)	0.362 (0.600)
ATTs with neg. weights	794/2035	
E. Treatment D^8 ("free" or "partially free" and $Polity2 \geq 8$)		
Avg. Effect on share of PAs	2.115 * (1.250)	0.765 ** (0.335)
ATTs with neg. weights	671/1496	

NOTE. This table indicates average estimates of the effect of democratization on the share of the country's area under PA. Democracy is defined as a country coded as "free" or "partially free" in Freedom House with a *Polity2* score greater than k ($k \in \{0, 2, 4, 6, 8\}$) in *Polity5*. We report average estimates obtained with OLS and DID_l. Below each estimate we report standard errors (clustered at the country level), obtained via bootstrapping for the DID_l estimates. *, **, *** indicate a p-value lower than 0.1, 0.05 and 0.01 respectively. Below each standard errors we report the number of ATTs receiving negative weights in the TWFE estimation procedure, expressed out of the total number of ATTs used in the TWFE estimation (obtained with the `twowayfweights` Stata command from De Chaisemartin and D'Haultfoeuille, 2020).

D Robustness check: doubly-robust estimator using the Acemoglu et al. (2019)’s procedure

Table A4: Doubly robust estimates of the effects of democratization on the share of the country’s area under PAs depending on the threshold on *Polity2* score (conditions on lagged share of countries’ area under PAs and year fixed effects)

	AVERAGE EFFECTS FROM							Joint test for Conditional Parallel trends Assumption
	-13 to -10 Years (1)	-9 to -5 Years (2)	-4 to 0 Years (3)	1 to 5 Years (4)	6 to 10 Years (5)	11 to 15 Years (6)	16 to 20 Years (7)	
	A. TREATMENT D^0 (“FREE” OR “PARTIALLY FREE” AND $Polity2 \geq 0$)							
Avg. Effect on hare of PAs	-0.073 (0.285)	0.052 (0.108)	0.006 (0.043)	0.048 (0.102)	0.530 (0.482)	2.045 (1.354)	3.170 (2.381)	Valid [$p=0.398$]
	B. TREATMENT D^2 (“FREE” OR “PARTIALLY FREE” AND $Polity2 \geq 2$)							
Avg. Effect on hare of PAs	-0.139 (0.264)	-0.01 (0.086)	-0.049 (0.041)	0.088 (0.118)	0.693 (0.578)	2.772 * (1.631)	4.042 * (2.354)	Valid [$p=0.421$]
	C. TREATMENT D^4 (“FREE” OR “PARTIALLY FREE” AND $Polity2 \geq 4$)							
Avg. Effect on share of PAs	-0.357 (0.408)	-0.256 (0.255)	-0.084 (0.073)	0.101 (0.131)	0.707 (0.562)	2.593 ** (1.263)	3.927 * (2.069)	Invalid [$p=0.065$]
	D. TREATMENT D^6 (“FREE” OR “PARTIALLY FREE” AND $Polity2 \geq 6$)							
Avg. Effect on share of PAs	-0.819 (0.542)	-0.327 (0.269)	-0.086 (0.065)	0.248 (0.232)	1.317 (0.989)	2.219 (1.398)	0.406 (1.995)	Invalid [$p=0.098$]
	E. TREATMENT D^8 (“FREE” OR “PARTIALLY FREE” AND $Polity2 \geq 8$)							
Avg. Effect on share of PAs	0.304 *** (0.116)	-0.130 (0.365)	0.033 (0.142)	1.336 * (0.800)	3.632 * (2.173)	4.008 (2.788)	7.846 (5.971)	Valid [$p=0.102$]

NOTE. This table indicates estimates of the effect of a democratization on the share of the country’s area under PAs over 5-years time horizons, indicated in the column labels. Democracy is defined as a country coded as “free” or “partially free” in Freedom House with a *Polity2* score greater than k ($k \in \{0, 2, 4, 6, 8\}$) in *Polity5*. We report doubly robust estimates of the ATT using the procedure of Acemoglu et al. (2019), using lagged share of countries’ area under PAs and year fixed effects as covariates. Below each estimate we report standard errors (clustered at the country level) obtained via bootstrapping. *, **, *** indicate a p-value lower than 0.1, 0.05 and 0.01 respectively. We report the p-value of the joint significance tests on the pre-treatment estimates between hooks.

Table A5: Doubly robust estimates of the effects of democratization on the share of the country’s area under PAs depending on the threshold on *Polity2* score (conditions on lagged share of countries’ area under PAs, lagged GDP per capita and year fixed effects)

	AVERAGE EFFECTS FROM							Joint test for Conditional Parallel trends Assumption
	-13 to -10 Years (1)	-9 to -5 Years (2)	-4 to 0 Years (3)	1 to 5 Years (4)	6 to 10 Years (5)	11 to 15 Years (6)	16 to 20 Years (7)	
	A. TREATMENT D^0 (“FREE” OR “PARTIALLY FREE” AND $Polity2 \geq 0$)							
Avg. Effect on share of PAs	-0.113 (0.261)	0.020 (0.08)	0.001 (0.044)	0.069 (0.102)	0.594 (0.499)	2.328 (1.501)	4.177 (2.788)	Valid [$p=0.404$]
	B. TREATMENT D^2 (“FREE” OR “PARTIALLY FREE” AND $Polity2 \geq 2$)							
Avg. Effect on share of PAs	-0.174 (0.239)	-0.047 (0.077)	-0.056 (0.042)	0.102 (0.118)	0.746 (0.571)	2.838 * (1.575)	4.066 * (2.238)	Valid [$p=0.405$]
	C. TREATMENT D^4 (“FREE” OR “PARTIALLY FREE” AND $Polity2 \geq 4$)							
Avg. Effect on share of PAs	-0.391 (0.406)	-0.301 (0.257)	-0.09 (0.064)	0.104 (0.138)	0.705 (0.627)	2.545 * (1.484)	3.885 * (2.280)	Valid [$p=0.346$]
	D. TREATMENT D^6 (“FREE” OR “PARTIALLY FREE” AND $Polity2 \geq 6$)							
Avg. Effect on share of PAs	-0.824 * (0.464)	-0.371 * (0.214)	-0.094 (0.063)	0.255 (0.219)	1.321 (0.875)	2.133 (1.368)	0.073 (2.233)	Invalid [$p=0.074$]
	E. TREATMENT D^8 (“FREE” OR “PARTIALLY FREE” AND $Polity2 \geq 8$)							
Avg. Effect on share of PAs	0.270 (0.162)	-0.138 (0.395)	0.039 (0.162)	1.299 (0.883)	3.511 * (2.036)	3.825 (2.610)	7.355 (4.936)	Valid [$p=0.122$]

NOTE. This table indicates estimates of the effect of a democratization on the share of the country’s area under PAs over 5-years time horizons, indicated in the column labels. Democracy is defined as a country coded as “free” or “partially free” in Freedom House with a *Polity2* score greater than k ($k \in \{0, 2, 4, 6, 8\}$) in *Polity5*. We report doubly robust estimates of the ATT using the procedure of Acemoglu et al. (2019), using lagged share of countries’ area under PAs, lagged GDP per capita and year fixed effects as covariates. Below each estimate we report standard errors (clustered at the country level) obtained via bootstrapping. *, **, *** indicate a p-value lower than 0.1, 0.05 and 0.01 respectively. We report the p-value of the joint significance tests on the pre-treatment estimates between hooks.

E Strictness effects: dynamic treatment effects of a first democratization event on the share of the countries' area under PAs of different IUCN categories

Table A6: Estimates of the dynamic treatment effects of a first democratization event on the share of the countries' area under PAs of different IUCN categories

	AVERAGE EFFECTS FROM							Joint test for Parallel trends Assumption
	-13 to -10 Years (1)	-9 to -5 Years (2)	-4 to 0 Years (3)	1 to 5 Years (4)	6 to 10 Years (5)	11 to 15 Years (6)	16 to 20 Years (7)	
A. IUCN IA ("STRICT NATURE RESERVE")								
Avg. Effect on share of PAs	0.254 (0.201)	0.002 (0.045)	-0.003 (0.002)	0.006 (0.004)	0.013 ** (0.006)	0.019 ** (0.008)	0.018 * (0.011)	Valid [$p=0.431$]
B. IUCN IB ("WILDERNESS AREA")								
Avg. Effect on share of PAs	-0.031 * (0.016)	-0.024 (0.015)	-0.006 (0.004)	0.011 ** (0.005)	0.025 ** (0.012)	0.032 ** (0.015)	0.034 ** (0.015)	Valid [$p=0.437$]
C. IUCN II ("NATURAL PARK")								
Avg. Effect on share of PAs	0.103 (0.125)	-0.066 (0.052)	-0.020 (0.017)	0.037 (0.028)	0.078 (0.048)	0.091 * (0.051)	0.088 (0.058)	Valid [$p=0.377$]
D. IUCN III ("NATURAL MONUMENT OR FEATURE")								
Avg. Effect on share of PAs	-0.007 (0.011)	-0.006 (0.006)	-0.002 (0.002)	0.005 (0.003)	0.011 ** (0.005)	0.016 ** (0.007)	0.017 * (0.009)	Valid [$p=0.109$]
E. IUCN IV ("HABITAT OR SPECIES MANAGEMENT AREA")								
Avg. Effect on share of PAs	-0.010 (0.039)	-0.019 (0.022)	-0.010 (0.008)	0.018 (0.014)	0.042 * (0.024)	0.043 (0.036)	0.043 (0.043)	Valid [$p=0.129$]
F. IUCN V ("PROTECTED LANDSCAPE OR SEASCAPE")								
Avg. Effect on share of PAs	-0.087 (0.058)	-0.088 * (0.049)	-0.019 (0.015)	0.039 (0.025)	0.076 * (0.046)	0.092 (0.061)	0.103 (0.068)	Valid [$p=0.232$]
G. IUCN VI ("PA with Sustainable Use of Natural Resources")								
Avg. Effect on share of PAs	-0.022 (0.081)	-0.020 (0.027)	-0.004 (0.005)	0.019 (0.013)	0.046 * (0.027)	0.069 * (0.041)	0.070 * (0.04)	Valid [$p=0.789$]

NOTE. This table indicates estimates of the effect of a first democratization on the share of the country's area under PAs over 5-years time horizons, indicated in the column labels. Democracy is defined as a country coded as "free" or "partially free" in Freedom House with a *Polity2* score greater than 0 in *Polity5*. We report estimates of the ATT using the De Chaisemartin and D'Haultfoeuille (2022a)'s DID_l estimator. Below each estimate we report standard errors (clustered at the country level) obtained via bootstrapping. * and ** indicate a p-value lower than 0.1 and 0.05 respectively. We report the p-value of the joint significance tests on the pre-treatment estimates between hooks.