Public goods and ethnic diversity: evidence from deforestation in Indonesia

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Public Goods and Ethnic Diversity: Evidence from Deforestation in Indonesia

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Abstract

This paper shows that the level of deforestation in Indonesia is positively related to the degree of ethnic fractionalization. To identify a causal relation we exploit the exogenous timing of variation in the level of ethnic heterogeneity due to the creation of new jurisdictions. We provide evidence consistent with a lower control of politicians, through electoral punishment, in more ethnically fragmented districts. Our results are consistent with the literature on (under) provision of public goods in ethnically diverse societies.

Keywords: Deforestation, Ethnic Diversity, Corruption, Indonesia

JEL: D73, L73, 010

INTRODUCTION

The Intergovernmental Panel on Climate Change attributes up to one-third of total anthropogenic carbon dioxide emissions to deforestation, mainly in tropical areas. Much of the latter can be attributed to illegal logging which is driven by the collusion of corrupt politicians and logging companies. In Indonesia corruption is endemic, much of logging

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is illegal and local politicians receive bribes in exchange of licenses to log (Burgess et al., 2012). Corruption leads to over exploitation of forests.

This paper investigates how the characteristics of local populations matter for illegal logging in Indonesia, which is an extremely ethnically fractionalized country. Forests are public goods. Local populations dislike corruption of their representatives. However, ethnic diversity reduces the ability of locals to coordinate to better control politicians and punish them when appropriate. In fact, ethnic fractionalization has a detrimental effect on social capital, trust, and participation in communal activities (Nannicini et al., 2013).[1] Control of politicians is another public good undersupplied in diverse societies. As a result, ethnic fragmentation increases deforestation.

Following the decentralization process started in 1998, Indonesian forests became controlled by district-level elected governments, in charge of allocating and enforcing logging licenses. The decentralization was accompanied by an increase in the number of administrative jurisdictions through the proliferation of district splits which allowed the creation of more homogeneous communities. Most of the newly-formed districts were more ethnically homogeneous; in fact, increasing homogeneity was one of the motivations of splitting.[2] We construct a time-varying measure of ethnic fractionalization during the period 2000-2012. We argue, and try to provide evidence for, that the timing of the splitting was exogenous to local conditions. The central government intervened at two points in time halting the redistricting process unexpectedly and introducing idiosyncratic variation across districts.

In this paper we set up a very simple illustrative model to provide the intuition behind the relationship between ethnic heterogeneity and illegal logging. Then we test the predictions of the model using a rich dataset on Indonesia districts. First, a simple cross sectional analysis supports our main hypothesis that ethnic fractionalized areas display more deforestation. We then construct a time-varying measure of ethnic fractionalization by considering the changes in administrative borders over the period 2000-2012. By exploiting the (most likely) exogenous timing of the creation of new jurisdictions, the evidence on panel data supports a causal relationship between ethnic diversity and deforestation. Finally, we provide an empirical test of the impact of ethnic fragmentation on the control of politicians and ultimately on deforestation. We highlight a sort of political deforestation cycle (PDF). In pre-electoral years politicians allow more deforestation and they are rewarded for that. However, this occurs only in ethnically fragmented districts where, as we assume, control of districts heads is lower. This finding is reminiscent of recent results on political budget cycles occurring mostly where the freedom of the press and control of politicians are lower especially in new democracies in central and eastern Europe (Akhmedov and Zhuravskaya, 2004).

This paper contributes to the body of works on the effect of ethnic fractionalization on public goods provision (Alesina et al. (1999), Alesina and La Ferrara (2005), Miguel and Gugerty (2005)). In Indonesia, Bandiera and Levy (2011), find that in villages with higher ethnic diversity, the level of public goods provision reflects the preferences of the wealthy elite when a democratic system is in place. Our paper is also related to the literature on the depletion of common resources such as water, fisheries and air (Lloyd (1833), Hardin (2009), Ostrom (1990)). In the absence of regulation or well defined property rights, the "tragedy of the commons" is pervasive. Related to this, our paper is linked to the literature on natural resource management, specifically deforestation, in developing countries. One of the first studies to use forest cover data is by Foster and Rosenzweig (2003) who show that income and population growth are the leading causes of forest growth in India. Another relevant branch of this literature has looked at the effect of decentralization of forest management. Baland et al. (2010), find that transferring forest management to local communities can reduce tree lopping by 20 percentage points. Baland et al. (2010) find a decrease in firewood and fodder collection activities. Our results also relate to those in Burgess et al. (2012) who show that greater political fragmentation is detrimental to deforestation due to increased competition among districts for the provincial wood market. Our findings suggest, however, an additional and different effect of political fragmentation. In an ethnically heterogeneous environment, an increase in political jurisdictions can have beneficial effects on deforestation if it leads to lower ethnic fragmentation. We compare in great detail our results to theirs in Section VI.[3]

The remainder of the paper is organized as follows. Section I describes the institutional background in Indonesia with a particular emphasis on the process of political fragmentation. In Section II, we present a simple theoretical framework that highlights one of the possible link between ethnic heterogeneity and deforestation. Section III describes the data while Section IV discusses the empirical methodology. The main results and relative robustness checks are in Section V. In Section VI we relate our results to the ones in Burgess et al. (2012) and Section VII provides evidence on the relationship between ethnic diversity, control of politicians and deforestation. The last section concludes.

I INSTITUTIONAL BACKGROUND

I.I POLITICAL FRAGMENTATION

Indonesia is very ethnically diverse with more than 500 ethnic groups and 742 languages and dialects. The majority of these groups are native to the country. Indonesia is divided into provinces, subdivided into districts (Kabupaten), the administrative units considered in our analysis. Districts are further subdivided into subdistricts (Kecamantan), and finally into villages (Desa). Ethnic and religious cleavages are a salient characteristic of Indonesian population since precolonial times. When the Dutch established their colonial rule they exploited the ethnic divisions to extend their political control over the country, a strategy which exacerbated ethnic cleavages. During the authoritarian regime of Sukarno (1945-1965) acts of violence perpetrated by the military and the police tapped into local ethnoreligious relations. Claims for ethnic identities were suppressed. The same applies to the Suharto's New Order (1966-1998). After his fall in 1998, the democratic government embraced multiculturalism with an uprise of identity politics and separatist movements (Ostwald et al., 2016).

A vast decentralization process, transferred power from the central government to the districts, with two laws of 1999 (Law 22 and Law 25). Only national defence, monetary and foreign policy remained under the central government authority. After the beginning of 2001, when decentralization laws were implemented, the country experienced a rapid growth in the number of newly created political jurisdictions. Between 2000 and 2010, the number of provinces increased from 27 to 34 and the number of districts from 341 to 497. Geographic dispersion, political and ethnic differences, natural resource wealth and bureaucratic rent seeking (Fitrani et al., 2005) were the key forces which influenced this process. Most importantly, administrative units would split because of a desire by some ethnic groups to establish their own district where they would become the majority ethnic group. According to the regulation on redistricting, if a district wanted to split, the parties putting forward the request should provide detailed evidence supporting the viability of the new unit. In particular the new district should demonstrate to satisfy 19 criteria, showing a sufficient level of institutional capacity and a minimum scale requirement. The proposals were submitted to the Regional Autonomy Advisory Council or DPOD (Dewan Pertimbangan Otonomi Daerah). The latter was responsible for reviewing proposals and draft a legislation for the national parliamentary approval. Finally, the request of creating a new district had to be approved by the district parliament, by the head of the original district as well as by the Indonesian parliament, the Interior Ministry and the relevant provincial government.

Our identification strategy relies on the plausible exogeneity of the time of splitting, which we discuss in great detail in Section IV.III. First in 2004, shortly after his election and later in 2009, President Yudhoyono halted the splitting process. In both cases the decision was unexpected and it was not clear how long it would last. The rationale behind the moratoria was that many of the new districts were draining fiscal resources from the central government, the reason being that many of the new districts created were not economically viable (Jeffreys et al., 2009). In 2004, to counteract this trend, the introduction of the law 32/2004 made the requirements to be met by new districts more stringent, increasing the minimum number of sub-districts from three to five and requiring the original district to be at least seven years old (Nordholt and van Klinken, 2007). Given the uncertainty about the duration of the ban, proposals for new districts continued to be submitted to the DPOD during the first moratorium.[4] The moratoria delayed the approval of new districts at various stages of the bureaucratic procedure and resulted in these districts being created at around the same time of other districts that initiated the formal process years later. In addition the muddled and cumbersome approval procedure was subject to various bureaucratic delays. Overall both the moratoria and these delays introduced idiosyncratic variation in the date of approval of new districts. Section IV.III provides detailed empirical evidence supporting the validity of our identifying assumption namely that the timing of the splits was exogenous to local conditions.

The decentralization process allocated a significant portion of timber revenues to local jurisdictions (Arnold, 2008) and empowered local public officials to issue logging permits beyond national control opening new opportunities for corruption and rent seeking (Martini, 2012).[5] Thus logging activities increased significantly, partly because deforestation that was considered "illegal" by the central government was made "legal" by several localities (Casson and Obidzinski, 2002). In reality, there is a large grey area between "legal" and "illegal" permits. District governments frequently issued permits which overlap with those issued by neighboring governments, exceeded caps imposed by the central government and allowed logging in customary forests that were reserved for use by indigenous people.[6]

Throughout the decentralization process, forest-dependent communities were empowered to exert property rights over customary forest. Heads of districts (*Bupatis*) were permitted to issue small-scale forest conversion licenses conditionally to a pre-negotiated agreement between a company and the community. Although a restructuring of the licensing system in 2003 resulted in small-scale licenses being banned by the central government, many district officials continued issuing them contributing to increase the overall amount of "legal" logging. In addition, heads of districts continued to be entitled to issue large logging concessions within their borders (Barr et al., 2006). Since 2003, forestry related revenues are shared between districts and national governments.

II A SIMPLE MODEL

Our simple model shares some features with Burgess et al. (2012) but we focus on ethnic heterogeneity. We assume a large number of logging firms which seek to obtain a permit in a district. The head of the district decides the number of permits to sell to firms taking the price of wood as given. Bribes are needed to obtain any permit which goes beyond the legal quota. Ethnic diversity decreases the control of politicians, through electoral or legal punishment.

The logging company solves the following problem:

$$\underset{f}{Max}\ \pi(f) \equiv f(p-c-b) \tag{1}$$

$$s.t.\ \pi(f) = 0 \tag{2}$$

where f is the amount of wood extracted by the company, p is the price that is determined at the province level, exogenous, c is the marginal cost of extraction and b is the bribe per unit of wood to be paid to the head of district. Given free entry, the company maximizes its profit under the zero profit condition. The maximum bribe the company is willing to pay is:

$$\pi(f) = 0 \ \rightarrow b^* = (p - c) \tag{3}$$

The local politician decides how many permits to allocate and faces the risk of being punished. The probability of punishment, $\phi(f - \bar{f}, EF)$, is a convex function of the difference between the number of illegal permits issued and the legal quota, $\bar{f}$, set for the district and a decreasing function of the level of ethnic fractionalization EF, i.e. $\phi_{EF}(f - \bar{f}, EF) < 0$ and $\phi_{f,EF}(f - \bar{f}, EF) < 0$. The loss for being caught is r. The politician solves:

$$\underset{f}{Max}\ V \equiv f(p - c) - \phi(f - \bar{f}, EF)r \tag{4}$$

Hence the first order condition is:

$$p - c = \phi_f(f - \bar{f}, EF)r \tag{5}$$

In equilibrium the politician issues an amount of logging permits such that the net marginal benefit of issuing an additional permit is equal to the marginal cost. The effect of an increase in ethnic diversity on the equilibrium number of permits is:

$$f_{EF}(EF) = -\frac{\phi_{f,EF}(f - \bar{f}, EF)}{\phi_{ff}(f - \bar{f}, EF)} \tag{6}$$

Recalling that ϕ is convex in f and decreasing in EF, we have that: $f_{EF}(EF) > 0$.

II.I SUMMING UP

The empirical implication of our model is that deforestation is higher in more ethnically diverse districts. The mechanism behind this result is highlighted in equation (6): more ethnically diverse districts, being less able to punish the politician's misbehavior, render bribing less costly for the politician. As a consequence, the latter releases a larger number of illegal logging permits. The empirical analysis that follows in Section V will test the main prediction of the model on the relationship between ethnic diversity and deforestation, exploiting an exogenous variation in the level of ethnic diversity. In Section VII we will provide some evidence supporting the specific channel described in the model, showing that in more ethnically heterogenous districts politicians are more likely to be re-elected in case of misbehavior. We will also compare the empirical implications of our model and our results with those of Burgess et al. (2012).[7]

III DATA

We measure deforestation at the district level over the period 2000-2012 using satellite forest cover data as provided by Hansen et al. (2013). The data are originally constructed from Landsat images at 30-meter spatial resolution. Forest cover loss is recorded as a binary variable and each pixel is assigned value 1, i.e. deforested, if it experienced a stand-replacement disturbance or the complete removal of tree canopy cover over the year. The data are measured in square meters for both forest cover in 2000 and annual deforestation over the period 2000-2012. A detailed description of our measure of deforestation is provided in Appendix B. The forest area can be divided into four categories: production, conversion, protection and conservation zones that spread across all districts. Production and conversion zones are those in which legal logging is allowed and negotiations take place between logging companies and community representatives (Barr et al., 2006). While production zones are devoted to the extraction of timber subject to the granting of a logging permit, in conversion zones authorized companies can clear the forest to set up plantations for oil palms and other estate crops. In protection and conservation zones, instead, logging is prohibited.

Table 1 shows the amount of deforestation, in thousands hectares, occurred during the period 2000-2012 in each province. About 12% of the initial forest area was deforested over the period. Most of it occurred in the island of Kalimantan and several provinces of Sumatra. We measure ethnic fractionalization at the district level using the 2010 Indonesian Census provided by the Indonesian National institute of statistics (BPS) and construct the following standard Herfindhal index of ethnic fractionalization:

$$EF_i = 1 - \sum s_j^2, \tag{7}$$

where s is the share of ethnic group j over the total population of the district i.[8]

Our unit of analysis is a district as defined by the original administrative borders in 2000 (pre-splitting). The cross section analysis compares deforestation and EF across 328 districts for which data are available.[9] Average levels of ethnic fractionalization by province are shown in Table 1 while overall average diversity is shown in Table 2, first row. There is no discernible pattern of ethnic fractionalization across islands but there is significant heterogeneity across districts as shown in the map in Figure C.1 of the Appendix .

The longitudinal analysis is based on 337 districts, as defined by the original administrative borders in 2000 (pre-splitting), and uses a time-varying measure of ethnic fragmentation.[10] 75 districts experienced one splitting event while 20 districts experienced two splitting events over the period 2000-2012. The last split in our sample occurred in 2009.

Table 1: Deforestation and Ethnic fractionalization by province

Province	Area	Forest Area	Logging (2000-2012)	EF (mean)	EF (sd)
Sumatra					
Nanggroe Aceh Darussalam	5,737	4,556	379	0.37	0.27
Sumatera Utara	7,161	5,088	884	0.56	0.25
Sumatera Barat	3,931	3,217	311	0.18	0.15
Riau	9,865	7,626	2,943	0.76	0.08
Jambi	4,929	3,958	1,031	0.65	0.13
Sumatera Selatan	8,761	5,856	1,738	0.81	0.05
Bengkulu	2,000	1,617	224	0.77	0.10
Lampung	3,392	1,486	179	0.56	0.17
Bangka Belitung	1,689	1,114	305	0.53	0.10
Java					
DKI Jakarta	66	2	0	0.76	0.03
Jawa Barat	3,752	1,608	45	0.28	0.24
Jawa Tengah	3,490	1,191	29	0.04	0.06
DI. Yogyakarta	323	99	1	0.07	0.07
Jawa Timur	4,707	1,466	55	0.10	0.13
Banten	947	480	19	0.50	0.23
Nusa Tenggara					
Bali	569	312	4	0.20	0.18
Nusa Tenggara Barat	2,002	1,013	30	0.33	0.26
Nusa Tenggara Timur	4,737	1,913	61	0.49	0.27
Kalimantan					
Kalimantan Barat	14,794	12,272	1,957	0.79	0.19
Kalimantan Tengah	15,483	12,965	2,070	0.77	0.06
Kalimantan Selatan	3,768	2,383	444	0.35	0.22
Kalimantan Timur	19,477	16,939	1,778	0.82	0.06
Sulawesi					
Sulawesi Utara	1,461	1,191	50	0.67	0.14
Sulawesi Tengah	6,159	5,222	338	0.73	0.20
Sulawesi Selatan	6,245	4,000	286	0.32	0.29
Sulawesi Tenggara	3,698	2,894	254	0.65	0.14
Gorontalo	995	808	47	0.22	0.06
Maluku					
Maluku	4,684	3,881	96	0.80	0.10
Maluku Utara	3,173	2,920	120	0.87	0.05
Papua					
Papua Barat	8,491	7,746	95	0.93	0.01
Papua	23,643	19,900	190	0.71	0.24

Total deforestation, area and forest cover are in thousand hectares from a cross-section of 328 districts based on 2000 administrative borders.

We consider the *de jure* time of splitting, which is the date in which the formal law to create the new district is passed. Because our unit of observation is the district according to pre-splitting boundaries, we do not distinguish between parent district that retains the

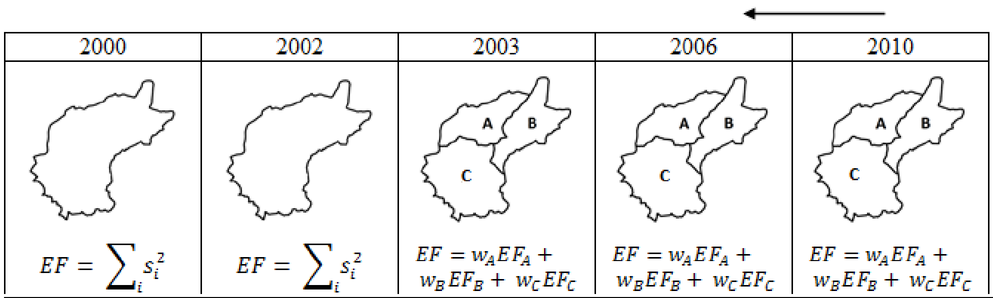
Table 2: Summary Statistics and Sources

Variable	Mean	SD	Min	Max	Source
Cross section Data (328 districts based on 2000 borders)					
Ethnic fragmentation (EF)	0.43	0.32	0.01	0.94	Census 2000
Population (thousands)	671.38	655.38	24.01	6114.62	INDO-DAPOER
Population growth	12.26	24.81	-55.43	112.98	INDO-DAPOER
Share of Javanese people	0.32	0.36	0.00	1.00	Census 2000
New districts (province)	1.45	0.89	1.00	8.00	BPS Dristrict crosswalk table
Employment shares in:					
Agriculture	58.38	22.19	8.24	95.96	Census 2000
Plantations	5.37	8.54	0.04	80.74	Census 2000
Forestry	16.50	21.88	0.04	95.12	Census 2000
Animal activities	7.78	5.82	0.21	60.11	Census 2000
Elevation (meters, mean)	330.27	316.29	5.61	2050.29	DIVA GIS
Elevation (meters, sd)	261.46	202.02	1.20	1277.61	DIVA GIS
Distance to sea (kilometers)	0.33	0.33	0.00	2.07	DIVA GIS
Number of rivers	2.20	7.09	0.00	89.00	DIVA GIS
Number of forest fires (province)	1242.72	1365.97	0.00	5625.00	Forestry Statistics 2011
Panel data (337 districts)					
Expenditure (Million IDR)	659,245	562,800	4,777	5,212,000	INDO-DAPOER
District-level GDP (Million IDR)	5,386,153	10,413,760	107, 106	117,434,140	INDO-DAPOER
Infrastructure expenditure (Million IDR)	105,067	138,102	391	3,150,000	INDO-DAPOER
Population (thousands)	657	638	24	5,470	INDO-DAPOER

The number of new districts indicates the number of new districts formed from the initial district based on 2000 administrative borders. Employment shares represent the share of the district population involved in the following activities: agriculture, forestry, animal activities and plantations such as palm, tea, tobacco, rubber, etc. All data used for the cross-section analysis refer to 2000 with the exception of population growth, number of districts, forest fires and conflicts and violence that refer to the entire period 2000-2012.

original capital, and child district that establishes a new capital.[11] We return on this point in Section IV.II.

Figure 1: Construction of the time-variant EF measure



This is based on the district Ogan Komering Ulu that split in 2003 to form the following three districts: Ogan Komering Ulu, Ogan Komering Ulu Timur and Ogan Komering Ulu Selatan.

Figures 1 illustrates the construction of our time-varying measure of EF. The 2010 census allows us to construct actual measures of EF for all districts in 2010. The data on ethnic fractionalization before splitting come from the 2000 population census and are available at the district level. Therefore, we cannot compute the change in ethnic fractionalization over time at a smaller scale than the pre-splitting borders, without imposing very strong assumptions. In the example we consider three districts (A, B and C), created after a splitting in 2003, with respective level of EF indicated by EF_A, EF_B and EF_C. For those districts that experienced one or more splitting since 2000, it is possible to re-construct pre-splitting population by aggregating the population within pre-splitting administrative borders. We compute the index of fractionalization of the original district, after splitting, as a weighted average of the indexes of fractionalization of all districts lying within pre-splitting district borders. This allows us to compute pre-splitting EF measures based on the aggregated distribution of population across ethnic groups (EF for 2000 and 2002 in Figure 1). Because the unit of analysis is a district as defined by 2000 administrative borders, in case of splitting, aggregate EF is measured by the weighted average of the

EF levels of the newly formed districts, where weights (w) correspond to the respective population shares.

Our measure implicitly assumes that changes in EF are only due to splitting. While migration from and to areas outside the 2000 administrative district borders and demographic changes are also likely to affect the level of heterogeneity of the population, the lack of data prevent us from constructing a more precise measure. We use the 2010 population census for the backward construction of our time-variant measure of ethnic fractionalization so that changes in administrative borders are the only drivers of the variations in ethnic fractionalization over time.[12] An index of EF constructed using the 2000 census shows a correlation coefficient of 99% with our "constructed" measure for 2000, which confirms the overall consistency of our measure with cross-districts differences in ethnic fractionalization in 2000. The two indices are not directly comparable, i.e. we cannot substitute our "constructed" EF in 2000 with actual EF from the 2000 census. This is because the two census differ in terms of representativeness and coverage.[13]

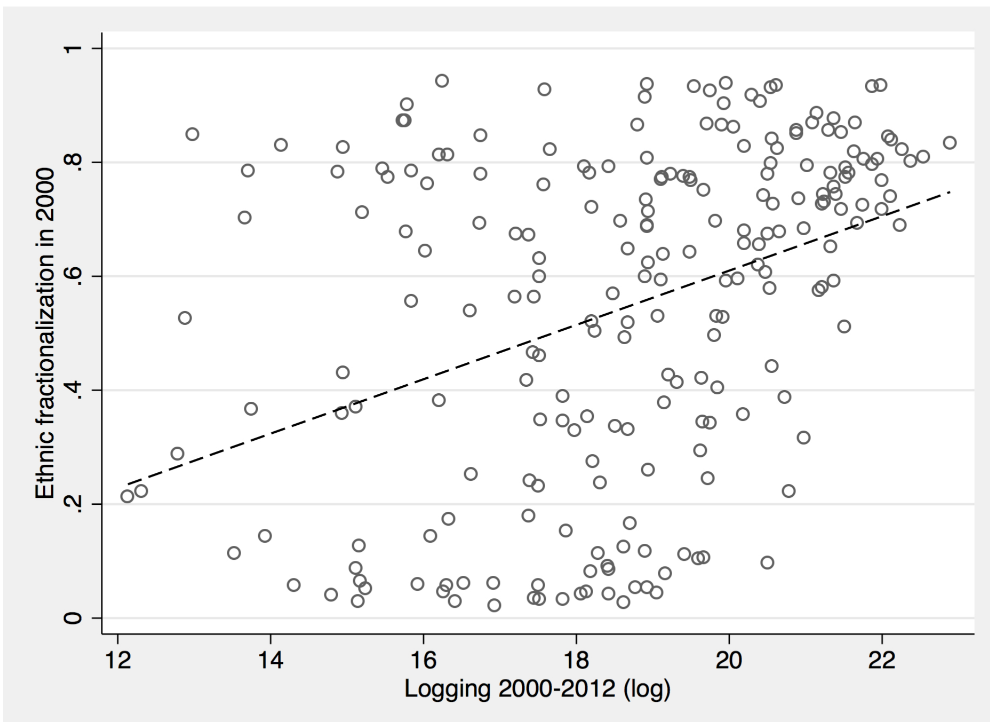
Data on elections are from Burgess et al. (2011), originally obtained from the Centre for Electoral Reform (CETRO). They include information on the year and results of the district head elections and the incumbent status of the candidates. We also use several control variables (descriptive statistics and relative sources are reported in Table 2). A set of variables capturing geographic and ecological characteristics were obtained using geo-referenced data on elevation (mean and standard deviation), distance from the sea and the number of rivers in the district. The estimated extent of forest fires by province was taken from the 2011 Forestry Statistics of Indonesia for the period 2007-2011. For the panel analysis we also include measures of district-level GDP[14], population and government expenditure obtained from INDO-DAPOER.

IV EMPIRICAL STRATEGY

IV.I SUGGESTIVE EVIDENCE

Figure 2 shows a positive correlation between deforestation and ethnic fractionalization.

Figure 2: Correlation between deforestation and ethnic diversity



Each circle represents a district based on 2000 borders. The dashed line indicates the linear fit. The graph omits districts in the Island of Java.

Table 3 confirms this correlation with a set of regressions which control for several additional variables. The dependent variable is total deforestation over the period 2000-2012. The coefficient of pre-splitting ethnic fractionalization, in the last column, suggests that a one standard deviation increase in ethnic fractionalization (0.3) is associated with a 16% increase in deforestation. We begin by controlling for overall size of the district both in terms of population and area of forest cover, both measured in 2000, and by including one of the major drivers of deforestation, population growth over the period 2000-2012, that is also possibly correlated with ethnic diversity. We are also concerned with another particular population phenomenon that is the migration resulted from the Transmigrasi program[15] that could have influenced both ethnic diversity, as it involved the relocation of people mainly of Javanese origin, and deforestation through land clearing for agriculture and infrastructure. The share of Javanese people is aimed at controlling for the presence of this particular ethnic group in a district. We also include the number of new districts created within 2000 district borders as a way to account for the possible correlation between the creation of new jurisdictions and ethnic diversity as a potential driver of district splitting and, consequently of deforestation as documented in Burgess et al. (2012). We then include measures of the importance of different land-related activities since ethnic fractionalization could potentially be associated to the presence of ethnic groups with particular preferences over certain forest-related activities. These are also measured at the beginning of the period. The coefficient gains size and significance when controlling for these variables. We then include a set of geographic and ecological endowments using geo-referenced data on elevation (mean and standard deviation), distance from the sea and the number of rivers in the district. Columns 6 and 7 of Table 3 deal with the potential role of ethnic fractionalization as a possible cause of forest fires and conflicts. The relationship between ethnic fractionalization and deforestation remains positive and statistically significant at the 5% in line with the main prediction of the model.

IV.II DISTRICT SPLITS, ETHNIC FRAGMENTATION AND DEFORESTATION

In this section we provide a more rigorous test for the main prediction of our simple theoretical framework. In particular, we regress the log of deforestation (f) on the time-varying level of ethnic diversity (EF) while controlling for district-level fixed-effects, u_i:

Table 3: Correlation between ethnic fractionalization and deforestation

Dep. var.: deforestation 2000-2012 (log)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EF	0.381	0.386	0.508**	0.540**	0.380*	0.434**	0.447**	0.503**
	(0.259)	(0.241)	(0.231)	(0.238)	(0.214)	(0.197)	(0.200)	(0.210)
Population growth	0.007**	0.007**	0.004	0.006*	0.005**	0.005**	0.005**	0.004**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Population (log)	0.268***	0.273***	0.308***	0.360***	0.331***	0.345***	0.349***	0.269***
	(0.072)	(0.073)	(0.076)	(0.080)	(0.077)	(0.072)	(0.075)	(0.083)
Forest Area (log)	1.097***	1.096***	1.111***	1.050***	1.090***	1.081***	1.079***	1.073***
	(0.041)	(0.041)	(0.040)	(0.038)	(0.032)	(0.029)	(0.030)	(0.040)
Share of javanese		0.369**	0.324*	0.304*	0.089	0.146	0.142	0.252
		(0.168)	(0.171)	(0.179)	(0.215)	(0.201)	(0.202)	(0.364)
Number of new districts in province			-0.202***	-0.167**	-0.113*	-0.117*	-0.119*	-0.067
			(0.073)	(0.065)	(0.060)	(0.059)	(0.059)	(0.054)
Share agriculture				-0.006	-0.004	-0.003	-0.003	-0.005
				(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
Share estate				0.000	-0.002	-0.002	-0.002	-0.011
				(0.008)	(0.009)	(0.009)	(0.009)	(0.007)
Share forest				-0.013***	-0.012***	-0.012***	-0.012***	-0.009**
				(0.004)	(0.004)	(0.003)	(0.003)	(0.004)
Share animal				-0.002	-0.009	-0.008	-0.008	-0.024***
				(0.010)	(0.011)	(0.011)	(0.011)	(0.008)
Elevation (mean)					-0.001***	-0.001***	-0.001***	-0.001***
					(0.000)	(0.000)	(0.000)	(0.000)
Elevation (sd)					-0.000	-0.000	-0.000	-0.001
					(0.000)	(0.000)	(0.000)	(0.000)
Distance to the sea					0.284*	0.284*	0.279*	0.270**
					(0.161)	(0.151)	(0.149)	(0.119)
Number of rivers					-0.014***	-0.014***	-0.014***	-0.010***
					(0.004)	(0.004)	(0.003)	(0.002)
Forest fires						-0.000	-0.000	-0.000**
						(0.000)	(0.000)	(0.000)
Conflicts							-0.000	0.000
							(0.000)	(0.000)
Number of districts	328	328	328	328	328	328	328	227

Standard errors are clustered at the province level (in parentheses), $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each observation is a district based on 2000 district boundaries. All specifications include island fixed-effects. The dependent variable is the log of square meters deforested over the period 2000-2012. The last column excludes the island of Java. All variables refer to 2000 with the exception of population growth, number of districts, forest fires and conflicts and violence that refer to the entire period 2000-2012. Employment shares represent the share of the district population employed in the following activities: agriculture, forestry, animal activities and plantations such as palm, tea, tobacco, rubber, etc.

$$f_{ipt} = \beta EF_{ipt} + \gamma X_{ipt} + \delta ysplit_{ipt} + d_t + u_i + d_t \times v_p + \epsilon_{ipt}, \tag{8}$$

where the coefficient β identifies the effect of a change in the index of ethnic fractionalization, EF, on the level of deforestation. District fixed effects control for time invariant, district-specific characteristics. We also include a dummy for the year of splitting, $ysplit_{ipt}$. Robust standard errors are clustered at the district level. Since EF changes only after the splitting and the time of splitting varies across districts, our exercise can be viewed as a generalization of a diff-in-diff estimation with more than two groups and more than two periods, where the change in EF corresponds to the intensity of treatment. This estimation procedure eliminates any potential heterogenous effect across post-splitting administrative units. For instance, after splitting ethnic fractionalization might decrease (relative to the pre-splitting index of EF of the district they originated from) less in parent districts than in child districts, and so could deforestation or vice-versa. The estimated β could mask such dynamics. However, this is not a major concern for two main reasons: first, we are interested in average changes in deforestation and ethnic diversity within pre-splitting borders. Second, ethnic fractionalization generally decreased in most post-splitting administrative units compare to their pre-splitting counterparts. In fact, one driver of district splitting was the level of ethnic fractionalization, with new districts being created with the purpose of having a more ethnically homogenous population. Table 4 confirms this pattern showing that ethnically heterogeneous districts were more likely to split and that the average level of EF decreased within all districts that experienced a splitting. This trend implies that at least the most populated areas had a decrease in ethnic fractionalization after splitting. Finally, because it is reasonable to expect a lagged effect of a change in ethnic diversity on

Table 4: Descriptive statistics of time-varying ethnic fractionalization

	Average EF	Change in EF (weighted average)	Change in EF (simple average)	Districts
Districts that split	0.58	-0.046	-0.051	95
By quintile:				
1		-0.002	0.009	19
2		-0.051	-0.054	19
3		-0.063	-0.075	19
4		-0.054	-0.064	19
5		-0.058	-0.071	19
Districts that did not split	0.35			242
All districts	0.42			337

The table reports sample averages. Differences between the 2nd, 3rd, 4th, and 5th quintiles are not statistically significant but they are statistically different from the first quintile (for both measures).

deforestation, we also estimate the following distributed lag model:

$$f_{ipt} = \sum_j \beta_j EF_{ipt-j} + \gamma X_{ipt} + \delta ysplit_{ipt} + d_t + u_i + d_t \times v_p + \epsilon_{ipt}, \tag{9}$$

where $\sum_j \beta_j EF_{ipt-j}$ is the sum over the number of lags of ethnic diversity included in the model. We consider both one and two lags.

IV.III IDENTIFICATION

We now discuss the exogeneity assumption of the timing of splitting.[16] First, we regress the number of years before splitting since 2000, on a set of initial district characteristics, each at a time. Results are reported in Table 5. We considered both the entire sample (column 1), and two separate samples; one including districts that split before 2005 (column 2) and the second, including districts that split after 2005 (column 3). We also use an indicator variable for whether the splitting took place after the first moratorium, which occurred between 2004 and 2006 (column 4). The evidence in Table 5 confirms that the timing of creation of new districts was uncorrelated to a number of relevant district initial characteristics such as ethnic fractionalization[17], pre-splitting deforestation, population and district size. The only significant coefficient is the one of district-level GDP for the pre-2005 period. This is not surprising since there is greater scope for regional autonomy in larger and/or richer districts. Hence, we control for district-level GDP in all our regressions and, in one additional specification (Table 8), we also interact initial GDP levels with a post-splitting dummy. In addition, we considered the change in ethnic fractionalization over the entire period to rule out the possibility that districts with higher expected gains in terms of increased homogeneity, were accommodated with an earlier splitting. The timing also appears to be independent on the number of pre-splitting ethnic conflicts.[18]

Finally we are also concerned with the possibility that ethnic groups having natural resources, i.e. forests, in their corner would apply for an early splitting. We depict this possibility in Figure C.3 of the Appendix. The district of type I (Panel I) has the same ethnic groups, A and B, of the district of type II (Panel II). A and B also represent the post-splitting homogenous administrative units. The two types of district have the same level of ethnic fractionalization and the same share of forest area but they differ in how the forest area is distributed across ethnic groups. In particular, for type I ethnic group B has the forest in its corner, while for type II the forest is populated by both ethnic groups. We propose two alternative specifications to rule out the possibility that a district of type I is likely to split earlier than a district of type II. First, while it is not possible to directly observe whether certain ethnic groups were in control of forest resources, we can construct a measure of ethnic fragmentation within the forestry and the agricultural sector, respectively. The implicit assumption behind this exercise is that ethnic groups that live in the proximity of the forest and are interested in pushing for an early split to increase logging activity are expected to be mainly employed in the forestry or agricultural sector. Results are reported in the last two rows of Table 5 and show no significant correlation between

Table 5: Test of exogeneity of the timing of splitting based on 2000 borders

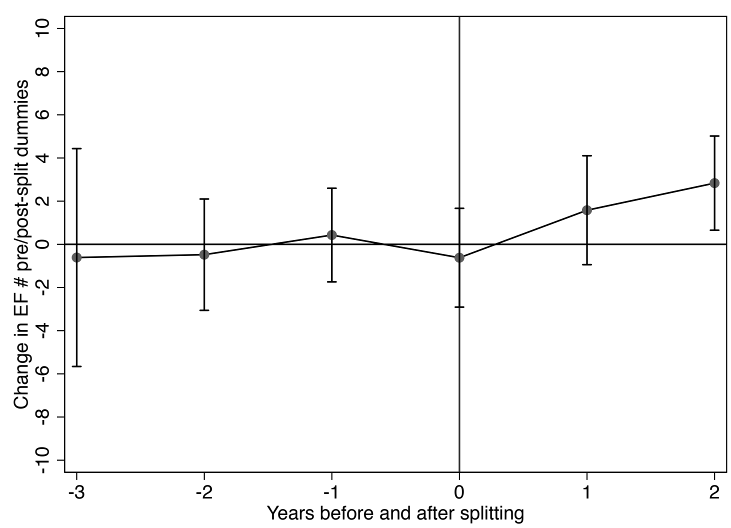
	(1)	(2)	(3)	(4)
Sample:	Entire sample	Split before moratoria	Split after moratoria	Entire sample
Dep. Var:	Years before splitting	Years before splitting	Years before splitting	After moratoria
EF in 2000	-0.650	0.030	0.126	-0.126
	(1.051)	(0.455)	(0.347)	(0.179)
Change in EF	-0.079	-0.492	-0.211	0.063
	(4.419)	(1.199)	(2.515)	(0.717)
Pre-split defor. (log)	-0.250	0.087	-0.082	-0.050
	(0.219)	(0.057)	(0.072)	(0.032)
Ethnic conflicts	-0.440	-0.254	0.400	-0.060
	(0.735)	(0.253)	(0.288)	(0.118)
GDP of district in 2000 (log)	-0.353	-0.288***	0.147	-0.043
	(0.360)	(0.080)	(0.131)	(0.056)
Population in 2000 (log)	-0.320	-0.248	0.134	-0.038
	(0.516)	(0.150)	(0.157)	(0.079)
Area (log)	-0.413	0.120	-0.027	-0.090*
	(0.349)	(0.111)	(0.203)	(0.053)
EF wihtin forestry sector	0.783	-0.172	-0.077	0.166
	(1.097)	(0.454)	(0.436)	(0.175)
EF within agricultural sector	0.267	-0.019	0.078	0.047
	(1.201)	(0.534)	(0.441)	(0.189)
Districts that split	95	70	25	95

Standard errors clustered at the province level in parenthesis, $*p < 0.1$, $**p < 0.05$, $***p < 0.01$. Each cell is a different bivariate OLS regression of the timing of the first split on district characteristics. The unit of observation is the district based on 2000 borders. For districts that split twice we consider only the first splitting event.

any of these measures and the time of splitting. Second, we consider districts as defined by 2010 borders (A and B units in Figure C.3), and interact ethnic fragmentation within 2010 borders with the share of forest in the district. The intent of this estimation exercise is to capture whether the ethnic homogeneity of the population living in a forest-rich area (corresponding to the new formed district), was a driver of the time of the splitting of the original district. Table C.1 of the Appendix shows that the coefficient on the interaction term is never significant. The same Table also shows no significant coefficient when in the interaction term we replace the share of forest area with the share of the population employed in the forestry sector in 2010.

In Figure 3, we provide a visual assessment of the impact of changes in ethnic fractionalization on deforestation over time. The plot is based on a specification where deforestation is regressed on a set of leads and lags of a dummy variable that is equal to one for all post-splitting years, interacted with the change in ethnic fractionalization experienced after the splitting. Figure 3 plots the coefficients of the interaction terms. It shows no statistically significant difference in deforestation patterns during the pre-splitting period. It also shows that, after the split, a change in ethnic fractionalization altered the pattern of deforestation. In particular, greater homogeneity post-splitting is associated to a decrease in deforestation.[19]

Figure 3: Event study: ethnic fractionalization and deforestation



The plot is created by estimating the following equation: $f_{it} = \sum_{j=-3}^{2} \beta_j (post_{i,t+j} \times changeEF_i) + d_t + u_i + \epsilon_{it}$, where *post* is a dummy variable taking value 1 for all years after the splitting. We take leads and lags of this dummy variable and interact them with the change in ethnic fractionalization observed at the time of the splitting. Note that the entire period of analysis is divided into three periods before the splitting and two periods after the splitting, where the second period captures all the years from the second after the splitting onwards. The graph plots the β_js and the corresponding 95% confidence intervals.

Table 6: Ethnic Fractionalization and deforestation

	(1)	(2)	(3)	(4)
EF	1.181**	1.428**		
	(0.469)	(0.556)		
EF (sum of L0 - L1)			1.711***	
			(0.001)	
EF (sum of L0 - L2)				2.379***
				(0.001)
Controls	No	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province-by-year FE	Yes	Yes	Yes	Yes
Observations	4044	3937	3937	3611
Districts that split	95	95	95	95
Total Number of Districts	337	331	331	331

Standard errors clustered at the district level in parentheses, $*p < 0.1$, $**p < 0.05$, $***p < 0.01$. The dependent variable is the log of square meters deforested. Each observation is a district based on 2000 district boundaries. Controls include a binary variable indicating the year of splitting, district-level GDP, population, government expenditure and expenditure on infrastructure. The coefficient of "EF (sum of L0 - L1)" is given by the cumulative sum of the contemporaneous and lagged effect. "EF (sum of L0 - L2)" includes also the second lag of EF.

V MAIN RESULTS

Table 6 reports the results from estimating the baseline model (equation (8)). In the first column the positive coefficient on EF measures the effect of an increase in ethnic fractionalization on deforestation. Since changes in average EF (within pre-splitting borders) were always negative, we can conclude that the reduction in ethnic heterogeneity due to splitting has induced a reduction in deforestation. The effect is large. A decrease in average EF corresponding to the average change observed in the sample (-0.05) leads to a 6% decrease in deforestation. In column 2 we include government expenditure, district-level GDP and expenditure on infrastructures, such as local roads and water systems, that are important drivers of deforestation. In Table C.2 of the Appendix we show that results persist when including district time trends.

In columns 3 and 4 we show the results of a distributed lagged model with one and two lags respectively. Coefficients show the sum of the immediate effect and the lagged effects of EF. The effect is larger in the longer run as one would expect. Column 3 indicates that one year after splitting the average change in EF (-0.05) would induce a decrease of 9% in deforestation. Two years after the splitting the cumulative impact reaches 12%.[20]

In Table 7 we estimate our main specification separately by land-use zones. Column 1 and 2 show the results for production and conversion zones, while column 3 and 4 present the results for the conservation and protection zones. The former are the zones where, up to a point, logging is legal even though "illegal" permits above the quota can be reasonably easily issued and the distinction between legal and illegal is not quite black and white. The latter are those forest areas where logging is illegal and therefore, concessions more difficult to be issued. As expected the effects of EF are significant only in production and conversion zones. We also find a smaller effect in "other" areas, which are those not classified under the main four categories. Overall the empirical results presented in this section support the main prediction of the model of a positive effect of ethnic diversity on deforestation.

V.I ROBUSTNESS

First, we are concern with the potential correlation between EF and other initial characteristics of the districts. Hence, we interact a dummy for the post-splitting period with a set of initial characteristics, such as population, district-level GDP, forest area in 2000 and the share of the population employed in the forestry sector. Column 1 and column 2 of Table 8 report the results. The effect of ethnic diversity on deforestation remains positive and statistically significant. The average reduction in EF induces a decrease of 4.7% in deforestation when all the interaction terms are included in the regression.

Table 7: Results by forest zones

	Production & Conversion		Conservation & Protection		Other	
	(1)	(2)	(3)	(4)	(5)	(6)
EF	2.876**		1.237		1.268*	
	(0.017)		(0.306)		(0.065)	
EF (sum L0 - L1)		3.579***		2.035		1.568**
		(0.010)		(0.131)		(0.022)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Province-by-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3937	3937	3937	3937	3937	3937
Districts	331	331	331	331	331	331

Standard errors clustered at the district level in parentheses, $*p < 0.1$, $**p < 0.05$, $***p < 0.01$. The dependent variable is the log of square meters deforested. Each observation is a district-by-forest zone based on 2000 district boundaries. Controls include a binary variable indicating the year of splitting, district-level GDP, population, government expenditure and expenditure on infrastructure. The Production and Conversion zones are those in which legal logging can take place, while the Conservation and Protection zones are those in which all logging is illegal. Other forest zones refer to forest areas that do not belong to any of the other four categories. The coefficient of "EF (sum of L0 - L1)" is given by the cumulative sum of the contemporaneous and lagged effect.

Second, our results might be driven by geographical factors or other unobservable characteristics that are correlated with logging activity and work at the level of the areas equivalent to post-splitting administrative units. In the baseline regression we consider total deforestation within the 2000 administrative borders. The advantage of our data on forest cover is that they are available at the pixel level and are characterized by an extraordinary high resolution (30 by 30 meters pixels). Hence we can aggregate the deforestation data at the level of post-splitting administrative borders, even though before splitting they had no autonomous jurisdiction to decide on logging permits. In this way it is possible to reconstruct the level of deforestation within new administrative units also for the period preceding the splitting, i.e. before their creation. One advantage of this specification is that we can estimate the baseline regression using narrower fixed effects, in particular, district fixed effects based on 2010 administrative borders, which are smaller than the 2000 district borders (See Figure 1). Column 3 in Table 8 illustrates the regression outcomes

Table 8: Robustness: additional specifications

	Initial characteristics (1)	Initial characteristics (2)	2010 boundaries (3)	EF Simple average (4)
EF	1.057**	0.927*	0.536**	1.176**
	(0.038)	(0.080)	(0.233)	(0.452)
Post # Forest area in 2000	-0.000	0.000		
	(0.756)	(0.542)		
Post # Population in 2000	-0.000	-0.000		
	(0.885)	(0.132)		
Post # GDP in 2000	0.000	-0.000		
	(0.570)	(0.838)		
Post # Share employment		0.041**		
forestry in 2000		(0.038)		
Controls	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province by year FE	Yes	Yes	Yes	Yes
Observations	3933	3933	5301	3937
Number of Districts	330	330	469	331

Standard errors clustered at the district level in parentheses, $*p < 0.1$, $**p < 0.05$, $***p < 0.01$. The dependent variable is the log of square meters deforested. Each observation is a district based on 2000 district boundaries. Controls include a binary variable indicating the year of splitting, district-level GDP, population, government expenditure and expenditure on infrastructure. *Post* is a dummy variable taking value 1 for all years after the splitting and it is interacted with the initial characteristics of the district: Forest area, Population, GDP and the share of the population employed in the forestry sector.

where the dependent variable is the level of deforestation within post-splitting administrative borders while as before EF is computed at the level of pre-splitting borders. The coefficient is significant and with the expected sign, and implies that an average reduction in EF induced a decrease in deforestation of 2.7% within the areas corresponding to the post-splitting administrative borders.

Third, thus far we have considered an index of ethnic fractionalization after splitting computed as a weighted average of the indexes of ethnic fractionalization of the post-splitting districts, where the weights correspond to their population shares. However, among the most populous districts there could be districts with small forest cover, so it could be misleading to assign those areas a higher weight. Column 4 of Table 8 proves that the effect of ethnic fractionalization on deforestation remains positive and significant when we assign equal weights to all post-splitting districts to compute the index of fractionalization.

Fourth, we test whether our results are driven by a particular island in Indonesia. Table 9 shows the results when we perform the Jackknife method and estimate the baseline regression excluding one island at a time. The coefficient of EF remains positive and significant in each column.

Fifth, migration of ethnic groups in the wake of district splitting could bias our results if it is correlated with trends in logging. Two types of migration could happen in the period of analysis: migration across 2000 district borders and migration across post-splitting districts but within 2000 administrative borders. We refer to the former as "external" migration and to the latter as "internal" migration. External migration is taken care of by the way we compute the index of fractionalization. Since we use the 2010 Census to construct both the pre-splitting and the post-splitting average index of fractionalization, we are abstracting from changes in ethnic diversity due to external migration and we only capture changes

Table 9: Robustness: Excluding one Island at a Time

Excluding:	(1) Sumatra	(2) Java	(3) Nusa Tenggara	(4) Kalimantan	(5) Sulawesi	(6) Maluku	(7) Papua
EF	1.374**	1.298***	1.327**	1.486***	1.280*	1.719***	1.457**
	(0.018)	(0.005)	(0.023)	(0.008)	(0.060)	(0.003)	(0.046)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province by year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2831	2689	3579	3482	3407	3841	3793
Districts	237	227	301	293	286	323	319

Standard errors clustered at the district level in parentheses, $*p < 0.1$, $**p < 0.05$, $***p < 0.01$. The dependent variable is the log of square meters deforested in the district. Each observation is a district based on 2000 district boundaries. Controls include a binary variable indicating the year of splitting, district-level GDP, population, government expenditure and expenditure on infrastructure.

due to administrative splitting. Internal migration is more problematic since we cannot track population movements within district boundaries. This could bias our results due to reverse causality, since changes in deforestation after splitting could induce movements of ethnic groups across new districts within pre-splitting administrative borders. For instance, if after splitting a new district head allowed for more deforestation to raise revenues, this might have led some ethnic groups to leave causing a change in the index of fractionalization both in the origin and in destination district. In turn, this would have an impact on our index of ethnic fractionalization in the post-splitting period. The direction of the bias is unclear but it is unlikely to be large. Indeed, the process of political fragmentation was driven by the willingness of ethnic groups to live in districts that were better reflecting their own identity, and individual and social preferences. Therefore, it is implausible that they moved to another district after such a political process of self-determination. Also it is unlikely to observe a sizable change in ethnic fractionalization due to deforestation-induced migration in such a short time period. In addition we construct a measure of internal migration using the 2010 population census. We are able to measure the share of population that was living in another district (as defined by 2010 boundaries) in the five years preceding the census, which we aggregate within the 2000 boundaries, as the unit of observation in our regressions. This measure of internal migration shows a very low correlation with both the change in ethnic fractionalization (7%) and total deforestation over the period 2005-2010 (16%).

Finally, in Table C.4 of the Appendix we present regressions at the level of village administrative boundaries. This allows us to control for village-level fixed effects and so to deal, at a very low scale, with geographic and administrative differences that might be relevant for deforestation patterns. For example, village heads could have some influence, although limited, on how the local forest is managed, for example through community-owned logging companies. The effect of ethnic fractionalization remains significant and comparable in size to previous specifications.

VI ETHNIC FRACTIONALIZATION AND COMPETITION

In this section we compare our results to those in Burgess et al. (2012). They show that greater political fragmentation increases deforestation due to increased competition among districts. A splitting of districts can have a direct and an indirect effect, where the former refers to the effect of splitting on the unit that splits, while the latter indicates the spillover on the rest of the provinces. The increase in competition due to the creation of new districts influences the provincial wood market and, in turn, the logging activity in all the administrative units within a given province. The increase in homogeneity due to splitting instead is expected to mainly affect the district that splits. In addition in our analysis it is not the number of districts which split that matter, but whether and by how much they are more homogenous. First, it is not clear in which direction potential spillover effects of ethnic homogeneity would work and second, they are likely to depend non-trivially on geographical proximity (to the unit that splits). Overall, we expect spillover effects to be small and difficult to quantify. For these two reasons, we only account for the direct effects of ethnic fractionalization on districts that split. In order to provide a comparison between the competition and homogeneity effects, we estimate the same specification presented by Burgess et al. (2012) (Table A8 of their Appendix). We run a regression at the district-level (using the 2000 pre-splitting boundaries) of deforestation on ethnic diversity, the number of district splits within the original district borders, as of 2000, and the number of district splits elsewhere in the province. The "number of districts within original district borders" captures the direct effect of an increase in competition while the "number of district splits elsewhere in the province" represents the indirect effect of an increase in competition. Our findings confirm that the two effects, competition and ethnic fractionalization, work in opposite directions. In line with Burgess et al. (2012), we find no evidence of a direct effect of an increase in competition due to splitting, while indirect effects of increased competition are positive.[21] The direct effect of a reduction in ethnic heterogeneity is always positive, leading to a decrease in deforestation.

We consider the sample of districts that split which allows us to quantify the direct effect of a change in ethnic fractionalization. Based on our estimates in Table 10, simple calculations indicate that the average gains from splitting in terms of lower heterogeneity are offset due to competitive effects, if two or more other splits occur within the same province. When, however, we consider the largest observed decrease in ethnic fractionalization, the positive effects of increased homogeneity are offset if other nine new districts are created in the province. Therefore, considering only districts that split, the benefits of homogeneity outweigh the costs of increased competition in 45% of the observed splitting events. On the other hand, when we analyze the overall impact of political fragmentation at the province level and we take into account the indirect effects of competition on districts that did not split, the positive effects of increased homogeneity are always offset by the negative effects of competition. Whether this result would still hold once the spillovers of ethnic homogeneity are taken into account, remains an open question that goes beyond the scope of this paper.[22]

Table 10: Ethnic fractionalization and competition

	(1)	(2)	(3)
EF	1.307*		
	(0.741)		
Number of districts within initial 2000 boundaries	-0.002		
	(0.063)		
Number of district elsewhere in the province	0.039**		
	(0.018)		
EF (sum L0 - L1)		0.816	
		(1.320)	
Number district within initial boundaries (sum L0 - L1)		-0.024	
		(0.114)	
Number of district elsewhere in the province (sum L0 - L1)		0.052*	
		(0.027)	
EF (sum L0 - L2)			3.078**
			(1.377)
Number district within initial boundaries (sum L0 - L2)			0.030
			(0.112)
Number of district elsewhere in the province (sum L0 - L2)			0.068**
			(0.028)
District-by-zone FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Island-by-year FE	Yes	Yes	Yes
Observations	17261	15833	14399
Districts by forest zones	1452	1452	1452

Standard errors are clustered at the province level in parentheses, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. An observation is a district-by-forest zone cell (at the 2000 borders) in a year. The dependent variable is the log of square meters deforested.

VII CONTROL OF POLITICIANS

The main prediction of our simple model is that deforestation increases with the level of ethnic fragmentation of the districts. In Section V we have shown that this is indeed the case. We now turn to the mechanism underlying our model, namely the effect of ethnic diversity on the control of politicians. According to our model, in ethnically diverse districts incumbent politicians face a lower probability to be punished, legally or electorally, for their misbehavior. As a consequence, heads of ethnically diverse districts are more likely to issue logging permits that exceed the legal quota in exchange of bribes from logging companies. In this Section, we study the probability of incumbent politicians to be re-elected and consider exceptionally high levels of deforestation as a signal of politicians' misbehavior. In the first part we show how incumbents are re-elected when allowing more permits before elections and, in the second one, how incumbents use this advantage strategically, but again, only in ethnically fragmented districts since this is where they face a lower probability of punishment for their misconduct. By doing this we reveal the existence of political deforestation cycles (PDF) in more heterogeneous districts. Direct elections of district heads started in 2005 but the timing of the elections varied from district to district depending on when the terms of previous Bupati's were coming to an end. Some districts had their first direct elections in 2005 while others only in 2010. Skoufias et al. (2014) show how the timing of direct elections was exclusively due to idiosyncratic factors. We investigate what happens to incumbent re-election probability as a function of deforestation.

The estimated equation is the following:

$$Reelection_i = \gamma \tilde{f}_i + \beta \tilde{f}_i * EF + \delta EF + p_i + t_i + \epsilon_i, \qquad (10)$$

where *Reelection* indicates the probability of of an incumbent head of district i. $\tilde{f}$ is our measure of deforestation in the year prior to the election. In particular, we compute the average level of deforestation over the pre-election period (2001- year of election), excluding the year prior to the election, and consider the difference between the level of deforestation

Table 11: Logging and incumbent re-election

Dep. Var.: re-election	(1)	(2)	(3)	(4)	(5)	(6)
Deviation from average pre-elec	-0.0000	-0.0005*				
	(0.0001)	(0.0003)				
EF		0.2338		0.2261		0.2463
		(0.1556)		(0.1575)		(0.1547)
Deviation from average pre-elec # EF		0.0007*				
		(0.0004)				
Deviation from previous year			0.0000	-0.0004		
			(0.0001)	(0.0004)		
Deviation from previous year # EF				0.0006		
				(0.0005)		
Deviation from initial deforestation					-0.0000	-0.0005
					(0.0000)	(0.0003)
Deviation from initial deforestation # EF						0.0006
						(0.0004)
Year Election FE	Yes	Yes	Yes	Yes	Yes	Yes
Districts	222	222	222	222	222	222

Robust standard errors in parentheses, *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Each column reports OLS cross-sectional regressions where the dependent variable takes value one in case of re-election of the incumbent. A unit of observation is a district, based on post-splitting 2010 borders, where the candidate is an incumbent. The deviation from average deforestation in the pre-election period captures exceptionally high levels of deforestation in the year prior to the elections. We also compute alternative measures. In columns 3 and 4 we measure the difference between pre-election deforestation and deforestation in the previous year. In columns 5 and 6 we use the difference between pre-election deforestation and deforestation in 2001.

in the year before the election and average deforestation.[23] We then interact this measure with the level of ethnic fractionalization EF at the time of election. As an additional check, we first repeat this exercise replacing $\tilde{f}$ with the overall change in deforestation activity between the initial year, 2001, and the year prior to the election. Second, we replace $\tilde{f}$ with the one period change in deforestation activity between two years and one year before the elections.[24] We also include province fixed effects, p, and year of election fixed effects, t. We expect the probability of re-election of the incumbent to decrease when in the year before the election the district experiences a higher deviation from average deforestation. At the same time we expect this effect to be smaller in ethnically heterogeneous districts. In other words, we expect the coefficient on the interaction term, β, in equation (10), to be positive. Results in Table 11 are consistent with this argument.

The first column shows that on average a higher level of pre-election deforestation has no effect on the probability of re-election. However, when we interact pre-election deviations in deforestation with the level of ethnic diversity (column 2) we find that in more homogenous districts an exceptionally high level of deforestation in the year before election decreases the probability of re-election, while the opposite holds in more heterogeneous districts. This evidence is consistent with the mechanism of a lower control of politicians in heterogeneous districts, as described in our model. Identification is derived from a cross-section of incumbents running for re-election and in our sample, given the relative short time period, we do not observe incumbents more than once. The specification might imply also a mechanism based upon self-selection. Voters might be more able to discourage politicians' misbehavior in ethnically homogeneous districts, either because politicians discipline themselves or because politicians with a lower propensity to misbehave enter politics anticipating voters behavior.

The presence of logging cycles is investigated by estimating the following equation:

$$f_{it} = \sum_{j=t-2}^{t+2} Election_{ij} + d_t + u_i + \epsilon_{it}, \tag{11}$$

where j indexes leads and lags of the *Election* variable, which is a dummy that indicates the year in which the election of the district head takes place. The results are reported in Table 12. Column 1 confirms the presence of logging cycles showing that deforestation increases systematically in the proximity of elections. Note that we also find a significant effect on deforestation in the period immediately after the election. This may be the result of permits issued immediately before the elections and executed right after it. However when we split the sample in high and low heterogeneous districts (defined as above or below the median ethnic fractionalization) we find that this effect is only present in districts with a high level of ethnic diversity, a result consistent with our hypothesis. This evidence is

Table 12: Logging and elections

	(1) Full sample	(2) EF>median	(3) EF<median
Lead 2	0.0950	0.2733*	-0.0805
	(0.397)	(0.050)	(0.640)
Lead 1	0.2270**	0.3755***	0.0740
	(0.029)	(0.002)	(0.641)
Election year	0.1229	0.2375*	0.0072
	(0.210)	(0.057)	(0.961)
Lag 1	0.3085**	0.4479***	0.1992
	(0.010)	(0.004)	(0.240)
Lag 2	0.1584	0.2350	0.0719
	(0.338)	(0.198)	(0.778)
District FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	2465	1225	1240
Districts	310	154	156
EF (mean)	0.56	0.79	0.34

Robust standard errors in parentheses, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. A unit of observation is a district based on post-splitting 2010 borders. The dependent variable is the log of square meters deforested in the district. A statistical test shows that the coefficients of the first lag and the first lead are statistically different between districts with a level of ethnic diversity below and above the median.

also coherent with results in Akhmedov and Zhuravskaya (2004), who find that political budget cycles occur mostly where the freedom of the press and control of politicians are lower.

VIII CONCLUSIONS

This paper studies the relationship between ethnic diversity and deforestation in Indonesia. We can use the exogenous timing of the splitting of jurisdictions and document a causal relationship between ethnic fractionalization and deforestation. We find that more ethnically fractionalized areas display more deforestation after controlling for a variety of possible confounding factors, including geographic and socioeconomic characteristics. Since districts splitting allowed by the decentralization process increases homogenization in the districts which split, we uncover an effect of decentralization that lowers deforestation and goes in the opposite direction of the one pointed out by Burgess et al. (2012). Our findings highlight a trade-off between reduced ethnic heterogeneity and increased competition in the natural resource market when deciding the optimal level of decentralization of natural resource management.

Acknowledgements

This research has benefited from the financial support of the UK Economic and Social Research Council through the Centre for Climate Change Economics and Policy. We wish to thank the editor, Tim Besley, two anonymous referees and Nicola Gennaioli, Eric Kere, Armando Miano, Charles Palmer, Alessandro Tavoni and seminars participants at the 2nd IAERE conference, LSE, Queen Mary, and the 5th World Congress of Environmental and Resource Economists for helpful comments. We also thank Ben Olken, Luhur Fajar and Stephanie Sieber for sharing some data, and Gregor Singer and Bryan Vadheim for excellent research assistance.

APPENDIX A: ADDITIONAL CHANNELS

A FIRST CHANNEL: ABILITY TO FIGHT

In this section we describe two additional channels that may link ethnic fractionalization and deforestation. The first is the ability of local communities to fight against logging companies. The second channel is that because of less cooperation in more diverse communities, in case of no conflict with the logging company they receive a lower compensation from the latter making logging cheaper. We retain all the main assumptions of the model in Section II and we add a stage in which the logging company starts a negotiation with the local community. In particular the company offers a compensation for using the forest. We allow for the possibility of conflict between the company and the community in case the negotiation fails. The timing is the following: in t_0 the politician decides the amount of logging concessions, f, to give to the company in exchange for a bribe, in t_1 the company decides how much to pay (in terms of bribes) to obtain the concessions. In t_2 the bargaining takes place and the company offers a compensation payment to the community. If the community refuses it, the negotiation fails and the community tries to block the logging activity. With probability q the community wins the conflict and stops the logging. In this case the logging company loses the bribe, b, it already paid, while the community controls the forest and enjoys a utility, $U(F)$, which is an increasing and concave function of the size of the standing forest, F, with $F \in [0, \bar{F}]$. With probability $(1 - q)$ the company wins the conflict and continues to log without paying any compensation to the community. In the next section we will assume that the probability that the community wins the conflict, q, depends negatively on its level of ethnic fragmentation. The model is solved backward and has two different equilibria, one where negotiation succeeds (*under negotiation*) and one where negotiation fails (*under conflict*).[25] For each equilibrium we derive the optimal level of deforestation and how this level is influenced by changes in ethnic diversity. First we characterize the equilibrium under negotiation and then we turn to the one under conflict. We begin describing the problem faced by the company and we analyze the outcome of the negotiation between the company and the community. Then we determine the bribe that the company is willing to pay and finally we study the decision of the local government and define the equilibrium.

Negotiation stage

In the last stage the company decides whether to start a conflict with the community comparing the payoffs under the two different scenarios. In case of conflict the expected payoff for the company is:

$$\pi_C^L = -bfq(EF) + (1 - q(EF))f(p - c - b) \tag{A-12}$$

where the superscript L stays for "logging company" and the subscript C indicates "conflict". EF stands for ethnic fractionalization, which, in the empirical section, will be measured by a commonly used Herfindhal index. We assume that $q_{EF}(EF) < 0$, namely more ethnically fractionalized communities are less likely to prevail against logging companies. f is the amount of wood extracted by the company, p is the price that is determined at the province level and we consider as exogenous, c is the marginal cost of extraction and b is the bribe per unit of wood to be paid to the local politician. Let $\bar{F}$ be the total size of the forest, then the expected payoff of the community is:

$$\pi_C^C = q(EF)U(\bar{F}) + (1 - q(EF))U(\bar{F} - f) \tag{A-13}$$

where the superscript C stays for "community" and $(\bar{F} - f)$ represents the size of the forest left to the community after deforestation. To avoid the conflict the company needs to compensate the local community and solves the following problem:

$$\underset{f}{Max}\ \pi^{L}_{NC}(f) \equiv pf(1-\alpha) - cf - bf \tag{A-14}$$

$$s.t.\ \pi^{L}_{NC}(f) = 0\ and\ U(\bar{F} - f) + \alpha pf \geq \pi^{C}_{C} \tag{A-15}$$

where the subscript NC indicates "no conflict". The profit of the logging company is reduced by α which is the share of the revenues from logging paid to the community as a compensation benefit. Given the free entry assumption, the company maximizes its profit under the zero profit condition. The share of the logging revenues given to the community needs to be at least equal to its reservation utility, which corresponds to the expected revenues that the community can extract from the forest if the arrangement with the company is not agreed, namely π^{C}_{C}. Notice that the compensation payment is lower when the community is ethnically heterogeneous. This result is supported by the empirical evidence found by Engel and Palmer (2006) who, looking specifically at Indonesia, show that the compensation benefits paid by the companies are increasing in the degree of ethnic homogeneity of the community. Substituting the expression for π^{C}_{C} in the zero profit condition, we can derive the maximum bribe the company is willing to pay, as: $b = p - c - \frac{q(EF)[U(\bar{F}) - U(\bar{F}-f)]}{f}$. Turning to the first stage of the problem, we need to determine the equilibrium bribe and the

number of logging permits the politician will supply in equilibrium. Recall that the politician makes this decision knowing the amount of the compensation the company pays to the community.

Equilibrium under negotiation

As before the local politician decides how many permits to sell to the companies, facing a probability of detection $\phi(f-\bar{f})$, which now depends only on the difference between the number of illegal permits issued and the legal quota, $\bar{f}$, set for the district. In case the head of the district is caught she loses all the future rents from holding office, r, or more generally she faces a penalty. The local politician solves:

$$\underset{f}{Max}\, V \equiv bf - \phi(f-\bar{f})r \tag{A-16}$$

which substituting with the expression for b, becomes:

$$\underset{f}{Max}\, V \equiv f(p-c) - q(EF)[U(\bar{F}) - U(\bar{F}-f)] - \phi(f-\bar{f})r \tag{A-17}$$

Hence the first order condition is:

$$p - c - q(EF))U_F(\bar{F}-f) \;=\; \phi_f(f-\bar{f})r \tag{A-18}$$

From equation (A-3) we can easily derive the effect of an increase in the degree of ethnic diversity on the number of logging permits supplied in equilibrium, as:

$$f_{EF}(EF) = -\frac{-q_{EF}(EF)U_F(\bar{F}-f)}{q(EF)U_{FF}(\bar{F}-f) - \phi_{ff}(f-\bar{f})r} \tag{A-19}$$

Given the denominator is negative[26] and recalling that $q()$ is a decreasing function of ethnic fractionalization, proposition 1 follows.

Proposition 1 *When ruling ethnically diverse communities, which are less able to organize and win a fight against the logging companies, the politician releases a larger number of illegal logging permits increasing the equilibrium level of deforestation. Formally,* *in equilibrium* $f_{EF}(EF) > 0$.

In this section we have shown that when the company goes for the agreement, the compensation payment to a fragmented community is lower, while the politician faces the prospect of a higher bribe. As a consequence the politician raises the number of logging permits and the equilibrium level of deforestation increases.

Equilibrium under conflict

If the company decides to go for conflict she sets $\pi_C^L = 0$ to determine its willingness to pay for a permit. In particular the optimal bribe in case of conflict is: $b = (1 - q(EF))(p - c)$. The local politician solves the same problem as above, which substituting with the new expression for b, becomes:

$$\underset{f}{Max}\, V \equiv f(1 - q(EF))(p - c) - \phi(f - \bar{f})r \tag{A-20}$$

Hence the first order condition is:

$$(1 - q(EF))(p - c) \quad = \quad \phi_f(f - \bar{f})r \tag{A-21}$$

The effect of an increase in the degree of ethnic diversity on the number of logging permits supplied in equilibrium can be derived as before:

$$f_{EF}(EF) = -\frac{q_{EF}(EF)(p - c)}{\phi_{ff}(f - \bar{f})r} \tag{A-22}$$

Given the denominator is negative and recalling that $q()$ is a decreasing function of ethnic fractionalization, we show that ethnic fractionalization increases deforestation also in the case of a conflict between the company and the community. In fact when the company goes for the conflict, the bribe paid to the politician increases with the chance of winning the conflict by the company. The latter in turn is higher if the company fights against an ethnically fragmented community. Expecting a higher bribe the politician raises the number of logging permits and the equilibrium level of deforestation increases. raises the number of logging permits and the equilibrium level of deforestation increases.

A SECOND CHANNEL: NEGOTIATION POWER

Ethnic diversity can also influence the compensation payment obtained by a community in a direct way. In particular, there can be situations in which conflict is not an option, for example because the logging company faces high reputation costs. However, even during a peaceful negotiation a community which is ethnically diverse, can extract a lower share of the logging company's revenues as a compensation benefit. The reason is that Ethnic diversity can also influence the compensation payment obtained by a community in a direct way. In particular, there can be situations in which conflict is not an option, for example because the logging company faces high reputation costs. However, even during a peaceful negotiation a community which is ethnically diverse, can extract a lower share of the logging company's revenues as a compensation benefit. The reason is that fractionalized communities, being less cooperative and experiencing more disagreement in the decision making process are able to exert a lower bargaining power. To illustrate this point we can simply assume the share, α, of the logging revenues that go to the community, being a decreasing function of ethnic fractionalization, i.e. $\alpha(EF)$, with $\alpha_{EF}(EF) < 0$. The problem is solved as before and it is easy to show that the equilibrium bribe, namely the maximum price the company is willing to pay for a permit, is: $b = p(1 - \alpha(EF)) - c$.

Substituting it in the politician's objective function, we can derive the first order condition:

$$p(1-\alpha(EF))-c=\phi_f(f-\bar{f})r \tag{A-23}$$

In this case the effect of an increase in ethnic diversity on the equilibrium number of logging permits is:

$$f_{EF}(EF)=-\frac{\alpha_{EF}(EF)p}{\phi_{ff}(f-\bar{f})r} \tag{A-24}$$

Recalling that the share $\alpha(EF)$ is decreasing in EF, the second proposition follows:

Proposition 2 *More ethnically diverse communities, being able to obtain a lower share of the logging revenues, render logging cheaper for the company. As a consequence the politician, with the prospect of a higher bribe, releases a larger number of illegal logging permits increasing the equilibrium level of deforestation. Formally, in equilibrium* $f_{EF}(EF)>0$.

APPENDIX B: DATA

The forest cover data come from a satellite generated forest cover database by Hansen et al. (2013), with pixels defined at a resolution of 1 arc-second, which is approximately 30mx30m squares near the equator, though the exact size depends on where a pixel is located on the globe. We used a dynamic conversion to take the change into account and areas in our database are reported in square meters. There are three data files that are relevant for our analysis and we use: *treecover2000*, *loss*, and *lossyear*. *Treecover2000*, based on matching the spectral signatures reflected off the surface of the earth to the spectral signatures of different land surface types, measures which pixels were covered in forest in the year 2000, which is taken as the base year of the data. The data in this raster (a geo-referenced grid that holds numbers) are integers that range from 0 to 100 that denote the percent forest cover of a particular pixel (defined as canopy closure for vegetation above 5m in height). Loss is binary in nature, and simply records whether or not the relevant change in forest cover occurred for a given pixel between 2000 and 2013. *Lossyear* is a fourth geo-referenced raster, but pixels can take on values from 0-13, with 0 recording no loss observed, and 1-13 record which year the loss occurred, essentially disaggregating the loss variable temporally. We have reconstructed the continuous loss information, using a combination of *treecover2000* and *lossyear*. The smallest forest loss that we measure is 900 square meters, which corresponds to 1 pixel of reported loss. Notice that *treecover2000* records percent forest cover for each pixel in the base year 2000, but subsequent losses are binary (pixels are either recorded as deforested or not). In order to measure forest cover in the subsequent years we have considered the percentage forest cover times the area: for instance, if a 900 sq. meters grid cell was recorded to have 50% of the area forested, it would count as 450 sq. meters of forest.

APPENDIX C: ADDITIONAL TABLES AND FIGURES

Figure C.1: Ethnic Diversity across Indonesian Districts (2006).

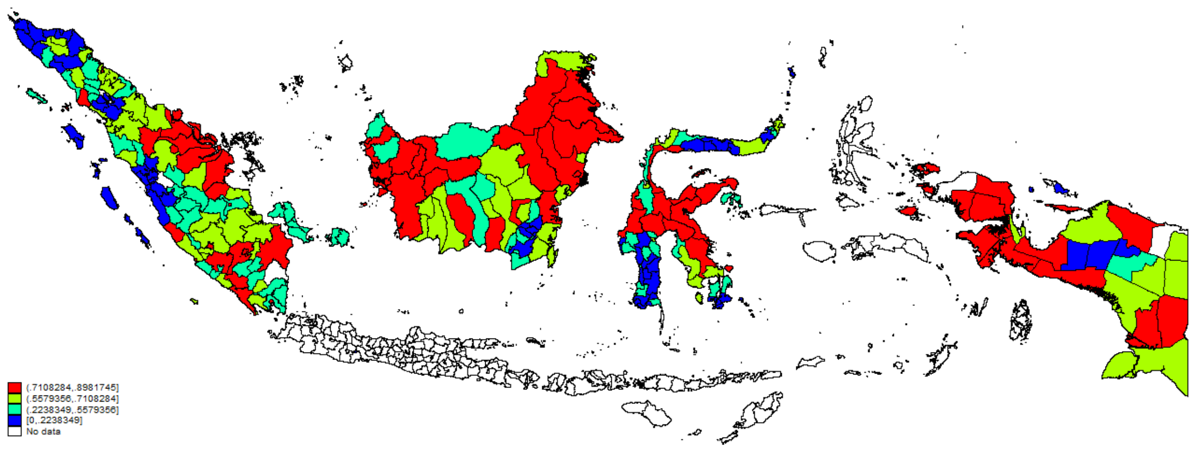
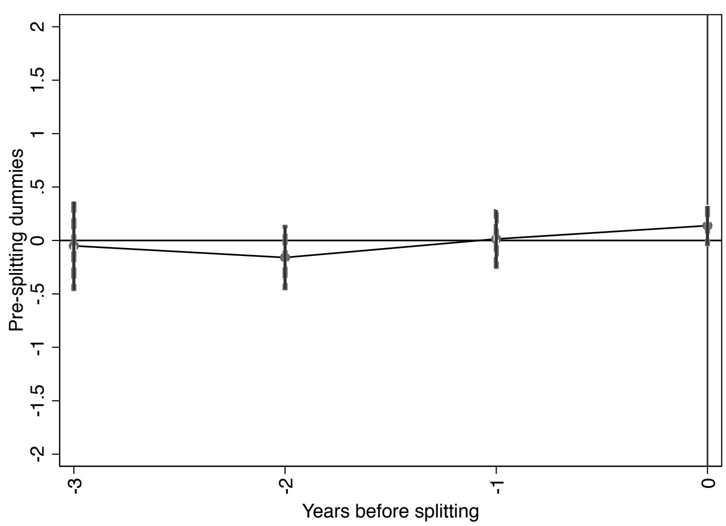


Figure C.2: Test of differences in deforestation trends



The plot is created estimating the following equation: $f_{it} = \sum_{j=-3}^{2} \beta_j(post_{i,t+j}) + d_t + u_i + \epsilon_{it}$, where *post* is a dummy variable taking value 1 for all years after the splitting. The graph plots the β_js for the period before the splitting and their corresponding 95% confidence intervals. The bars indicates the 95% confidence intervals.

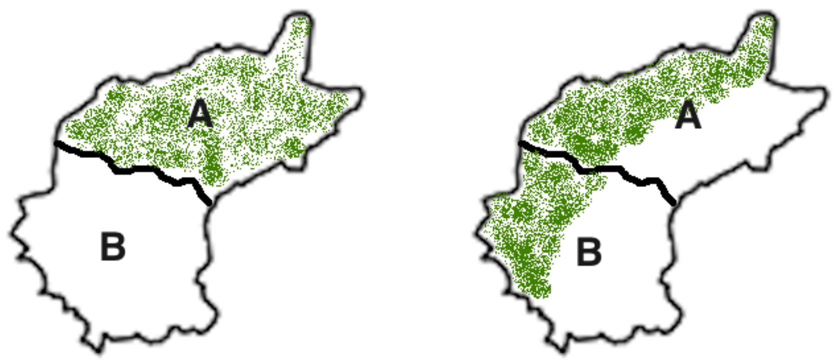
Table C.1: Test of exogeneity of the timing of splitting based on 2010 borders

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Entire sample		Split before moratoria		Split after moratoria		Entire sample	
	Years before splitting		Years before splitting		Years before splitting		Dummy var: after moratoria	
EF in 2010	1.329	-0.182	-0.445	0.110	1.776	-0.095	0.167	-0.055
	(2.997)	(0.886)	(0.926)	(0.444)	(1.162)	(0.476)	(0.396)	(0.170)
Share of forest area	-0.283		1.174		0.738		-0.222	
	(2.267)		(0.696)		(1.401)		(0.321)	
EF # Share of forest area	-2.044		0.405		-2.546		-0.256	
	(3.745)		(1.247)		(1.750)		(0.497)	
Share of forest sector		-0.032		-0.063		0.219		-0.005
		(0.228)		(0.093)		(0.368)		(0.041)
EF # share of forest sector		-0.010		0.062		-0.174		-0.000
		(0.269)		(0.113)		(0.546)		(0.049)
District that have split	241	239	184	182	57	57	241	239

Standard errors clustered at the province level in parenthesis, *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. The unit of observation is the district based on 2010 borders. Regarding the timing of splitting, for districts that split twice we consider only the first splitting event.

Figure C.3: Forest cover distribution across post-splitting administrative units and timing of splitting.

(a) Type I (b) Type II



The district represented here is Ogan Komering Ulu. The areas A and B are an example of post-splitting administrative units. The shaded green area indicates the forest cover. The location of forest cover and the location of the internal border between A and B in the Figure, are hypothetical and for an explicative purpose only.

Table C.2: Robustness: district time-trends

	(1)	(2)	(3)	(4)	(5)
EF	0.999	0.904		2.895	
	(0.300)	(0.506)		(0.148)	
EF (t-1)		1.559		-0.375	
		(0.111)		(0.819)	
EF (t-2)				3.137***	
				(0.003)	
EF (sum L0 - L1)			2.463*		
			(0.072)		
EF (sum L0 - L2)					5.657**
District FE	Yes	Yes	Yes	Yes	Yes
Province-by-year FE	Yes	Yes	Yes	Yes	Yes
District time-trend	Yes	Yes	Yes	Yes	Yes
Observations	4044	3707	3707	3370	3370
Number of districts	337	337	337	337	337

Standard errors are clustered at the district level (in parenthesis), $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. The unit of observation is the district based on 2000 borders. The dependent variable is the log of square meters deforested in the district.

Table C.3: Ethnic Fractionalization and deforestation before and after the first moratorium

	(1) Split before 2004 moratorium	(2) Split after 2004 moratorium
EF	1.678**	4.026**
	(0.706)	(1.687)
Year FE	Yes	Yes
District FE	Yes	Yes
Observations	3645	3124
Districts	306	262

Standard errors clustered at the district level in parentheses, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. The dependent variable is the log of square meters deforested. Controls include a binary variable indicating the year of splitting, district-level GDP, population, government expenditure and expenditure on infrastructure.

Table C.4: Robustness: Village level regressions

	(1)	(2)	(3)	(4)
EF	1.061*	1.094*		
	(0.071)	(0.067)		
EF (sum L0 - L1)			1.177**	
			(0.038)	
EF (sum L0 - L2)				1.424**
				(0.026)
Village FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province by year FE	Yes	Yes	Yes	Yes
Observations	919224	919224	833536	758094
Number of villages	76602	76602	76225	76225

Standard errors clustered at the district level in parentheses, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. The unit of observation is a village as defined by 2010 administrative borders. The dependent variable is the log of square meters deforested in a village. Controls include a binary variable indicating the year of splitting, district-level GDP, population, government expenditure and expenditure on infrastructure. Ethnic fractionalization is still measured within 2000 district boundaries.

Notes

[1]On the positive role of social capital in the development of localities and their ability to provide public goods, see Banfield (1958), Putnam et al. (1993), Guiso et al. (2013). For a survey of the literature on the effect of ethnic fractionalization on (among other things) public goods provision see Alesina and La Ferrara (2005). In addition forests are common (public) goods for local communities and may be subject to exploitation by logging companies. Low social capital interferes with the communities' capacity to organize and lowers their ability to extract compensations from the logging companies making it cheaper for the latter to increase deforestation.

[2]This is consistent with work on the size of political jurisdictions by Alesina and Spolaore (2005). They argue that communities split to create more homogenous places even at the cost of giving up economies of scale.

[3]Morjaria (2016) examines the effect of democratization on deforestation in Kenya. The paper suggests that deforestation might be used for patronage politics, especially in loyal districts, defined as those whose major group in the population has the same ethnicity as the political leader. Morjaria (2016) uses the cross sectional variation in ethnic diversity to define loyal, swing and opposition groups. More recently, Burgess et al. (2016) adopt a regression discontinuity approach to show the causal effect of Brazilian national forest policies on deforestation.

[4]According to Bappenas (2007), at the end of the ban period in 2006, around a hundred of requests at different steps of the approval process were kept on hold for evaluation.

[5]At its peak in 2000, some 75% of logging activity was illegal, falling to 40% by 2006, according to an estimate by the British think-tank Chatham House (Hoare and Wellesley, 2014). The NGO Environmental Investigation Agency, alleged in 2005 that $600 millions worth of Indonesian timber was being smuggled to China each month, with both the army and the police taking an active role. A more recent report by Transparency International Indonesia (2011) on the existing corruption risks in the forestry sector in three Indonesian provinces (Riau, Aceh and Papua) has identified bribery to obtain licenses and logging concessions as a major source of corruption. In Pelawan district the head of the district was arrested in 2008 for issuing illegal licenses to 15 logging companies.

[6]Kasmita Widodo, the national coordinator of the Participatory Mapping Network (JPKK), an organization that supports efforts to map indigenous people, estimates that as much as 70% of forest area in Indonesia is covered by these overlapping permits. Link: http://www.thejakartaglobe.com/news/indigenous-peoples-vow-to-map-customary-forests/

[7]In Appendix A we describe two additional channels which may link ethnic fractionalization and deforestation. The first is the ability of local communities to fight against logging companies. For instance, Collier and Hoeffler (2004) have established that ethnically diverse communities can coordinate less, hence are less effective in organizing a political battle. The second channel is that more diverse communities, which are less able to negotiate because of coordination issues, receive a lower compensation from logging companies. As a result, deforestation is higher in more ethnically fragmented communities, since it becomes relatively cheaper for logging companies.

[8]This is a broadly used measure of ethnic fractionalization which is the probability that two individuals randomly drawn from the population belong to two different ethnic groups.

[9]Of the 341 original districts, we excluded 9 districts for which we could not get data on deforestation and 4 districts that could not be matched across data sources.

[10]Of the 341 original districts, 4 districts could not be matched across data sources.

[11]In theory, child and parent districts could experience differences in institutional capacity after splitting, e.g. enforcement and access to financial resources. In the context of deforestation Burgess et al. (2012) show that there is no temporary decline in enforcement by comparing the parent and the child district after splitting. On the other hand, Bazzi et al. (2015) find that ethnic fractionalization matters relatively less for conflict and crime in child districts and relatively more in parent districts.

[12]Mapping 2000 census data to final 2010 district boundaries was not possible because data on ethnicity are not available at a lower administrative level than the district.

[13]In fact, according to Ananta et al. (2013), ethnicity classification changed between the two census for many of the 15 largest groups and there is reported under-estimation of some ethnic groups (Acehnese, Dayak and Chinese in particular) in 2000 mainly because of political and security issues. Therefore the two sources are strictly speaking not compatible.

[14]The name GDP is normally used in this literature (see Burgess et al. (2012)). It is a measure of gross regional domestic product that includes gas and oil revenues. McCulloch and Malesky (2011) point out that although all districts are supposed to follow the same procedures in computing their GDP, there is variation in the capacity of local statistical offices across the country. Moreover, some components of GDP such as agricultural or manufacturing output are much better measured than others, due to the accuracy of their underlying sources. Nevertheless, sub-national level data are cleaned and standardized by the World Bank upon release into the INDO-DAPOER dataset.

[15]The program aimed at relocating landless people from highly populated areas, mainly Java, to less

density populated areas. Javanese is the most widespread ethnic group in Indonesia.

[16]See also Burgess et al. (2012), Bazzi et al. (2015), and Padro et al. (2013).

[17]The fact that the timing is independent of the level of ethnic fractionalization does not contradict the fact that more diverse places were more likely to split.

[18]These data were obtained from UNSFIR and cover only 14 out of 28 provinces for the period 1990-2003. The variable refers to the number of conflicts, classified by a team of expert as ethnically motivated, that occurred in a given district from 1990 to the year of splitting up to 2003.

[19]In Figure C.2 of the Appendix, we also show that no differences in deforestation trends can be detected between original districts that split and those that did not split.

[20]In Table C.3 of the Appendix we show that the results persist also when we consider separately the pre- and post-moratorium periods. Arguably, one might expect that, in the second period, districts could potentially anticipate a second moratorium and hence push to anticipate or accelerate the redistricting process under the pressure of certain ethnic groups. When considering the first period, potentially the most exogenous, we find very similar results.

[21]The lack of immediate direct effects might be attributable to initial disruptions in logging activities as institutions get organized in the newly created political jurisdictions.

[22]Back of the envelope calculations give an indication of the overall magnitude of the effect of ethnic homogeneity on deforestation. When we consider its short run effect, we find that the reduction in ethnic diversity due to splitting accounts for 1.76 percent of the total deforestation that we observe in our sample over the entire period. This effect corresponds to a reduction in deforestation of about 283,000 hectares.

[23]The measure can be formalized as follow: $\tilde{f}_i^P = f_{it-1} - 1/(t-2)\sum_{j=0}^{t-2} f_{ij}$ for the pre-election period, where t is the year elections take place.

[24]Our results do not change when we include a control for oil and gas revenues received by the district in the year of the election.

[25]Given the free entry assumption the company is always indifferent between negotiation and conflict. Hence it is not possible to pin down a unique equilibrium where the agreement is the option preferred by the company. The understanding of the emergence of conflict vs negotiation goes beyond the scope of this paper.

[26]The denominator represents the second order condition of the maximization problem thus it has to be negative at the optimum. This is the case given the concavity of $U()$.

References

Akhmedov, A. and E. Zhuravskaya (2004). Opportunistic political cycles: test in a young democracy setting. *The Quarterly Journal of Economics 119*(4), 1301–1338.

Alesina, A., R. Baqir, and W. Easterly (1999). Public goods and ethnic divisions. *The Quarterly Journal of Economics 114*(4), 1243–1284.

Alesina, A. and E. La Ferrara (2005). Ethnic diversity and economic performance. *Journal of Economic Literature 43*, 762–800.

Alesina, A. and E. Spolaore (2005). *The size of nations.* Mit Press.

Ananta, A., E. N. Arifin, M. S. Hasbullah, N. B. Handayani, and A. Pramono (2013). Changing ethnic composition: Indonesia, 2000-2010. In *XXVII IUSSP International Population Conference*, pp. 26–31.

Arnold, L. L. (2008). Deforestation in decentralised indonesia: what's law got to do with it? *4/2 Law, Environment and Development Journal (2008)*, 75–101.

Baland, J.-M., P. Bardhan, S. Das, and D. Mookherjee (2010). Forests to the people: Decentralization and forest degradation in the Indian Himalayas. *World Development 38*(11), 1642–1656.

Baland, J.-M., P. Bardhan, S. Das, D. Mookherjee, and R. Sarkar (2010). The environmental impact of poverty: evidence from firewood collection in rural Nepal. *Economic Development and Cultural Change 59*(1), 23–61.

Bandiera, O. and G. Levy (2011). Diversity and the power of the elites in democratic societies: Evidence from indonesia. *Journal of Public Economics 95*(11), 1322–1330.

Banfield, E. C. (1958). *The moral basis of a backward society.* New York: Glencol.

Bappenas (2007). *Evaluasi Pemekaran Daerah,*. Ministry of National Development Planning / National Development Planning Agency (Bappenas), Jakarta.

Barr, C., I. A. P. Resosudarmo, A. Dermawan, and B. Setiono (2006). Decentralization's effects on forest concessions. In C. Barr, I. A. P. Resosudarmo, A. Dermawan, and J. McCarthy (Eds.), *Decentralization of Forest Administration*. Center for International Forestry Research (CIFOR).

Bazzi, S., M. Gudgeon, et al. (2015). Local government proliferation, diversity, and conflict. Technical report, Boston University-Department of Economics.

Burgess, R., F. Costa, and B. A. Olken (2016). The power of the state: National borders and the deforestation of the Amazon. *Unpublished paper, London School of Economics*.

Burgess, R., M. Hansen, B. A. Olken, P. Potapov, and S. Sieber (2011, September). The political economy of deforestation in the tropics. *Working Paper Series, National Bureau of Economic Research 17417*.

Burgess, R., M. Hansen, B. A. Olken, P. Potapov, and S. Sieber (2012). The political economy of deforestation in the tropics. *The Quarterly Journal of Economics 127*(4), 1707–1754.

Casson, A. and K. Obidzinski (2002). From new order to regional autonomy: Shifting dynamics of illegal logging in Kalimantan, Indonesia. *World Development 30*(12), 2133–2151.

Collier, P. and A. Hoeffler (2004). Greed and grievance in civil war. *Oxford economic papers 56*(4), 563–595.

Engel, S. and C. Palmer (2006). Who owns the right? The determinants of community benefits from logging in Indonesia. *Forest Policy and Economics 8*(4), 434–446.

Fitrani, F., B. Hofman, and K. Kaiser (2005). Unity in diversity? the creation of new local governments in a decentralising Indonesia. *Bulletin of Indonesian Economic Studies 41*(1), 57–79.

Foster, A. D. and M. R. Rosenzweig (2003). Economic growth and the rise of forests. *The Quarterly Journal of Economics 118*(2), 601–637.

Guiso, L., P. Sapienza, and L. Zingales (2013). The Determinants of Attitudes toward Strategic Default on Mortgages. *The Journal of Finance 68*(4), 1473–1515.

Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. Turubanova, A. Tyukavina, D. Thau, S. Stehman, S. Goetz, T. Loveland, et al. (2013). High-resolution global maps of 21st-century forest cover change. *Science 342*(6160), 850–853.

Hardin, G. (2009). The tragedy of the commons. *Journal of Natural Resources Policy Research 1*(3), 243–253.

Hoare, A. and L. Wellesley (2014). Illegal logging and related trade: The response in indonesia. *A Chatham House Assessment. London (UK): C House.*

Jeffreys, A., P. Kuncinas, and O. B. Group (2009). *The Report: Indonesia 2009.* Oxford Business Group.

Lloyd, W. F. (1833). *Two lectures on the checks to population.*

Martini, M. (2012). Causes of corruption in indonesia. U4 anti-corruption resource centre, Transparency International.

McCulloch, N. and E. Malesky (2011). Does better local governance improve district growth performance in Indonesia? *IDS Working Papers 2011*(369), 1–48.

Miguel, E. and M. K. Gugerty (2005). Ethnic diversity, social sanctions, and public goods in kenya. *Journal of public Economics 89*(11), 2325–2368.

Morjaria, A. (2016). Is democracy detrimental for the environment in developing countries? evidence from Kenya. *mimeo*.

Nannicini, T., A. Stella, G. Tabellini, and U. Troiano (2013). Social capital and political accountability. *American Economic Journal: Economic Policy 5*(2), 222–50.

Nordholt, H. and G. van Klinken (2007). *Renegotiating Boundaries: Local Politics in Post-Suharto Indonesia*. OAPEN (Open Access Publishing in European Networks). KITLV Press.

Ostrom, E. (1990). Governing the commons: The evolution of institutions for collective action.

Ostwald, K., Y. Tajima, and K. Samphantharak (2016). Indonesia's decentralization experiment: Motivations, successes, and unintended consequences. *Journal of Southeast Asian Economies (JSEAE) 33*, 139–156.

Padro, G., N. Qian, Y. Yao, et al. (2013). Social fragmentation, public goods and elections: Evidence from china. Technical report, CEPR Discussion Papers.

Putnam, R. D., R. Leonardi, and R. Y. Nanetti (1993). *Making democracy work: Civic traditions in modern Italy*. Princeton university press.

Skoufias, E., A. Narayan, B. Dasgupta, and K. Kaiser (2014). Electoral accountability and local government spending in Indonesia. *World Bank Policy Research Working Paper* (6782).

Transparency International Indonesia (2011). Forest governance integrity report. indonesia. Technical report, Transparency International Indonesia.