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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 at the district level. To identify a casual relation we exploit the exogenous timing of variations 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 bring a new perspective on the political economy of deforestation. They are consistent with the literature of (under) provision of public goods and social capital in ethnically diverse societies and suggest that when the underlying communities are ethnically fractionalized, decentralization can reduce deforestation.

Keywords: Deforestation, Ethnic Diversity, Indonesia

JEL: D73, H0, L73, 010

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1 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 cooperation of corrupt politicians and agroforestry companies disregarding the preferences of locals.

This paper investigates the relationship between deforestation in Indonesia and the characteristics of local populations. In particular, we show that ethnic diversity reduces the ability of locals to coordinate to achieve better control of politicians, and, as a result, ethnic fragmentation increases deforestation. We construct a time-varying measure of ethnic fractionalization by exploiting the change in administrative jurisdictions occurred during the period 2000-2008. In fact, following the decentralization process started in 1998, Indonesian forests became controlled by district-level elected governments that were in charge of allocating and enforcing logging licenses. The decentralization of forest management duties was accompanied by an increase in the number of administrative jurisdictions through the proliferation of district splits. However, these splits allowed for more homogeneous communities, adding a new dimension to the analysis of decentralization and deforestation. These events provide a unique quasi-experimental setting to study the relationship between ethnic fractionalization and deforestation in the context of decentralized natural resource management. In fact most of the newly-formed districts were more ethnically homogeneous and we can exploit the exogenous variation in the time of splitting across districts to estimate the impact of changes in ethnic fractionalization on district-level logging.

Ethnic fractionalization is correlated with corruption of elected politicians, who are less controlled and less responsive to local needs in fragmented societies. This is because ethnic fractionalization has a detrimental effect on social capital, trust, participation in communal activities and protection of public goods.[1] This is consistent with a large body of theoretical and empirical literature pointing out that fragmented communities can coordinate less and are characterized by lower participation rates in social activities. Forests are public goods for local communities and may suffer from excessive 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 related to Okten and Osili (2004) who find that ethnic diversity in Indonesia has a negative impact on the contributions and prevalence of community organizations.

We set up a simple theoretical framework to provide the intuition behind the relationship between illegal logging and ethnic heterogeneity. Then we take the predictions of the model to the data and, using a cross section of Indonesian districts, find evidence supporting our main hypothesis that ethnic fractionalized areas display more deforestation. The results are robust to the inclusion of a full set of potential confounding factors. We then con-

[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).

[2] 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).

struct a time-varying measure of ethnic fractionalization by considering the changes in administrative borders over the period 2000-2008. By exploiting the exogenous timing of the creation of new jurisdictions, panel data evidence confirms the cross sectional results and supports a casual 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, as outlined in the model.

This paper contributes to the literature on the political economy of deforestation by introducing a new perspective on the effect of decentralization. We relate our results 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. The two effects, therefore, work in opposite directions. In particular, we show that in more than half of the districts that split during the period 2000-2008, the benefits (lower deforestation) of decreased ethnic diversity overtake the negative effects due to increased competition. In doing so we also contribute to the literature on the optimal size of local governments (Alesina and Spolaore, 2003; Alesina, 2003) that highlights the trade-off between the benefits of size versus the costs of heterogeneity of preferences, culture and attitudes of the population. In our context, the trade-off is between lower ethnic heterogeneity and increased competition in the natural resource market. Our results show that both effects can be substantial and the net balance varies across districts. The optimal size of a community from the point of view of deforestation depends upon a trade off between size and heterogeneity of its population.

The remainder of the paper is organized as follows. Section 2 describes the institutional background in Indonesia. In section 3, we present a simple theoretical framework that highlights one of the possible link between ethnic heterogeneity and deforestation. Section 4 describes the data. Sections 5 presents the cross-sectional results while Section 6 examines how changes in ethnic fractionalization due to district splits have affected deforestation. Section 7 provides evidence on the relationship between ethnic diversity, control of politicians and logging. The last section concludes.

2 Institutional Background

After the end of the Suharto regime in 1998, Indonesia initiated a vast decentralization process. Geographic dispersion, political and ethnic differences, natural resource wealth and bureaucratic rent seeking (Fitrani et al., 2005) were the key parameters that influenced this process. Afterwards logging activities increased significantly, partly because deforestation that was considered "illegal" by the central government was considered "legal" by some localities (Casson and Obidzinski, 2002). There is a large gray area between "legal" and "illegal" permits. District governments frequently issue permits which overlap with those issued by neighboring governments, exceed caps imposed by the central government and allow logging in customary forests that were reserved for use by indigenous people. 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.[3]

While the decentralization process allocated a significant portion of timber revenues to local jurisdictions, particularly if compared to their share of income tax and oil and gas revenues (Arnold, 2008), it also empowered local public officials to issue logging permits beyond national control opening new opportunities for corruption and rent seeking (Martini, 2012). 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. The Environmental Investigation Agency, a non-profit organization, 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. Throughout the decentralization process, forest-dependent communities were empowered to exert property rights over customary forest. Heads of districts (*Bupatis*) were initially permitted to issue small-scale forest conversion licenses conditionally to a pre-negotiated agreement between a company and the community, which contributed to the proliferation of

[3]Link: http://www.thejakartaglobe.com/news/indigenous-peoples-vow-to-map-customary-forests/

overlapping permits. In many cases this resulted in communities negotiating directly with logging companies in exchange for financial and social benefits (Engel and Palmer, 2006). Some communities were much more successful in appropriating these benefits from the issuing of permits than others, but the system resulted in a huge proliferation of small-scale licenses (Engel and Palmer, 2006). 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. Moreover, districts continued to negotiate contracts within their borders (Barr et al., 2006). Since 2003, forestry related revenues are shared between district and national governments and accrue through three main channels: a reforestation fund, harvest royalties, and land rents that are usually in the form of licensing fees. While the reforestation fund and harvest royalties are usually tariffs exacted on a per-cubic meter or per-ton harvested basis, the licensing fees are assessed by the hectare of the area. Though the national government has provided some benchmarks for the base tariffs for each channel, the taxation rates vary drastically between districts and even between permitted tracts, as some communities are more successful than others in claiming their share of the benefits.

Indonesia is very ethnically diverse. Its population includes more than 300 ethnic groups and 742 distinct languages and dialects. The majority of these groups are native to the country, and their presence on the islands predates written history. Strong regional identities continue to be prevalent today, which are partly responsible for recent subdivision and splitting of provinces and districts. Ethnic diversity also plays an important role in community decisions and local politics. This latter, in particular, is central to our analysis since the presence of different ethnicities, through the negative effect on social capital, can decrease the ability of the community to punish politicians and protect the forest from illegal extraction by logging companies.

3 A simple model

Our model of illegal logging shares some features with Burgess et al. (2012) but the important difference is that we focus upon ethnic heterogeneity. We assume a large number of logging firms which seek to obtain a permit to log in the representative district. Local governments (heads of districts) decide the number of permits to sell to firms taking the price of wood as given. A bribe is needed to obtain any permit that goes beyond the legal quota set for the district.[4] Ethnic diversity can influence deforestation by decreasing the cost of bribing sustained by politicians. The reason is that control of politicians, through electoral or legal punishment, is a public good tipically under supplied in communities characterized by low social capital which is the case of ethnically fragmented districts.[5] Therefore politicians in fragmented districts facing a lower probability of being punished for being corrupted, have a greater incentive to increase the amount of illegal logging permits issued, thus their "price", the bribe, goes down.

[4]As we mentioned above, in reality the distinction between legal and illegal permit is a bit fuzzy, but for simplicity in the model we assume away this complication.

[5]For example, Nannicini et al. (2013) show that low levels of social capital are associated with a lower tendency to punish politicians misbehavior.

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, considered exogenous, c is the marginal cost of extraction and b is the bribe per unit of wood to be paid to the local politician (head of district). Given the free entry assumption, 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 equilibrium bribe per unit of wood extracted equals the marginal benefit of extraction.

The local politician decides how many permits to allocate and faces the risk of being punished for exceeding the amount of logging permitted by the national government. 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. It is also a decreasing function of the level of ethnic fractionalization EF, i.e. $\phi_{EF}(f-\bar{f}, EF) < 0$ and $\phi_{f,EF}(f-\bar{f}, EF) < 0$. This assumption captures the idea discussed above that legal or electoral punishment of political corruption is lower in more ethnically fragmented districts. The loss for being caught corresponds to all future rents from holding office, r, or, more generally, to a penalty of size r. The local politician solves the following problem:

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

Substituting 3) into the above equation, we obtain:

$$\underset{f}{Max}\, V \equiv f(p - c) - \phi(f - \bar{f}, EF)r \tag{5}$$

Hence the first order condition is:

$$p - c = \phi_f(f - \bar{f}, EF)r \tag{6}$$

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. From equation (6) we can easily derive the effect of an increase in ethnic diversity on the equilibrium number of logging permits as:

$$f_{EF}(EF) = -\frac{\phi_{f,EF}(f - \bar{f}, EF)}{\phi_{ff}(f - \bar{f}, EF)} \tag{7}$$

Recalling that ϕ is convex in f and decreasing in EF, the following proposition holds:

Proposition 1 *More ethnically diverse districts, less able to punish politician misbehavior, render bribing less costly for the politician. As a consequence, the latter releases a larger number of illegal logging permits* *increasing the equilibrium level of deforestation. Formally, in equilibrium* $f_{EF}(EF) > 0$.

In Appendix 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. For instance, Collier and Hoeffler (2004) have established that ethnically diverse communities can coordinate less, hence are less effective in organizing a political battle. In addition ethnic diverse communities have a lower social capital and individuals tend to participate less in social and political activities (Alesina and La Ferrara, 2000) which can be the case also for protests against logging companies. 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.

4 Data

Our measure of deforestation is from Burgess et al. (2012). The data were originally constructed from MODIS sensor and are provided annually for the period 2000-2008 at district (*kabupaten*) and forest-zone level. The forest area is divided into four categories: production, conversion, protection and conservation zones that spread across 305 districts. We consider only districts in the main forest islands of Indonesia: moving from West to East, these are Sumatra, Kalimantan, Sulawesi and Papua. 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 subjected to the granting of a logging permit, in conversion zones authorized companies can clear-cut the forest to set up plantations for industrial timber, oil palm and other estate crops. The rate of deforestation is constructed as the change in forest area during the entire period (i.e. the number of cells likely to have been deforested). Higher values indicate greater deforestation. It is worth noting that while our model describes illegal logging, our dependent variable measures total deforestation that can also be the result of land conversion for agricultural and other purposes, forest fires or other natural causes. In the next section we will discuss how our empirical results can be linked to the predictions of the model.

Table 1: Changes in Forest Cover over Time (2000-2008)

	Forest Area (2000)	Share of Total Forest Area	Forest Area (2008)	Logging (2000-2008)	Share of Total Logging
All Forest	25,374,453	1	24,113,085	-1,261,368	1
Conversion	3,088,789	12.172	2,879,894	-208,895	16.56
Conservation	2,929,277	11.544	2,859,104	-70,173	5.563
Production	9,565,410	37.697	8,998,520	-566,890	44.942
Protection	4,875,925	19.215	4,809,920	-66,005	5.232
Other	4,915,052	19.37	4,565,647	-349,405	27.7

The units of measurement are pixels (1 pixel=6.25 hectares).

Table 1 shows the amount of logging occurred between 2000 and 2008 in each forest zone. The forest area is measured in pixels where one pixel represents an area of 6.25 hectares. Deforestation is high in production and conversion zones that together cover the 50% of the total forest area (in 2000) and contribute to over 60% of the total logging in our sample. The bulk of logging comes from production zones that alone represent the 37% of the forest area and contribute to 45% of total logging. Table 2 displays t he descriptive statistics for our dependent variable representing the number of pixels deforested during the period 2000-2008. Averages at the district and forest zone level confirm previous findings: most of the logging activities take place in production and conversion zones.

Table 2: Summary Statistics by Forest Zone

Zones	Number of districts	Forest Area 2008	Logging(2000-2008)	Average EF
Conversion	148	19,458.74	1,411.453	0.577
		(27,975.19)	(3,059.227)	(0.282)
Conservation	190	15,047.92	369.332	0.543
		(28,236.55)	(1,231.153)	(0.287)
Production	262	34,345.50	2,163.702	0.526
		(59,881.95)	(5,388.869)	(0.286)
Protection	269	17,880.74	245.372	0.492
		(29,322.09)	(607.994)	(0.297)
Other	300	15,218.82	1,164.863	0.506
		(23,609.04)	(2,600.076)	(0.293)
All Forest	1169	20,657.10	1,079.015	0.522
		(37,755.39)	(3,201.498)	(0.291)

Averages by district and forest zone are reported. The units of measurement are pixels (1 pixel=6.25 hectares). Standard deviations in parentheses.

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 Herfindahl index:

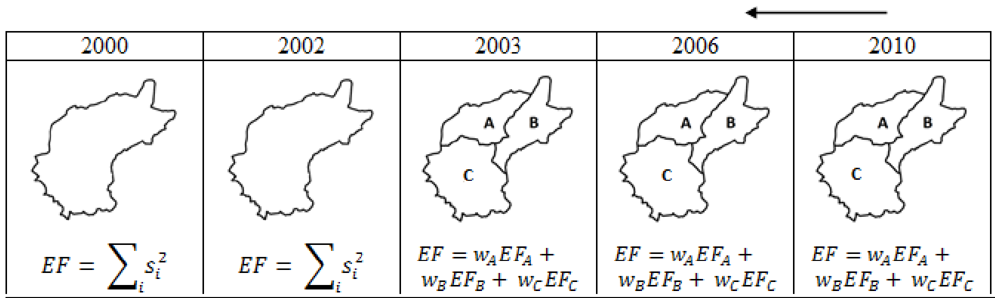
$$EF_i = 1 - \sum s_j^2, \quad (8)$$

where s is the share of ethnic group j over the total population of the district i. 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. Our analysis uses two different units of analysis. The cross section analysis compares deforestation and EF across 305 districts as defined by the 2008 administrative borders. Table 2 shows that the degree of ethnic fractionalization is pretty similar across forest zones. On the other hand, there is significant heterogeneity across districts as shown in the map in Figure 2 of the Appendix. Such heterogeneity in ethnic fractionalization across districts allows us to test the main predictions of the model.

The longitudinal analysis, instead, is based on 188 districts, as designed in 2000, and uses a time-varying measure of ethnic fragmentation. The splitting of districts offers a unique opportunity to observe changes in ethnic fragmentation (EF) over time due to the redrawing of administrative borders. In particular, 60 districts experienced one splitting event while 15 districts experienced 2 splitting events over the period 2000-2008.

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. In the example we considers 3 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. This allows us to

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.

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 have occurred only because of splitting. While migration 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. Nevertheless, using the 2000 census it was possible to construct the actual level of ethnic diversity in 2000. This measure correlates highly (99%) with our "constructed" measure for 2000.[6] This shows that our measure closely resembles pre-splitting

[6] Our results remained unaffected when the actual level of EF in 2000 is used instead of the constructed one.

levels of heterogeneity and suggests that no major changes have affected the distribution of ethnic groups within the 2000 boundaries.

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 3), such as the share of people involved in different land-related activities over the total population obtained from the 2010 population census. 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 include measures of GDP, population and public expenditure obtained from the Indonesia Database for Policy and Economic Research.

5 Ethnic fragmentation and deforestation - cross-section evidence

We begin by estimating the following equation:

$$f_i = \alpha + \beta EF_i + \gamma X_i + \mu_{pi} + \epsilon_i, \quad (9)$$

Table 3: Summary Statistics

Variable	Mean	Std. Dev	min	max	N	Source
Cross section Data						
EF	0.504	0.293	0	0.980	305	2010 Census
Pop_growth	23.928	18.886	2.777	75.409	305	2000 & 2010 Census
Population	271,986.7	248,771.4	23,790	2,049,090	305	2010 Census
Herf. Activities	0.478	0.135	0.005	0.716	305	2010 Census
Elevation (mean)	382.917	403.515	3.680	2,050.292	305	DIVA GIS
Elevation (sd)	296.334	238.807	1.195	1,277.614	305	DIVA GIS
Distance to Sea	0.397	0.382	0.001	2.068	305	DIVA GIS
Share forestry	1.096	3.770	0.015	40.258	305	2010
Share animal husbandry	0.727	1.102	0.042	9.772	305	2010 Census
Share crops	24.759	20.923	0.268	99.508	305	2010 Census
Rivers	3.031	7.969	0	89	305	DIVA GIS
Dummy Javanese	0.816	0.388	0	1	305	2010 Census
Fires	667.491	1,177.028	0	5625	305	Forestry Statistics 2011
Panel Dataset						
GDP (in IDR Million)	3,153,676	4,509,761	112,261	31,373,951	188	INDO-DAPOER
Population	396,934	316,740	24,012	2,369,158	188	INDO-DAPOER
Expenditure (in IDR Million)	369,493	385,015	0	4,010,000	188	INDO-DAPOER
Infrastructure (in IDR Million)	85,713	131,932	391	1,400,000	188	INDO-DAPOER

where f indicates the number of pixels deforested during the period 2000-2008 in district i, EF is our measure of ethnic fractionalization, X is a set of district-level control variables and μ_{pi} are province fixed effects.

Table 4: Deforestation and ethnic diversity by forest zone

	(1) All forest	(2) Conversion	(3) Production	(4) Conservation	(5) Protection	(6) Other
EF	0.846**	1.422*	2.151***	1.079	-0.354	1.300***
	(0.341)	(0.780)	(0.634)	(0.740)	(0.482)	(0.453)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1143	144	256	185	264	294

One observation represents one forest zone in a district. The dependent variable is the logarithm of logging. Controls include population growth and population level. Clustered standard errors at the district level in parentheses, *$p < 0.1$, **$p < 0.05$, *** $p < 0.01$.

Table 4 reports the first set of results for the entire sample and for each forest zone separately. One observation represents one forest zone in a district. In the Appendix we also provide the results where we aggregate deforestation across all forest zones. In that case one observation represents one district. All specifications control for population growth at the province level, population at the district level and province dummies.

Deforestation is higher in more ethnically fractionalized areas and the effect varies across forest zones. In particular, the results show a stronger positive association between ethnic fractionalization and deforestation in conversion and production zones. These are the areas where some commercial logging is allowed subject to a concession from the head of district. In the protection and conservation zones, instead, all logging is strictly illegal. While we do observe logging also in these protected areas, it is most likely driven by small-scale activities while commercial logging companies are most likely to operate in production and conversion areas. Therefore, we expect the mechanism described in our model to hold especially in production and conversion zones where the Bupati is most likely to issue "illegal" logging licenses.[7] The effect is large; a one standard deviation (0.29) increase in ethnic fractionalization leads to a 27% increase in logging across forest zones.

There are several factors that might be correlated with both ethnic diversity and deforestation. We now add several additional control variables to our baseline specification in order to rule out potential confounding effects. In Table 5 controls are included sequentially such that the last panel,

[7]This also implies that the relationship especially holds in zones where the agreements between local communities and logging companies are required by the government which is consistent with the mechanism described in the model in Appendix.

f, includes all of them. In the Appendix we provide the results adding one control at a time and when we aggregate deforestation across forest zones. Our results are robust to different specifications.

5.1 Migration

Indonesia has experienced various transmigration programs 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). After the 2000 financial crisis and the fall of Suharto regime, the government has maintained this program, although on a far smaller scale than in previous decades. This program, therefore, affected the ethnic composition of districts and villages. At the same time, the relocated populations were often provided with land and infrastructure with consequent effects on deforestation (Dewi et al., 2005). While part of these effects should be captured by our measure of population growth, we also control for the presence of Javanese people in the district. Panel a of Table 5 confirms the robustness of the results to the inclusion of this control.

5.2 Political Jurisdictions

Following the findings of Burgess et al. (2012) on the relationship between the increased number of political jurisdictions and deforestation we control for the number of new districts created in a given province since 2000. The positive relationship found by the authors is confirmed in our cross-section setting. The coefficient of ethnic fractionalization remains positive and sig-

Table 5: Additional control variables

	(1)	(2)	(3)	(4)	(5)	(5)
	All forest	Conversion	Production	Conservation	Protection	Other
Panel a: Presence of Javanese						
EF	0.872**	0.950	1.801***	0.896	-0.019	1.487***
	(0.374)	(0.923)	(0.674)	(0.764)	(0.565)	(0.509)
Dummy: Javanese	-0.034	0.560	0.484	0.300	-0.411	-0.240
	(0.239)	(0.626)	(0.440)	(0.482)	(0.322)	(0.296)
Panel b: number of districts						
EF	0.872**	0.950	1.801***	0.896	-0.019	1.487***
	(0.374)	(0.923)	(0.674)	(0.764)	(0.565)	(0.509)
Number of new districts	0.081	0.142**	0.232**	0.609***	0.118*	-0.226***
	(0.073)	(0.058)	(0.106)	(0.103)	(0.065)	(0.086)
Panel c: land-related activities						
EF	1.031***	2.385**	2.048**	0.603	0.259	1.344**
	(0.394)	(1.023)	(0.930)	(0.562)	(0.177)	(0.577)
Share agriculture	0.017	0.017	0.005	-0.019	-0.010	-0.017
	(0.017)	(0.050)	(0.035)	(0.014)	(0.009)	(0.018)
Share forestry	0.047**	0.076**	0.158**	-0.012	0.001	0.019
	(0.021)	(0.035)	(0.071)	(0.011)	(0.008)	(0.014)
Share estate	0.032***	0.046***	0.043**	-0.000	0.002	0.033***
	(0.005)	(0.017)	(0.018)	(0.004)	(0.002)	(0.007)
Share animal	0.171***	0.814*	0.091	-0.084	-0.001	0.085*
	(0.063)	(0.428)	(0.089)	(0.104)	(0.015)	(0.046)
Share crops	0.025***	0.055***	0.021*	0.013*	0.008***	0.016**
	(0.005)	(0.018)	(0.012)	(0.008)	(0.002)	(0.007)
Panel d: diversity in land-related activities						
EF	0.799**	0.931	1.721***	1.018	0.028	1.255**
	(0.373)	(0.960)	(0.658)	(0.759)	(0.563)	(0.493)
Herf. Agriculture	1.247	0.223	1.455	-1.511	-0.996	5.099***
	(0.852)	(2.099)	(1.645)	(1.671)	(1.086)	(1.065)
Panel e: geographic endowments						
EF	0.695*	0.577	1.445**	0.881	0.031	1.124**
	(0.369)	(0.973)	(0.669)	(0.751)	(0.529)	(0.501)
Elevation (mean)	-0.001	-0.002	-0.002**	-0.000	0.001	-0.001**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Elevation (sd)	0.002***	0.003*	0.002	0.002	0.002	0.004***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)
Distance to sea	0.169	-0.190	0.613	-0.480	-0.222	0.548
	(0.277)	(0.509)	(0.485)	(0.606)	(0.423)	(0.501)
Number of rivers	0.038***	0.037***	0.043***	0.060***	0.026**	0.033**
	(0.008)	(0.010)	(0.013)	(0.009)	(0.011)	(0.014)
Panel f: forest fires						
EF	0.695*	0.577	1.445**	0.881	0.031	1.124**
	(0.369)	(0.973)	(0.669)	(0.751)	(0.529)	(0.501)
Forest fires	-0.013	-0.057	0.010	0.071	-0.043	0.078**
	(0.030)	(0.064)	(0.066)	(0.063)	(0.027)	(0.038)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1143	144	256	185	264	294

One observation represents one forest zone in a district. The dependent variable is in thousands of pixels. Controls include population growth and population level. Clustered standard errors at the district level in parentheses, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. All controls are included progressively but only new controls are reported. So each panel includes also the controls in the previous one.

nificant for production zones. This suggests that although, as we show below, ethnic fractionalization is correlated with political fragmentation, the former has additional effects on deforestation. We will address this point below.

5.3 Land Use

Ethnic diversity could potentially be associated to the presence of ethnic groups with particular preferences over land-related activities. In particular, if groups that specialize in certain extensive agricultural practices are more likely to be found in more heterogeneous communities, this could influence our results. To address this potential confounding effect we control for the share of different land-related activities in the district. Activities are categorized as agriculture, forestry and hunting, estate activities (palm, tea, tobacco, rubber), animal husbandry and crop production. Results are reported in Panel c of Table 5. The positive association between ethnic fractionalization and deforestation remains almost unchanged in production and conversion areas. Ethnic diversity could also be associated with a more heterogeneous range of land-related activities with unclear consequences on deforestation. To address this issue we control for the degree of heterogeneity of land-related activities at district level. The evidence reported in Panel d of Table 5 shows that our results are robust to the inclusion of this control.

5.4 Geography

Michalopoulos (2012) established that geographical variability is an important driver of ethnic diversity. Geographical characteristics are likely to have a direct impact on deforestation as well. Hence geography is an additional confounding factor we need to account for. In panel e of table 5 we control for 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. Also in this case the coefficient is reduced but remains large. Considering the results for all type of zones a one standard deviation increase in ethnic fractionalization can lead to an increase in logging of about 15%.

5.5 Forest Fires

Forest fires are recurrent events in Indonesia that destroy hectares of forest every year. While some forest fires are the natural results of extreme summer heats, the majority are initiated by companies and communities to clear large areas of land for plantation of industrial crops. If fires are not contained promptly their can easily spread beyond the targeted area. Forest fires are often associated to corrupted local officials that turn a blind eye to fires starters in exchange for bribes. While there is no expected relationship between the level of ethnic heterogeneity and a more or less widespread use of forest fires, it is worth considering such effect to control for a potential spurious correlation between the causes of deforestation. When we account for the extent of forest fires, the coefficients are unaltered and the results are reported in panel f.

5.6 Summing up

Overall, Table 5 confirms that our results are robust to the inclusion of several control variables and ethnic diversity affects deforestation as predicted by the model. The most robust result we find is the positive impact of ethnic fractionalization on deforestation in production zones where logging companies are most likely to operate and profit sharing arrangements are in place between logging companies and local communities.

6 District splits, ethnic fragmentation and deforestation

In this section we exploit the differential timing of district splits to provide corroborating evidence on the relationship between ethnic fragmentation and deforestation. The analysis employs a district fixed-effects model where we regress logging (f_{it}) on the time-varying level of ethnic diversity (EF_{it}):

$$f_{it} = \beta EF_{it} + \gamma X_{it} + d_t + u_i + \epsilon_{it}, \tag{10}$$

where u_i represents district fixed effects based on 2000 administrative borders. Our identification strategy relies on the exogeneity of the time of splitting with respect to logging, which has been extensively proven in Burgess et al. (2012). District splits provide a unique opportunity to measure changes in EF overtime as newly formed districts show different, always lower, levels of EF. While we do not exclude the influence of internal migration flows, changes in EF are, by construction, only driven by the creation of new jurisdictions and, therefore, not subject to potential confounding effects. Since EF changes only after the splitting and the time of the splitting varies across districts, this exercise can be viewed as a generalization of a diff-in-diff estimation with more than two groups and more than two periods. This specification allows for multiple splitting which we observe in our sample, i.e. 15 districts split twice during the period. We estimate this model using both OLS, where we consider the logarithm of logging as dependent variable, and a Quasi-Poisson estimator. The latter better deals with the presence of zero deforestation (8% of the observations). Robust standard errors are clustered by district to account for arbitrary serial correlation over time within districts.

Table 6: Descriptive statistics of time-varying ethnic fragmentation

	EF	Change in EF	Districts
Districts that split	0.57	-0.050	75
By quintile:			
1	0.093	-0.025	12
2	0.420	-0.077	15
3	0.638	-0.058	19
4	0.756	-0.042	14
5	0.867	-0.030	15
Districts that did not split	0.480		113
All districts	0.534		188

The table reports sample averages. Average changes in EF refers to splitting events.

Table 6 shows that ethnically heterogeneous districts were more likely to split. This is in line with the argument that ethnic fractionalization can increase political fragmentation since each (sufficiently strong) ethnic group tends to create its own jurisdiction. This however, does not constitute a concern for our empirical analysis that relies on the exogeneity of the time of splitting with respect to logging. Moreover, because EF is highly persistent over time, as shown above, the timing of the splitting is also uncorrelated with pre-splitting EF.

The same table also shows that districts at the extremes of the (EF) distribution are the ones experiencing the smallest reductions in ethnic diversity after the splitting (about - 0.03). This might be due to the fact that at very low levels of ethnic diversity, it is the minority group(s) that is more likely to separate and create its own district, leaving the average level of ethnic diversity almost unchanged. At very high levels of fractionalization reducing heterogeneity by splitting may be difficult unless a district is split in many very small ones.

Table 7 reports our results. All specifications include year fixed effects and a dummy for the year of splitting to control for possible confounding events occurring at the time of splitting. For example in the immediate aftermath of the splitting, while competences are re-assigned, deforestation might increase due to a temporary uncertainty on the authority in charge of monitoring.[8]

The first column tests the hypothesis that the creation of new jurisdictions led to an increase in competition for the provincial wood market and increased deforestation as found in Burgess et al. (2012). We find that the effect of an increase in the number of districts within a province on district-level deforestation is larger than what is found in Burgess et al. (2012) at the province level. In column 2 we include our time-varying measure of ethnic

[8] Burgess et al. (2012) show that there is no temporary decline in enforcement by comparing the new (the one with a new capital) and the old part (the one with the previous district capital) of a district after splitting.

Table 7: Ethnic fragmentation, district splits and logging - panel data evidence

Dep. var: logging (log)	(1)	(2)	(3)	(4)	(5)
EF		8.043***	7.820***	7.681***	5.930**
		(2.536)	(2.535)	(2.524)	(2.937)
Number of districts (province)	0.087*	0.108**	0.107**	0.116**	0.128**
	(0.045)	(0.047)	(0.047)	(0.049)	(0.061)
GDP (log)			-1.365**	-1.493**	-0.664
			(0.661)	(0.656)	(0.864)
Population (log)			-0.430	-0.373	-0.498
			(0.657)	(0.641)	(1.192)
Expenditure (log)				0.003	0.006
				(0.006)	(0.006)
Infrastructure exp (log)				-0.067	0.026
				(0.064)	(0.073)
Year FE	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes
Time trend	No	No	No	No	Yes
Observations	1316	1316	1316	1305	1305
Districts	188	188	188	188	188

Robust standard errors clustered at the district level in parentheses, $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. The results are from a log-linear model. All regressions control for a dummy indicating the year of splitting. Districts are defined using the 2000 pre-splitting boundaries. The dependent variable represents the logarithm of the number of pixels deforested. EF is the Herfindhal index of ethnic fragmentation at the district level. The "number of districts (province)" variable counts the number of districts within each province in a given year, where provinces are defined using the 2000 boundaries.

fractionalizaton and find that an increase in EF has a positive and significant impact on deforestation (as shown in our previous cross-section analysis). Since in our case changes in EF after a splitting are always negative (districts always become more homogenous), we can conclude that the reduction in ethnic heterogeneity due to splitting induces a reduction in deforestation. At the same time the coefficient on the number of districts becomes larger. This suggests that omitting EF from the model leads to an underestimation of the competition effect. Indeed an increase in the number of districts in the province is correlated with a decrease in ethnic diversity, which in turn leads to a decrease in deforestation.

In the third and fourth columns we gradually add control variables such as GDP, population, government expenditure and expenditure on infrastructures to deal with potential confounding effects. The separation of a major ethnic group, for instance, could be followed by political turmoil and as a result by a change in public expenditure with ambiguous consequences on deforestation. Considering the results in the last column where we include all controls, we find that the median change in EF for districts that split (-0.029) would induce a decrease of 17% in deforestation due to decreased ethnic diversity. This can be compared to a 12% increase in deforestation due to increased competition when the splitting results in the creation of one more district. However, we observe a wide range of changes. When we consider the entire distribution of changes in EF and the number of districts created during each split, in 52% of the splitting events the negative effect of a decrease in EF prevails on the positive effect of increased competition. This evidence highlights the presence of heterogeneous effects of the splitting across districts, depending on their ethnic composition. Notice that these results are still compatible with an overall positive impact of splitting on deforestation at the province level as found in Burgess et al. (2012). The comparison between our district-level results and the province level effects is complex. For example, while a decrease in EF might affect mostly within-district deforestation[9], the competitive effects caused by a splitting ought to

[9] We do not consider potential spillover effects across districts so we cannot infer the overall effect at the province level.

have an impact also on deforestation in other districts.

In the previous specification we have studied the contemporaneous effect of ethnic diversity. In the next specification we account for different dynamics. First, it is reasonable to expect a lagged effect if we believe that institutions take some time to adjust to the new order. Second, the effect of a change in ethnic diversity might last longer than just one year, therefore we also study what happens in the medium run. In Table 8 we show the results of the individual lagged effect of EF and a distributed lagged model with one and two lags respectively.

Table 8: Changes in EF and logging: lagged effects

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) Poisson	(6) Poisson
EF (sum of L0 - L1)	6.515***		7.649**		7.329*	
	(2.433)		(3.056)		(4.484)	
Number of districts (sum of L0 - L1)	0.115**		0.108		0.097	
	(0.057)		(0.088)		(0.062)	
EF (sum of L0 - L2)		7.135***		10.231***		7.910**
		(2.570)		(3.528)		(4.023)
Number of districts (sum of L0 - L2)		0.144**		0.178		0.082
		(0.061)		(0.113)		(0.077)
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Island FE	Yes	Yes	Yes	Yes	Yes	Yes
District time-trends	No	No	Yes	Yes	Yes	Yes
Observations	1316	1316	1316	1316	1295	1295
Districts	188	188	188	188	188	188

Robust standard errors clustered at district level in parentheses, $*p < 0.1$, $**p < 0.05$, $***p < 0.01$. All regressions control for the year of splitting, GDP, expenditure and population. Columns 3-6 control for pre-splitting trends in population and forest cover. Districts are defined using the 2000 pre-splitting boundaries. The dependent variable represents the number of pixels deforested. In columns 1 - 4 the dependent variable is in logarithm. EF is the Herfindhal index of ethnic fragmentation at the district level. The number of districts in province variable counts the number of districts within each province in a given year, where provinces are defined using the 2000 boundaries.

Table 8 reports the sum of the immediate effect and the lagged effects of both EF and the number of districts at the province level. Considering column 3 and 4 where we include all controls, the coefficient shows the impact of a change in EF one and two years, respectively, after the splitting. The effect is larger in particular when considering the longer time span. The impact of the number of districts is also larger when considering two lags but is marginally insignificant. Results indicate that one year after the splitting a median change in EF would induce a decrease of almost 22% in deforestation. Two years after the splitting the impact reaches 29%. Looking at the entire distribution of changes in EF observed over the period, in 57% of the splitting events the effect of a decrease in EF prevails on the effect of increased competition, also over a two-year period. Results by forest zones are reported in Table 14 of the Appendix. The effects are more prominent within conversion, protection and other areas. The fact that we find an effect also in areas where no legal logging takes place indicates that the results are not just driven by changes in the allocation of deforestation quotas across districts. On the other hand, the lack of significant effects in production zones might be explained by changes in the actual demarcation of forest zones concomitant with the splitting. While the creation of new jurisdictions could have affected the design of forest zones boundaries, our data on forest zones do not capture changes in land allocation over time due to lack of information. This could create a potential discrepancy between actual and recorded forest zones that is more likely in districts that split.

7 Control of politicians

In this section we focus upon the control of politicians through electoral punishment as highlighted in our stylised model. Voting is of course an individual decision but diffusion of information among voters, political activities or social propaganda against the incumbent, is a public good under supplied in communities characterized by low social capital which is the case of ethnically fragmented communities. Thus according to our theory politicians misbehaviour is less likely to be punished in heterogeneous districts. We assume that the share of illegal logging increases with total logging[10] and voters dislike illegal logging. Therefore we consider exceptionally high levels of deforestation as a signal of politicians' bad behaviour.

Skoufias et al. (2014) provide a comprehensive description of local elections in Indonesia. In the pre-1999 Soeharto era district heads (Bupatis) were appointed by the regime. The decentralization law (Law 22), passed in 1999, stipulated that district heads were to be indirectly elected by local parliament. The following law on regional autonomy (Law 32), passed in 2004, established that district heads had to be elected directly by the population. Therefore direct elections of Bupatis 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. In our sample we know the incumbent status of the candidates running

[10] This assumption stems from the fact that any logging beyond the legal boundary is to be considered illegal.

for reelection and so we can study the probability of reelection as a function of Bupati's misbehaviour. We start by studying whether logging is subject to political cycles, such that its level changes close to the election date of the district head and whether we observe a different pattern in ethnically heterogeneous districts. As discussed in Burgess et al. (2011), pre-election logging can be used by the incumbent politician as other sources of public revenues to finance the campaign, to try to extract as much as possible while still in office or as a way to buy votes by redistributing logging revenues. This "bad behavior" should be higher with lower control of politicians in more diverse districts.

Since the date of election can be considered exogenous to the level of logging, we estimate 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 9. Column 1 confirms as in Burgess et al. (2011), the presence of logging cycles showing that deforestation increases in the proximity of elections.

However when we split the sample in high and low heterogeneous districts (defined as above or below the average ethnic fractionalization) we find that this effect is only present in districts with a high level of ethnic diversity.

We now investigate what happens to the incumbents reelection probabil-

Table 9: Logging and elections

	(1) Whole sample	(2) EF above mean	(3) EF below mean
Election year	0.1554	0.3124*	-0.0515
	(0.311)	(0.056)	(0.863)
Lead 1	0.2437*	0.4042**	0.0402
	(0.081)	(0.020)	(0.861)
Lead 2	0.3915***	0.4658***	0.2767
	(0.001)	(0.002)	(0.158)
Lag 1	0.2104	0.3511	0.0366
	(0.263)	(0.137)	(0.910)
Lag 2	0.2564	0.3260	0.1262
	(0.187)	(0.202)	(0.694)
Year FE	Yes	Yes	Yes
District FE	Yes	Yes	Yes
Observations	2488	1464	1024
Districts	311	183	128

Clustered standard errors at the district level in parentheses, $*p < 0.1$, $**p < 0.05$, $***p < 0.01$. A unit of observation is a district based on post-splitting 2008 borders. EF is the Herfindhal index of ethnic fragmentation at the 2008 district level. In column 2 and 3 districts are divided into two groups based on the level of EF.

ity as a function of logging. The estimated equation is the following:

$$Reelection_i = \gamma \tilde{f}_i + \beta \tilde{f}_i * EF + \delta EF + \zeta oil\&gas_i + p_i + t_i + \epsilon_i, \qquad (12)$$

where *Reelection* indicates the probability of reelection of the incumbent head of district i and $\tilde{f}$ is our measure of exceptionally high levels of deforestation in the year prior to the elections. In particular, we compute the average level of deforestation over the whole period (2001- 2008) and over the pre-election period (2001- year of election), in both cases excluding the year prior to the elections, and consider the difference between the level of deforestation in the year before the election and these averages.[11] This leaves us with two measures of incumbent's misbehaviour.

We then interact these measures with the level of ethnic fractionalization EF at the time of elections. We control for oil and gas revenues, $oil\&gas$, received by the district in the year of election.[12] We do so since Burgess et al. (2012) finds that $oil\&gas$ revenues influence the number of candidates running in the elections and also the level of logging since politicians tend to substitute between different sources of rents, at least in the short run. In any case our results of interest hold even when excluding oil and gas revenues.[13] We also include province fixed effects, p, and year of election fixed effects, t, in order to control for common province and time unobservable characteristics.

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. Results in Table 10 confirm this argument.

Columns 1 and 2 report the results for the two measures of incumbent Bupati's misbehaviour. Both columns show that on average a higher level of pre-election logging has no effect on the probability of re-election. However when we include the interaction between the pre-election deviation in

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

[12] Oil and gas revenues per capita at the district level come from Burgess et al. (2012). The revenues data were originally obtained from the Indonesian Ministry of Finance webpage (http://www.djpk.depkeu.go.id/datadjpk/57/) and the population data for 2008 from the Indonesian Central Bureau of Statistics.

[13] Results are available upon request.

Table 10: Logging and elections

Dep. var: re-election = 1, 0 otherwise	(1)	(2)	(3)	(4)
Dev. from avg deforestation	-0.0000		-0.0007**	
	(0.912)		(0.024)	
Dev. from avg deforestation (pre-election)		0.0000		-0.0004
		(0.440)		(0.161)
EF			0.2900**	0.2785**
			(0.040)	(0.048)
(Deviation from avg) X (EF)			0.0010**	
			(0.027)	
(Deviation from avg pre-elec) X (EF)				0.0006*
				(0.097)
Oil & gas revenues	0.0006	0.0004	0.0006	0.0004
	(0.261)	(0.425)	(0.185)	(0.321)
Year FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Districts	242	242	236	236

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-elections. A unit of observation is a district, based on post-splitting 2008 borders, where the candidate is an incumbent. EF is the Herfindhal index of ethnic fragmentation at the 2008 district level. The two deviations from average deforestation variables capture exceptionally high levels of deforestation in the year prior to the election.

deforestation and the level of ethnic diversity 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. Back on the envelope calculations show that the latter actually happens in 27% of the districts.

8 Conclusions

This paper studies the relationship between ethnic diversity and deforestation in Indonesia. Our model predicts that in a corrupt environment, where local politicians receive bribes from logging companies in exchange of logging permits, areas characterized by high ethnic diversity experience more deforestation. Empirically we find that this is indeed the case: ethnically fractionalized areas display more deforestation than their more homogenous counterparts after controlling for a variety of possible confounding factors, including several geographic and socio-economic controls. We are able to exploit the exogenous timing of variations in ethnic diversity due to the splitting of jurisdictions and document a casual relation between ethnic fractionalization and deforestation. We also provide evidence consistent with one of the channels that may link ethnic fractionalization and deforestation in the context of Indonesian institutional and socio-political background. In particular, we find that more ethnically fragmented districts experience higher degree of corruption due to less control of politicians through electoral punishment leading to greater deforestation. Our results shed new light on the political economy of deforestation. A previous work by Burgess et al. (2012) highlights the negative effect of decentralization on deforestation, which has led some researchers to conclude that centralization might be desirable to reduce logging. This paper, instead, suggests that when the underlying communities are ethnically fragmented, decentralization in natural resource management can reduce the scope for rent seeking behavior. 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. The optimal size of a community from the point of view of deforestation depends upon a trade off between size and heterogeneity of its population.

Appendix

A Additional Channels

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 3 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*).[14] 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.

A.0.1 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:

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

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.

[14] 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.

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:

$$\pi_C^C = q(EF)U(\bar{F}) + (1 - q(EF))U(\bar{F} - f) \tag{A-2}$$

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:

$$\underset{f}{Max}\ \pi_{NC}^L(f) \equiv pf(1 - \alpha) - cf - bf \tag{A-3}$$

$$s.t.\ \pi_{NC}^L(f) = 0\ and\ U(\bar{F} - f) + \alpha pf \geq \pi_C^C \tag{A-4}$$

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.

A.0.2 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:

$$\underset{f}{Max}\, V \equiv bf - \phi(f - \bar{f})r \tag{A-5}$$

which substituting with the expression for b, becomes:

$$\underset{f}{Max}\, V \equiv f(p-c) - q(EF)[U(\bar{F}) - U(\bar{F}-f)] - \phi(f-\bar{f})r \qquad \text{(A-6)}$$

Hence the first order condition is:

$$p - c - q(EF))U_F(\bar{F}-f) \;\; = \;\; \phi_f(f-\bar{f})r \qquad \text{(A-7)}$$

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:

$$f_{EF}(EF) = -\frac{-q_{EF}(EF)U_F(\bar{F}-f)}{q(EF)U_{FF}(\bar{F}-f) - \phi_{ff}(f-\bar{f})r} \qquad \text{(A-8)}$$

Given the denominator is negative[15] 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

[15]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 $U()$.

politician raises the number of logging permits and the equilibrium level of deforestation increases.

A.0.3 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:

$$\underset{f}{Max}\ V \equiv f(1 - q(EF))(p - c) - \phi(f - \bar{f})r \tag{A-9}$$

Hence the first order condition is:

$$(1 - q(EF))(p - c) \quad = \quad \phi_f(f - \bar{f})r \tag{A-10}$$

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:

$$f_{EF}(EF) = -\frac{q_{EF}(EF)(p - c)}{\phi_{ff}(f - \bar{f})r} \tag{A-11}$$

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.

A.1 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 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:

$$p(1 - \alpha(EF)) - c = \phi_f(f - \bar{f})r \tag{A-12}$$

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

$$f_{EF}(EF) = -\frac{\alpha_{EF}(EF)p}{\phi_{ff}(f - \bar{f})r} \tag{A-13}$$

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* $f_{EF}(EF) > 0$.

B Additional Results

Table 11: Additional controls included one at a time

	(1)	(2)	(3)	(4)	(5)	(5)
	All forest	Conversion	Production	Conservation	Protection	Other
Panel a: Presence of Javanese						
EF	0.872**	0.950	1.801***	0.896	-0.019	1.487***
	(0.374)	(0.923)	(0.674)	(0.764)	(0.565)	(0.509)
Dummy: Javanese	-0.034	0.560	0.484	0.300	-0.411	-0.240
	(0.239)	(0.626)	(0.440)	(0.482)	(0.322)	(0.296)
Panel b: number of districts						
EF	0.846**	0.988*	2.086***	0.110	-0.045	1.061***
	(0.341)	(0.510)	(0.711)	(0.501)	(0.116)	(0.399)
Number of new districts	0.081	0.056**	0.024	0.079***	0.039***	-0.036
	(0.073)	(0.025)	(0.068)	(0.027)	(0.011)	(0.031)
Panel c: land-related activities						
EF	1.226***	2.915***	1.863**	0.616	0.201	1.296**
	(0.391)	(1.108)	(0.822)	(0.577)	(0.145)	(0.520)
Share agriculture	0.016	0.004	0.006	-0.020	-0.010	-0.017
	(0.017)	(0.044)	(0.034)	(0.014)	(0.008)	(0.018)
Share forestry	0.050**	0.080**	0.156**	-0.011	0.001	0.018
	(0.021)	(0.036)	(0.070)	(0.011)	(0.009)	(0.014)
Share estate census 2010	0.031***	0.043**	0.044**	-0.000	0.002	0.033***
	(0.005)	(0.017)	(0.018)	(0.004)	(0.002)	(0.007)
Share animal census 2010	0.164***	0.800*	0.103	-0.082	0.001	0.087*
	(0.062)	(0.418)	(0.086)	(0.111)	(0.015)	(0.045)
Share crops	0.023***	0.046***	0.022*	0.013	0.008***	0.016**
	(0.005)	(0.015)	(0.012)	(0.008)	(0.003)	(0.007)
Panel d: diversity in land-related activities						
EF	0.698**	1.159*	1.927**	0.228	0.057	0.909**
	(0.339)	(0.619)	(0.785)	(0.384)	(0.116)	(0.410)
Herf. Agriculture	1.141	-0.621	1.483	-0.829	-0.915**	1.536*
	(0.819)	(1.483)	(2.324)	(1.595)	(0.368)	(0.894)
Panel e: geographic endowments						
EF	0.743**	0.343	1.644**	-0.021	0.019	0.947**
	(0.340)	(0.441)	(0.701)	(0.307)	(0.110)	(0.429)
Elevation (mean)	-0.001	0.000	-0.001	0.000	0.000	-0.001***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
Elevation (sd)	0.002***	-0.000	0.001	0.000	0.000	0.002**
	(0.001)	(0.001)	(0.002)	(0.002)	(0.000)	(0.001)
Distance to sea	0.092	-1.046	-2.425	-0.214	-0.113	0.937*
	(0.275)	(0.898)	(1.587)	(0.273)	(0.246)	(0.495)
Number of rivers	0.039***	0.048**	0.032	0.068**	0.005	0.026**
	(0.008)	(0.022)	(0.025)	(0.031)	(0.005)	(0.011)
Panel f: forest fires						
EF	0.846**	0.988*	2.086***	0.110	-0.045	1.061***
	(0.341)	(0.510)	(0.711)	(0.501)	(0.116)	(0.399)
Forest fires	0.028	0.020**	0.008	0.027***	0.013***	-0.012
	(0.025)	(0.009)	(0.024)	(0.009)	(0.004)	(0.011)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1143	144	256	185	264	294

One observation represents one forest zone in a district. The dependent variable is in thousands of pixels. Controls include population growth and population level. Clustered standard errors at the district level in parentheses, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 12: Regressions at district level: all forest, all controls progressively

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
EF	0.477***	0.530**	0.530**	0.640**	0.505**	0.434*	0.434*
	(0.160)	(0.220)	(0.220)	(0.290)	(0.219)	(0.221)	(0.221)
Dummy: Javanese		-0.068	-0.068	0.135	-0.101	-0.063	-0.063
		(0.114)	(0.114)	(0.123)	(0.123)	(0.153)	(0.153)
Number of new districts			0.002	-0.023	0.004	-0.021	0.043***
			(0.018)	(0.028)	(0.019)	(0.023)	(0.014)
Share agriculture				-0.009			
				(0.008)			
Share forestry				0.039**			
				(0.015)			
Share estate				0.018***			
				(0.003)			
Share animal husbandry				0.047*			
				(0.023)			
Share crops				0.015***			
				(0.003)			
Herf. Agriculture					0.433	0.250	0.250
					(0.554)	(0.521)	(0.521)
Elevation (mean)						-0.001**	-0.001**
						(0.000)	(0.000)
Elevation (sd)						0.001***	0.001***
						(0.000)	(0.000)
Distance to sea						0.182	0.182
						(0.329)	(0.329)
Number of rivers						0.024***	0.024***
						(0.006)	(0.006)
Forest fires							-0.004*
							(0.002)
Pop growth	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pop level	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	305	305	305	305	305	305	305

One observation represents one district. The dependent variable is in thousands of pixels. Controls include population growth and population level. Clustered standard errors at the province level in parentheses, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 13: Regressions at district level: all forest, one control at a time

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
EF	0.477***	0.530**	0.477***	0.717**	0.433**	0.405**	0.477***
	(0.160)	(0.220)	(0.160)	(0.264)	(0.163)	(0.169)	(0.160)
Dummy: Javanese		-0.068					
		(0.114)					
Number of new districts			-0.001				
			(0.016)				
Share agriculture				-0.009			
				(0.008)			
Share forestry				0.040**			
				(0.015)			
Share estate				0.018***			
				(0.003)			
Share animal husbandry				0.044*			
				(0.024)			
Share crops				0.014***			
				(0.003)			
Herf. Agriculture					0.376		
					(0.573)		
Elevation (mean)						-0.001**	
						(0.000)	
Elevation (sd)						0.001**	
						(0.000)	
Distance to sea						0.165	
						(0.323)	
Number of rivers						0.025***	
						(0.006)	
Forest fires							-0.000
							(0.001)
Pop growth	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pop level	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	305	305	305	305	305	305	305

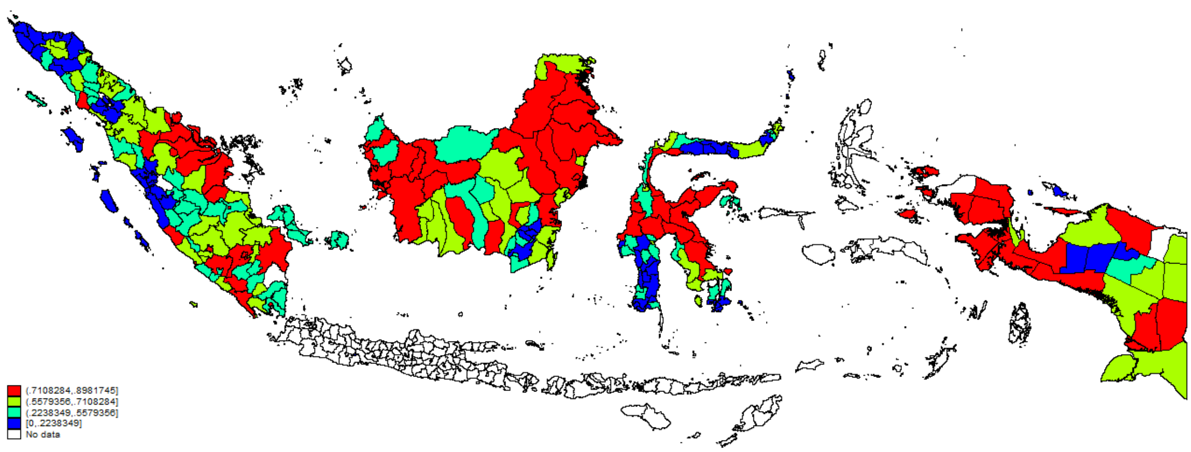
One observation represents one district. The dependent variable is in thousands of pixels. Controls include population growth and population level. Clustered standard errors at the province level in parentheses, *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Table 14: Ethnic fragmentation, district splits and logging - panel data evidence by forest zones

Dep var = Logging (log)	(1) All forest	(2) Conversion	(3) Production	(4) Conservation	(5) Protection	(6) Other
EF	10.848***	10.198*	4.707	12.304	12.216**	5.779*
	(0.000)	(0.095)	(0.396)	(0.214)	(0.011)	(0.093)
Number of district	0.176***	0.281**	0.076	0.145	0.400***	0.071
	(0.000)	(0.039)	(0.528)	(0.335)	(0.000)	(0.346)
EF (sum L0 - L2)	9.470***	4.828	4.587	13.359	12.083*	9.456***
	(0.009)	(0.532)	(0.430)	(0.220)	(0.066)	(0.007)
Number of district	0.151**	0.175	0.025	0.247	0.345**	-0.026
(sum L0 - L1)	(0.048)	(0.430)	(0.865)	(0.253)	(0.025)	(0.804)
EF (sum L0 - L1)	12.238**	2.598	4.089	16.347	21.096**	11.047**
	(0.013)	(0.838)	(0.598)	(0.165)	(0.010)	(0.021)
Number of district	0.276**	0.250	0.004	0.408	0.643***	0.097
(sum L0 - L1)	(0.015)	(0.377)	(0.984)	(0.196)	(0.001)	(0.477)
District-forest zone FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
District - Time trend	No	Yes	Yes	Yes	Yes	Yes
Observations	5082	616	1127	875	1155	1309

Robust standard errors clustered at the district level in parentheses, $*p < 0.1$, $**p < 0.05$, $***p < 0.01$. The results are from a log-linear model. All regressions control for the year of splitting, GDP, expenditure and population and pre-splitting trends in population and forest cover.

Figure 2: Ethnic Diversity across Indonesian Districts (2006).



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