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Public Goods and Ethnic Diversity: Evidence from Deforestation in Indonesia*

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Abstract

We show that the level of deforestation in Indonesia is positively correlated with the degree of ethnic fractionalization of the communities. We explore several channels that may link the two variables. They include the negative effect of ethnic fractionalization on the ability to coordinate and organize resistance against logging companies and a higher level of corruption of politicians less controlled in more fragmented communities.

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 logging companies at the expenses of local populations.

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This paper studies the relationship between deforestation in Indonesia and the characteristics of local populations. In particular, we show a robust correlation between ethnic diversity of local communities and deforestation in Indonesia. We provide support for several possible channels linking ethnic fractionalization to deforestation. One is through the detrimental effect of fractionalization on social capital, trust, participation in communal activities and protection of public goods[1]. Forests are public goods for the local communities and they may need to defend them from excessive exploitation from logging companies. Low social capital interferes with the community ability to organize and lowers their ability to extract compensations from the logging companies making it cheaper for the latter to increase deforestation. In addition, ethnic fractionalization is correlated with corruption of elected politicians, who are less controlled and less responsive to local needs in fragmented societies. Finally, more ethnically diverse regions are more likely to split in smaller and more numerous jurisdictions[2]. Thus our paper relates to Burgess et al. (2012) who convincingly show how an increase in the number of political jurisdictions has increased deforestation in Indonesia. We add to Burgess et al. (2012) the idea that the level of ethnic heterogeneity is both a determinant of political fragmentation and has other additional effects on deforestation and logging.

We characterize the process as follows. Following the decentralization process started in 1998, district governments required logging companies to stipulate profit sharing arrangements with local communities as a form of compensation for the use of the forest (Barr et al., 2006). The amount of the payment is established through a negotiation between the company and the community. In case the negotiation fails, the community enters into a conflict with the company to stop the logging activity. To avoid the fight and reach an agreement the company compensates the community at least up to the latter's reservation utility corresponding to the expected utility that the community enjoys from the forest. We argue that ethnic heterogeneity can decrease the reservation utility of the community because fragmented communities facing coordination problems are less able to fight against the logging companies in case they offer an unfair compensation. This possibility 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 (Alesina

[1] On the positive role of social capital in the development of localities and their ability to provide public goods, including protection from adversaries see Banfield (1958), Putnam et al. (1993) and Guiso et al. (2013).

[2] See Alesina et al. (2004) for the case of US cities.

and La Ferrara, 2000). Other studies (Alesina et al., 1999; Alesina and La Ferrara, 2000, 2002, 2005) have shown that public goods shared among different ethnic groups provide a lower utility and that ethnic diversity can lead to negative economic outcomes (Easterly and Levine, 1997; La Porta et al., 1999; Alesina et al., 2003). Thus in our framework ethnically diverse communities, having a low reservation utility, are able to obtain a lower payment by logging companies. As a consequence, the local politician taking into account that she can extract a higher share of revenues from the logging company as a bribe, has the incentive to increase the total number of logging permits. The result is that deforestation is increasing in the level of ethnic diversity.

First, 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, we find evidence supporting our main hypothesis. The empirical results show that ethnic fractionalized areas display more deforestation. This effect is stronger and significant in production and conversion areas, the only areas where logging is legal and arrangements are required between logging companies and the local communities. The results are robust to the inclusion of a full set of potential confounding factors. Second, we empirically test several channels through which ethnic diversity can influence deforestation including its effect on social capital and corruption.

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 some of the possible links between ethnic heterogeneity and deforestation. Section 4 describes the data. Sections 5 presents the basic empirical results. Section 6 investigates the channels linking ethnic fractionalization to deforestation. The last section concludes.

2 Institutional Background

The fall of the Suharto regime in 1998 initiated a decentralization process that involved many aspects of the economic and political system of Indonesia. 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 local governments (Casson and Obidzinski, 2002). It should be noted that the distinction between "legal" and "illegal" permits is not always clear, with a large "grey area" in the law. District governments frequently issue permits that 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 indigenous people mapping efforts, 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 for issuing illegal licenses to 15 logging companies.

Throughout the decentralization process, forest-dependent communities were empowered to exert property rights over customary forest. District officials 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 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

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

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.

As it is well known, Indonesia is very ethnically diverse. More than 300 ethnic groups and 742 distinct languages and dialects make up the population of Indonesia. 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 can affect a community involvement in forest management. For example, Okten and Osili (2004) find that ethnic diversity across Indonesia and the consequent heterogeneity in preferences within communities has a negative impact on the contributions and prevalence of community organizations.

3 Theory

3.1 The basic set up

We set up a stylized model to guide the empirical analysis. This is a model of illegal logging which shares some features with the framework developed by Burgess et al. (2012). The main difference with respect to their model, is that we introduce and focus upon the level of ethnic heterogeneity.

We assume that there exists a large number of logging firms which seek to obtain a permit to log. Local governments 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. In reality, as we discussed above, the legal boundary is not clear. We describe three channels linking ethnic fractionalization and deforestation. The first is the ability to fight against logging companies. For instance, Collier and Hoeffler (2004) have established that ethnically diverse communities can coordinate less and so are less effective in organizing a conflict. Ethnic diverse communities have also 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 the ability of fragmented communities to control and punish the politicians who issue illegal logging permits. For example, Nannicini et al. (2013) have shown that low levels of social capital are associated with a lower tendency to punish politicians misbehavior. The third 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.

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. 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.

3.1.1 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:

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

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.

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:

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

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:

$$\underset{f}{Max}\ \pi_{NC}^L(f) \equiv pf(1 - \alpha) - cf - bf \tag{2}$$

$$s.t.\ \pi_{NC}^L(f) = 0\ and\ \alpha pf \geq \pi_C^C$$

where the subscript NC indicates "no conflict". The profit of the logging company incorporates 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. 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: $b = p - c - \frac{q(EF)U(\bar{F})+(1-q(EF))U(\bar{F}-f)}{f}$. Comparing (1) and (2), and plugging in the expression for b, it is straightforward to pin down the condition under which the company prefers the agreement to the conflict. In particular, the logging company pays exactly the reservation utility to the community and the negotiation succeeds whenever:

$$q(EF)f(p - c) > q(EF)U(\bar{F}) + (1 - q(EF))U(\bar{F} - f) \tag{3}$$

This condition implies that the company stipulates the agreement with the community if the expected foregone revenues under conflict are greater than the expected foregone revenues under negotiation. When condition (3) is satisfied, the company chooses the agreement and needs to compensate the community with its reservation utility, namely the expected payoff of the community under conflict. Hence the compensation payment will be: $\pi_C^C =$

$q(EF)U(\bar{F}) + (1 - q(EF))U(\bar{F} - f)$, which 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. 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.

3.1.2 Equilibrium bribe

The local politician decides how many permits to sell to the companies, facing a probability of detection $\phi(f - \bar{f})$, which is a convex function of the difference between the number of illegal permits issued and the legal quota, $\bar{f}$, set for the district[4]. 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:

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

which substituting with the expression for b, becomes:

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

Hence the first order condition is:

$$p - c + (1 - q(EF))U_F(\bar{F} - f) \quad = \quad \phi_f(f - \bar{f})r \tag{4}$$

Equation (4) implies that in equilibrium the politician issues an amount of permits such that the net marginal benefit of issuing an additional permit (left hand side) is equal to the marginal cost (right hand side). The marginal benefit has two components; the first captures the effect of an additional permit on the expected revenues from logging, while the second component represents the effect of an additional permit on the total compensation benefit paid to the community. This result is very intuitive; an increase in the size of the logging area increases the expected revenues from logging. At the same time, it decreases the reservation utility of the community which

[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.

in case of a defeat under the conflict scenario ends up enjoying a smaller forest area. Therefore the release of an additional logging permit decreases the amount of revenues the community needs to be compensated with. As a result, the bribe the company is willing to pay to the politician increases and the latter has the incentive to issue more illegal permits. From equation (4) 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:

$$f_{EF}(EF) = -\frac{-q_{EF}(EF)U_F(\bar{F}-f)}{-(1-q(EF))U_{FF}(\bar{F}-f) - \phi_{ff}(f-\bar{f})r} \qquad (5)$$

Given the denominator is negative[5] 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 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 $f_{EF}(EF) > 0$ holds.*

Equation (5) also indicates that the effect of ethnic fragmentation on deforestation is higher in areas where some logging is permitted ($\bar{f} > 0$), while the effect becomes small where all logging is illegal and it is more costly for the politician to release logging permits. In this section we have shown that ethnic fragmentation increases deforestation in two ways. First, given that fragmented communities are less effective in fighting against the logging companies, agreements between the two are less frequent and the community has no voice on the use of the forest. Under this scenario the companies pay a high bribe to the politician which has the incentive to release more logging permits, in turn increasing deforestation. Second, even when the company decides to go 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.

[5]The denominator represents the second order condition of the maximization problem thus it has to be negative at the optimum.

3.2 A second channel: Control of Politicians

Ethnic diversity can influence deforestation by decreasing the cost of bribing sustained by politicians. In particular, politicians facing a lower probability of being punished for being corrupted, have a greater incentive to increase the amount of illegal logging permits issued. The reason is that control of politicians, through electoral or legal punishment, is a public good under supplied in communities characterized by low social capital which is the case of ethnically fragmented communities.

Assume that the politician's probability of getting caught, $\phi()$, is a decreasing function of ethnic fractionalization, i.e. $\phi(f-\bar{f}, EF)$, with $\phi_{EF}(f-\bar{f}, EF) < 0$ and $\phi_{f,EF}(f-\bar{f}, EF) < 0$. This assumption changes the problem solved by the politician. Including the new cost function in the politician's objective function, we can derive the first order condition:

$$p - c + (1-q)U_F(\bar{F} - f) = \phi_f(f - \bar{f}, EF)r$$

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

$$f_{EF}(EF) = -\frac{\phi_{f,EF}(f-\bar{f}, EF)}{-(1-q)U_{FF}(\bar{F}-f) - \phi_{ff}(f-\bar{f}, EF)r} \tag{6}$$

Recalling that ϕ is decreasing in EF and the denominator is negative[6], the second proposition follows:

Proposition 2 *More ethnically diverse communities, 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* $f_{EF}(EF) > 0$ *holds.*

3.3 A third 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

[6] This results is derived from the second order condition.

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, 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:

$$p(1 - \alpha(EF)) - c \quad = \quad \phi_f(f - \bar{f})r \tag{7}$$

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

$$f_{EF}(EF) = -\frac{\alpha_{EF}(EF)p}{\phi_{ff}(f - \bar{f})r} \tag{8}$$

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

Proposition 3 *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* $f_{EF}(EF) > 0$ *holds.*

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. 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.

We measure ethnic fractionalization at the district level using the 2010 Indonesian Census (10% of the population) provided by IPUMS. Incidentally for some channels, like the ability to mobilize for struggles against logging companies, fragmentation at the community level might seem the more relevant level of analysis. However, often several villages are likely to be involved in the negotiations making a more aggregated measure of ethnic fractionalization a more suitable indicator of bargaining power[7]. Moreover, we observe that village-level heterogeneity resembles quite well the level of diversity at the district level. In particular, we compare the village/community-level index of ethnic fractionalization from Olken (2006), which was constructed using disaggregated information at village (desa) level from the 2000 Indonesia census for a subsample of districts, with our district-level counterpart. We find a strong positive correlation (0.58) between the two measures. Although average ethnic fractionalization is lower at the village level, heterogeneity within villages is substantial indicating a relatively low level of segregation.

We construct a Herfindahl index using the following equation:

$$EF_i = 1 - \sum s_j^2, \tag{9}$$

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 that can be interpreted as the probability that two individuals randomly drawn from the population belong to two different ethnic groups.

[Table 1 about here.]

We also use several control variables (descriptive statistics and relative sources are reported in Table 1), such as the share of people involved in different land-related activities over the total population obtained from the

[7]Nine villages in the Kampar Peninsula in central Sumatra, for example, have joint their effort in stopping the dubious "legal logging" of the Asia Pacific Resources International Limited (APRIL) paper company (Vidal, 2013).

2010 population census. A set of variables capturing geographic and ecological endowments 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 provided by the 2011 Forestry Statistics of Indonesia for the period 2007-2011.

Social capital is measured using community-level data from the 2007 wave of the Rand Indonesian Family Life Survey (IFLS). The survey is representative of about 83% of the Indonesian population and contains over 30,000 individuals living in 16 of the 27 provinces in the country. We consider participation rates in community activities, turnout rates and trust. Community events include: community meetings, cooperatives, voluntary labor, programs to improve the village, youth group activities, village library, Women Association activities, Neighborhood Security Organization. We construct turnout rates in elections for the head of the province (vote_prov), the head of the village (vote_villagehead) and all types of elections (vote_all). Finally, trust is measured using survey responses to whether individuals "feel safe in the village", "have to be alert otherwise someone is likely to take advantage of them", and "would ask the neighbors to look after their house if leaving for few days". Our variables indicate the share of the village population in agreement with the above statements.

Finally, we measure corruption using two sets of data; the first is a perception-based survey done by KPPOD/Asia Foundation in 2007 that studies the business climate in Indonesia. The survey is conducted at the district level for 99 districts. Respondents (enterprise owners) are asked to rate statements about the transparency of the business license services in the district. This survey has already been used to study a number of topics such as the relationship between the quality of local governance, level of decentralization and economic performance (Patunru et al., 2009; McCulloch and Malesky, 2011; Von Luebke, 2009, 2012). The second source of data is the 2007 IFLS, which asks leading people in the village about corruption cases in various sectors (government offices at different levels, health units, schools and police). This survey has also been used to measure the quality of local governance in Cameron and Shah (2014).

[Table 2 about here.]

Table 2 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 3 displays the 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 3 about here.]

Table 3 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 below. We have seen that the main result of the model links the number of logging permits released by the district government to the degree of ethnic diversity. The observed heterogeneity in ethnic fractionalization across districts allows us to test the main predictions of the model.

[Figure 1 about here.]

5 Results

5.1 Basic regressions

We begin by estimating by OLS the following equation:

$$f_i = \alpha + \beta EF_i + \gamma X_i + \mu_{pi} + \epsilon_i, \tag{10}$$

where f indicates the number of pixel 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 which capture unobserved heterogeneity at the province level.

[Table 4 about here.]

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 but the effect varies according to the different forest zones. In particular, the results show a stronger positive association between ethnic fractionalization and deforestation in areas where some legal logging is allowed (conversion and production zones). This association is also stronger in production areas compared to conversion areas[8]. This result supports our model of illegal logging since in production areas, mainly devoted to logging, our measure of deforestation provides a better proxy for actual (illegal) logging. Moreover this 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. The effect is large; a one standard deviation (0.29) increase in ethnic fractionalization can lead to an increase in logging in production zones of about 607 pixels that corresponds to 38 square kilometers of forest[9]. This represents the 28% of total deforestation per district occurred during the period 2000-2008. The effect is comparable to a 25 percentage point increase in the population at the province level.

5.2 Additional controls

There are several factors that might affect deforestation directly or can be correlated with both ethnic diversity and deforestation. In this section we add several additional control variables to our baseline specification in order to rule out potential confounding effects[10].

[Table 5 about here.]

5.2.1 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 the transmigration 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

[8]The difference in the coefficients is statistically significant at 7%.

[9]This number is derived from the coefficient of ethnic fractionalization for production zones, in Table 4. Recall that the depend variable is in thousands of pixels.

[10]In table 5 controls are included sequentially such that the last panel, f, includes all of them. In the Appendix we provide the results adding one control at a time.

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 in the district. Panel a of table 5 confirms the robustness of the results to the inclusion of this control.

5.2.2 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 significant for production zones suggesting that also additional channels are likely to be at work. 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 in the next section.

5.2.3 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 associate 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.

5.2.4 Geography

An additional explanation for the positive relationship between ethnic diversity and deforestation is that ethnic diversity could be related to geographic diversity (Alesina et al., 2012) with ambiguous consequences on deforestation. 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 production zones a one standard deviation increase in ethnic fractionalization can lead to an increase in logging of about 570 pixels. This effect is similar to a 18 percentage point increase in population at the province level.

5.2.5 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 of some financial benefits. 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.

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 some logging is legal and profit sharing arrangements are in place between logging companies and local communities.

6 Channels

In this section we examine which channels may link ethnic fractionalization to deforestation as suggested by our model.

6.1 Social Capital

Higher level of fractionalization is associated with lower social capital, trust and cooperation among local communities. As discussed above in the model section this may lead to lower levels of success of communities in confrontation with logging companies and/or lower levels of compensation extracted from the loggers. Moreover, when politicians are responsible for monitoring deforestation, low levels of social capital might foster deforestation, decreasing the accountability in the political sector[11].

We test this hypothesis for Indonesia, using information on participation rates, turnout rates, trust and ethnicity. In particular we study the correlation between ethnic fragmentation and various indicators of social capital. In all specifications we include province fixed effects. Despite having data at the village level, we cannot include district fixed effects since we only have few observations within each district. Results are reported in Table 6 and Table 7. In the first table we look at participation rates, measured both in terms of community activities and turnout rates in elections at different administrative levels. In all columns we control for the education level of the village, the share of poor, the share of people having access to electricity and the population. The results show a significant and negative correlation between ethnic fragmentation in the village and the average number of community events attended. Columns (2)-(4) show the results for turnout rates. We find a significant and negative correlation between ethnic fragmentation and average turnout rate irrespective of the administrative level of the elections, though the effect seems to be larger for local elections (village head).

[Table 6 about here.]

In Table 7 we study the correlation between ethnic diversity and various measures of trust presented in section 4. The results are in line with the previous table, and indicate that lower levels of trust characterize villages with a higher ethnic fragmentation.

[Table 7 about here.]

6.2 Corruption

Ethnic diversity can influence deforestation through its effect on corruption of policymakers. Table 8 reports the results. In the first two columns we use the data from the Asia Foundation survey. The dependent variables measure the scores given by respondents on the presence of unofficial charges

[11]Banfield (1958) already noted how low levels of social capital imply no control of politicians, since such control is under supplied being a public good. For recent results along these lines see Nannicini et al. (2013)

in the license practice ("$Corruption_{un}$") and on the presence of any form of bribery ("$Corruption_{br}$"), with higher values indicating higher corruption. Our measures of corruption represent the average scores at the district level where scores range between -4 and -1. The most corrupted districts are Nias Selatan (-2) and Kota Medan (-1.98)[12] and the least corrupted are Soppeng (-3.18) and Musi Rawas (-3.29). In the third column we use the data for 312 villages from the IFLS and we measure the average number of corruption cases reported by respondents in each village.

[Table 8 about here.]

All the coefficients are positive and significant and confirm that ethnic fragmentation is associated with higher levels of corruption and this holds both at the district and at the village level. This evidence suggests that regions characterized by high ethnic fragmentation experience widespread corruption. This result is supporting our model, according to which ethnic diversity increases the bribe opportunities (for the politician) related to deforestation when the logging company has to negotiate with an ethnically fragmented community. Hence the local politician allows more illegal logging and the level of corruption increases.

6.3 Political Fragmentation

Burgess et al. (2012) find that deforestation in Indonesia has been driven by an increase in political competition due to the political fragmentation that follows post-Suharto decentralization wave. Ethnic fractionalization can increase political fragmentation since each (sufficiently strong) ethnic group tends to create its own jurisdiction. We study this channel by analyzing the correlation between ethnic and political fragmentation. We begin by presenting a simple t-test, where we compare ethnic fragmentation of districts that split and districts that did not split both before and after the splitting. The t-test in table 9 suggests that in 2000 (before the splitting) ethnic fragmentation was significantly higher in districts that split in the following years compared to districts that did not split. However when we look at 2010 (after splitting), districts that split do not display a significantly different level of ethnic fragmentation compare to districts that did not split.

[Table 9 about here.]

[12]Medan city, the capital of the district, is among the most corrupted cities surveyed by Transparency International in 2008. See the report Indonesia Corruption Perception Index 2008.

This descriptive evidence is confirmed when we run a simple regression to study the drivers of the splitting. Table 10 shows that, once we account for other determinants of splitting identified by the literature (eg. population and geographical size), districts characterized by a higher ethnic fragmentation, are more likely to split.

[Table 10 about here.]

Where "$d\_split2000$" is a dummy equal to one for the districts that split and "$Area\_distr$" is the log of the district area. We also run a difference-in-differences estimation, comparing the change in ethnic fragmentation over the period 2000-2010 (before and after splitting), between districts that split and the ones that did not. Results are reported in table 11.

[Table 11 about here.]

In the first two columns we compare the change in ethnic fragmentation using the districts as designed in 2000 (pre splitting) as units of analysis. In the third and fourth columns we use the districts as of 2008 (post splitting) instead. Looking at the second and fourth columns, where we include province fixed effects, results are very similar, showing that ethnic fragmentation has decreased more in districts that split compared to the ones that did not split, by roughly 6 percentage points. Overall this evidence demonstrates that ethnically heterogeneous districts are more likely to split with ethnic groups clustering in new, relatively homogenous districts.

7 Conclusions

This paper studies the association between ethnic diversity and deforestation in Indonesia, finding that in a corrupt environment, where local politicians receive bribes from the logging companies in exchange of logging permits, areas characterized by high ethnic diversity experience more deforestation. The empirical results show that ethnically fractionalized areas display more deforestation than their more homogenous counterparts after controlling for a variety of possible confounding factors, including several geographic controls. We suggest, theoretically and empirically, three main channels that may link ethnic fractionalization and deforestation in the context of Indonesian institutional and socio-political background. First, higher fractionalization lowers social capital. The latter leads to a lower ability of communities of "defending" themselves against logging companies both in terms of a lower ability to fight them and lower compensations extracted from them. Second, more ethnically fragmented places experience higher degree of corruption of politicians due to less control and punishment of politicians misbehavior. Finally, more fragmented places are characterized by smaller and more numerous jurisdictions, less capable to contrast the operations of logging companies. Moreover greater ethnic fragmentation has contributed, among other causes, to the creation of new districts with negative consequences on deforestation due to an increase in competition among jurisdictions.

Appendix

[Table 12 about here.]

[Table 13 about here.]

[Table 14 about here.]

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Table 1: Summary Statistics

Variable	Mean	Std. Dev	min	max	N	Source
District Level Data						
EF	0.504	0.293	0	0.980	305	2010 Census/IPUMS
Pop_growth	23.928	18.886	2.777	75.409	305	2010 Census/IPUMS
Population	271,986.7	248,771.4	23,790	2,049,090	305	2010 Census/IPUMS
Herf. Activities	0.478	0.135	0.005	0.716	305	2010 Census/IPUMS
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 /IPUMS
Share animal husbandry	0.727	1.102	0.042	9.772	305	2010 Census/IPUMS
Share crops	24.759	20.923	0.268	99.508	305	2010 Census/IPUMS
Rivers	3.031	7.969	0	89	305	DIVA GIS
Dummy Javanese	0.816	0.388	0	1	305	2010 Census /IPUMS
Fires	667.491	1,177.028	0	5625	305	Forestry Statistics 2011
Corruption_un	-2.649	0.288	-3.188	-1.98	99	KPPOD/Asia Foundation 2007
Corruption_br	-2.668	0.299	-3.292	-2	99	KPPOD/Asia Foundation 2007
Community Level Data						
EF	0.230	0.265	0	0.852	312	IFLS 2007
Village_Activities	0.165	0.064	0.033	0.358	311	IFLS 2007
Vote_prov	0.860	0.119	0.413	1.000	312	IFLS 2007
Vote_villagehead	0.730	0.331	0	1	283	IFLS 2007
Vote_all	0.939	0.055	0.719	1	312	IFLS 2007
Feelsafe	0.968	0.054	0.571	1	311	IFLS 2007
Takeadvantage	0.926	0.066	0.651	1	311	IFLS 2007
Watchhouse	0.831	0.101	0.429	1	311	IFLS 2007
Corruption	1.667	1.624	0	7	312	IFLS 2007
Poor	0.119	0.108	0	0.409	313	IFLS 2007
Electricity	0.966	0.110	0	1	313	IFLS 2007
School	0.018	0.034	0	0.223	312	IFLS 2007
Population	165.067	453.616	6	8042	312	IFLS 2007

Table 2: 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 3: 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.

Table 4: Deforestation and ethnic diversity by forest zone

	(1) All forest	(2) Conversion	(3) Production	(4) Conservation	(5) Protection	(6) Other
EF	0.803***	0.988*	2.086***	0.110	-0.045	1.061***
	(0.258)	(0.510)	(0.711)	(0.501)	(0.116)	(0.399)
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 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 5: Additional control variables

	(1) All forest	(2) Conversion	(3) Production	(4) Conservation	(5) Protection	(6) Other
Panel a: Presence of Javanese						
EF	1.018***	0.912	2.397***	0.249	0.122	1.362***
	(0.302)	(0.562)	(0.890)	(0.423)	(0.153)	(0.525)
Dummy: Javanese	-0.283*	0.090	-0.430	-0.228	-0.205*	-0.389*
	(0.151)	(0.353)	(0.366)	(0.384)	(0.115)	(0.217)
Panel b: number of districts						
EF	1.018***	0.912	2.397***	0.249	0.122	1.362***
	(0.302)	(0.562)	(0.890)	(0.423)	(0.153)	(0.525)
Number of new districts	0.026	0.059**	0.027	0.068**	0.039***	-0.035
	(0.022)	(0.027)	(0.065)	(0.028)	(0.013)	(0.029)
Panel c: land-related activities						
EF	1.083***	2.385**	2.048**	0.603	0.259	1.344**
	(0.331)	(1.023)	(0.930)	(0.562)	(0.177)	(0.577)
Share agriculture	-0.011	0.017	0.005	-0.019	-0.010	-0.017
	(0.012)	(0.050)	(0.035)	(0.014)	(0.009)	(0.018)
Share forestry	0.046*	0.076**	0.158**	-0.012	0.001	0.019
	(0.024)	(0.035)	(0.071)	(0.011)	(0.008)	(0.014)
Share estate	0.016***	0.046***	0.043**	-0.000	0.002	0.033***
	(0.005)	(0.017)	(0.018)	(0.004)	(0.002)	(0.007)
Share animal	0.076*	0.814*	0.091	-0.084	-0.001	0.085*
	(0.041)	(0.428)	(0.089)	(0.104)	(0.015)	(0.046)
Share crops	0.013***	0.055***	0.021*	0.013*	0.008***	0.016**
	(0.004)	(0.018)	(0.012)	(0.008)	(0.002)	(0.007)
Panel d: diversity in land-related activities						
EF	0.995***	0.997*	2.295**	0.307	0.161	1.280**
	(0.301)	(0.597)	(0.913)	(0.399)	(0.155)	(0.522)
Herf. Agriculture	0.393	-1.038	1.837	-0.709	-0.823**	1.806*
	(0.718)	(1.801)	(2.408)	(1.436)	(0.325)	(0.934)
Panel e: geographic endowments						
EF	0.838***	0.452	1.962**	0.168	0.144	1.181**
	(0.302)	(0.601)	(0.905)	(0.335)	(0.149)	(0.535)
Elevation (mean)	-0.000	0.000	-0.001	0.000	0.000	-0.001**
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Elevation (sd)	0.001	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	-0.492	-1.155	-2.395	-0.328	-0.147	1.065**
	(0.417)	(0.924)	(1.612)	(0.262)	(0.250)	(0.513)
Number of rivers	0.034***	0.049**	0.032	0.068**	0.005	0.024**
	(0.012)	(0.022)	(0.025)	(0.031)	(0.005)	(0.011)
Panel f: forest fires						
EF	0.838***	0.452	1.962**	0.168	0.144	1.181**
	(0.302)	(0.601)	(0.905)	(0.335)	(0.149)	(0.536)
Forest fires	0.029**	0.033	0.078*	0.011	0.004	0.025
	(0.013)	(0.027)	(0.039)	(0.015)	(0.006)	(0.023)
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 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 6: Participation and Ethnic Diversity

	(1) village_activities	(2) vote_prov	(3) vote_villagehead	(4) vote_all
EF	-0.066***	-0.055*	-0.283***	-0.043**
	(0.001)	(0.065)	(0.010)	(0.040)
Controls	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Observations	311	311	282	311

In all columns OLS regressions at the village level. Controls include: population level, poor quota, education and electricity in the house. Clustered standard errors at the province level in parentheses, $*p < 0.1$, $**p < 0.05$,$***p < 0.01$.

Table 7: Trust and Ethnic Diversity

	(1) feelsafe	(2) takeadvantage	(3) watchhouse
EF	-0.051*	0.037***	-0.122**
	(0.073)	(0.000)	(0.019)
Controls	Yes	Yes	Yes
Province FE	Yes	Yes	Yes
Observations	311	311	311

In all columns OLS regressions at the village level. Controls include: population level, poor quota, education, electricity. Clustered standard errors at the province level in parentheses, $*p < 0.1$, $**p < 0.05$,$***p < 0.01$.

Table 8: Corruption and Ethnic Diversity

	(1) Corrup_un	(2) Corrup_br	(3) Corruption
EF	0.124**	0.085*	1.023*
	(0.035)	(0.077)	(0.092)
Controls	Yes	Yes	Yes
Province FE	Yes	Yes	Yes
Observations	99	99	311

In columns (1) and (2) OLS regressions at the district level, in column (3) OLS regression at the village level. Controls include: population growth and level in columns (1) and (2) and population level, poor quota, education and electricity in the house in column (3). Clustered standard errors at the province level in parentheses, $*p < 0.1$, $**p < 0.05$,$***p < 0.01$.

Table 9: T-test

	Districts that split (mean)	Districts that did not split (mean)	Mean Difference (p-value)
Before Splitting (2000)			
EF	0.608	0.479	0.003
	(0.249)	(0.303)	
After Splitting (2010)			
EF	0.527	0.486	0.345
	(0.272)	(0.3)	
Observations	72	110	

Standard deviations in parentheses.

Table 10: Splitting of Jurisdictions and Ethnic Diversity

	(1) d_split2000	(2) d_split2000	(3) d_split2000
EF_2000	0.291	0.245	0.311*
	(0.269)	(0.266)	(0.151)
population		0.000***	0.000
		(0.000)	(0.000)
Area_distr			0.166***
			(0.019)
Province FE	Yes	Yes	Yes
Observations	182	182	182

The binary dependent variable is equals 1 for districts that split after 2000 and "*Area_distr*" is the log of the district area. Clustered standard errors at the province level in parentheses, $*p < 0.1$, $**p < 0.05$,$***p < 0.01$.

Table 11: Change in Ethnic Diversity after the Splitting

	(1) diff_EF2000	(2) diff_EF2000	(3) diff_EF2008	(4) diff_EF2008
d_split2000	-0.075***	-0.062***	-0.096***	-0.061***
	(0.022)	(0.020)	(0.031)	(0.019)
Province FE	No	Yes	No	Yes
Observations	182	182	293	293

The dependent variable measures the change in ethnic fractionalization of a district before and after the splitting. "*d_split*2000"equals 1 for districts that split after 2000. The change pre-post splitting in ethnic fractionalization considers 2000 administrative boundaries as the unit of analysis in columns 1) and (2), while specifications in columns (3) and (4) use 2008 boundaries. Clustered standard errors at the province level in parentheses, $*p < 0.1$, $**p < 0.05$,$***p < 0.01$.

Table 12: Additional controls included one at a time

	(1) All forest	(2) Conversion	(3) Production	(4) Conservation	(5) Protection	(5) Other
Panel a: Presence of Javanese						
EF	1.018***	0.912	2.397***	0.249	0.122	1.362***
	(0.302)	(0.562)	(0.890)	(0.423)	(0.153)	(0.525)
Dummy: Javanese	-0.283*	0.090	-0.430	-0.228	-0.205*	-0.389*
	(0.151)	(0.353)	(0.366)	(0.384)	(0.115)	(0.217)
Panel b: number of districts						
EF	0.803***	0.988*	2.086***	0.110	-0.045	1.061***
	(0.258)	(0.510)	(0.711)	(0.501)	(0.116)	(0.399)
Number of new districts	0.028	0.056**	0.024	0.079***	0.039***	-0.036
	(0.023)	(0.025)	(0.068)	(0.027)	(0.011)	(0.031)
Panel c: land-related activities						
EF	1.013***	2.915***	1.863**	0.616	0.201	1.296**
	(0.304)	(1.108)	(0.822)	(0.577)	(0.145)	(0.520)
Share agriculture	-0.010	0.004	0.006	-0.020	-0.010	-0.017
	(0.012)	(0.044)	(0.034)	(0.014)	(0.008)	(0.018)
Share forestry	0.045*	0.080**	0.156**	-0.011	0.001	0.018
	(0.023)	(0.036)	(0.070)	(0.011)	(0.009)	(0.014)
Share estate	0.017***	0.043**	0.044**	-0.000	0.002	0.033***
	(0.005)	(0.017)	(0.018)	(0.004)	(0.002)	(0.007)
Share animal	0.079*	0.800*	0.103	-0.082	0.001	0.087*
	(0.040)	(0.418)	(0.086)	(0.111)	(0.015)	(0.045)
Share crops	0.014***	0.046***	0.022*	0.013	0.008***	0.016**
	(0.004)	(0.015)	(0.012)	(0.008)	(0.003)	(0.007)
Panel d: diversity in land-related activities						
EF	0.781***	1.159*	1.927**	0.228	0.057	0.909**
	(0.257)	(0.619)	(0.785)	(0.384)	(0.116)	(0.410)
Herf. Agriculture	0.168	-0.621	1.483	-0.829	-0.915**	1.536*
	(0.703)	(1.483)	(2.324)	(1.595)	(0.368)	(0.894)
Panel e: geographic endowments						
EF	0.604**	0.343	1.644**	-0.021	0.019	0.947**
	(0.243)	(0.441)	(0.701)	(0.307)	(0.110)	(0.429)
Elevation (mean)	-0.000	0.000	-0.001	0.000	0.000	-0.001***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
Elevation (sd)	0.001	-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	-0.495	-1.046	-2.425	-0.214	-0.113	0.937*
	(0.411)	(0.898)	(1.587)	(0.273)	(0.246)	(0.495)
Number of rivers	0.034***	0.048**	0.032	0.068**	0.005	0.026**
	(0.012)	(0.022)	(0.025)	(0.031)	(0.005)	(0.011)
Panel f: forest fires						
EF	0.803***	0.988*	2.086***	0.110	-0.045	1.061***
	(0.258)	(0.510)	(0.711)	(0.501)	(0.116)	(0.399)
Forest fires	0.010	0.020**	0.008	0.027***	0.013***	-0.012
	(0.008)	(0.009)	(0.024)	(0.009)	(0.004)	(0.011)
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 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 13: Regressions at district level: all forest, all controls progressively

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
EF	3.225**	3.972**	3.972**	4.245**	3.802**	3.111**	3.111**
	(1.187)	(1.548)	(1.548)	(1.897)	(1.509)	(1.373)	(1.373)
Dummy: Javanese		-0.965	-0.965	-0.177	-1.190	-1.050	-1.050
		(0.635)	(0.635)	(0.550)	(0.756)	(0.795)	(0.795)
Number of new districts			0.283**	0.158	0.295**	0.210	0.009
			(0.125)	(0.158)	(0.128)	(0.159)	(0.095)
Share agriculture				-0.052			
				(0.044)			
Share forestry				0.200**			
				(0.082)			
Share estate				0.086***			
				(0.026)			
Share animal husbandry				0.262			
				(0.174)			
Share crops				0.058**			
				(0.021)			
Herf. Agriculture					2.972	0.474	0.474
					(3.249)	(3.696)	(3.696)
Elevation (mean)						-0.002	-0.002
						(0.001)	(0.001)
Elevation (sd)						0.004	0.004
						(0.003)	(0.003)
Distance from sea						-1.754	-1.754
						(2.820)	(2.820)
Number of rivers						0.177***	0.177***
						(0.057)	(0.057)
Forest fires							0.011
							(0.011)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	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: Regressions at district level: all forest, one control at a time

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
EF	3.225**	3.972**	3.225**	4.144**	2.959**	2.377**	3.225**
	(1.187)	(1.548)	(1.187)	(1.742)	(1.169)	(1.106)	(1.187)
Dummy: Javanese		-0.965					
		(0.635)					
Number of new districts			0.246**				
			(0.110)				
Share agriculture				-0.052			
				(0.044)			
Share forestry				0.199**			
				(0.082)			
Share estate				0.086***			
				(0.026)			
Share animal husbandry				0.265			
				(0.178)			
Share crops				0.059**			
				(0.021)			
Herf. Agriculture					2.303		
					(3.270)		
Elevation (mean)						-0.002	
						(0.002)	
Elevation (sd)						0.005	
						(0.003)	
Distance to sea						-1.829	
						(2.833)	
Number of rivers						0.177***	
						(0.055)	
Forest fires							0.014**
							(0.006)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	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, *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

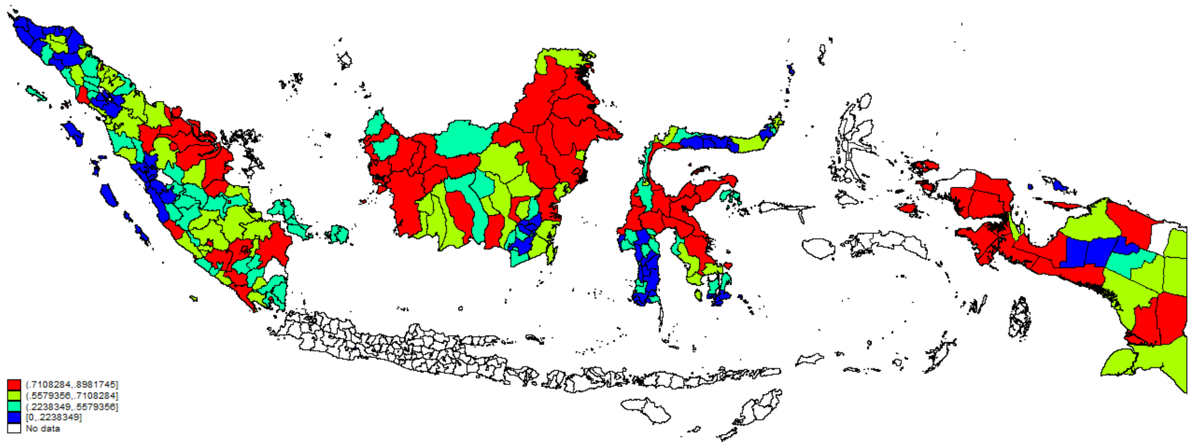

Figure 1: Ethnic Diversity across Indonesian Districts (2006).