The Institutional Design of Environmental Control

Gemma Dipoppa * Saad Gulzar † Annalisa Pezone ‡ Farzad Yaghoobi §

March 1, 2026

Abstract

Governments routinely regulate activities that generate cross-jurisdictional spillovers, none more consequential than pollution. Regulating pollution requires balancing two competing design principles: coordination across jurisdictions to internalize spillovers, and local capacity to control environmental damage. We develop a simple model that formalizes this tradeoff and test its implications using large-scale government fragmentation episodes in India and Pakistan. Empirically, we show that emissions from crop-burning, a large air pollution problem in the region, rise substantially after district splits, in line with environmental theories emphasizing incentives to shift pollution across newly created borders. At the same time, we show that gains in administrative capacity produced by the split partially offset these coordination losses. On net, fragmentation increases emissions, suggesting that planners underaccount for environmental spillovers when designing jurisdictions. These findings highlight that, unlike government functions with limited externalities, policies characterized by cross-jurisdictional spillovers amplify the tradeoffs of institutional reform, making coordination failures especially costly.

*Columbia University, Department of Political Science (gd2733@columbia.edu)
†Notre Dame University, Department of Political Science, (sgulzar@nd.edu)
‡New York University, Department of Politics, (ap8979@nyu.edu)
§Notre Dame University, Department of Political Science, (fy.farzadyaghoobi@gmail.com)

1 Introduction

When a forest fire burns across borders or polluted water flows downstream, a fundamental challenge of governance is exposed: government boundaries rarely align with ecological ones. The same tension recurs wherever shared risks or benefits spill across jurisdictions, such as, in times of outbreaks of disease or violent conflict and migration pressures. In each of these contexts, effective governance hinges on institutions that can both coordinate across units and act effectively within them. In theory, this entails balancing two core principles: coordination, which enables governments to internalize cross-border externalities, and capacity to deliver, grounded in local information and embeddedness.

In practice, distinct literatures have emphasized only one side of this tradeoff. Political science research has shown that the provision and quality of public goods often improve with administrative fragmentation, which lowers governance costs via superior local information and monitoring capacity (see, for example, Grossman, Pierskalla and Dean (2017)). In contrast, the environmental governance literature has stressed the importance of administrative centralization, arguing that higher-level coordination is necessary to internalize spillovers and manage shared resources such as air, water, or forests (see for instance, Lipscomb and Mobarak (2017)). This tension highlights an institutional design problem that remains empirically underexplored: how to balance central control with local administrative strength in the organization of jurisdictions.

This paper addresses this gap by theoretically framing and empirically analyzing the relation between coordination and capacity in the context of a typical governance reform around the world: the reorganization of government jurisdictions through the creation of new districts from parts of old ones (Grossman and Lewis, 2014). We develop a simple model that formalizes how administrative fragmentation produces opposing effects on pollution through coordination losses and capacity gains. We then use quasi-experimental variation generated by jurisdictional reorganization in India and Pakistan to reveal how both forces operate following government fragmentation: pollution decreases with increasing service delivery capacity, and increases with deteriorating coordination across jurisdictions. Environmental governance, therefore, unlike other government functions that generate minimal cross-jurisdictional spillovers, introduces institutional

challenges that complicate the net impact of governance reform.

We study these questions in the context of South Asia's air pollution emergency, one of the world's most severe environmental crises. Each winter, a dense haze blankets northern India and Pakistan, when millions of farmers set fire to leftover rice stubble to clear crops for the next planting cycle, producing up to 40-60% of the region's seasonal particulate matter (Bikkina et al., 2019; Lan et al., 2022). The World Health Organization estimates that this pollution causes more than two million premature deaths annually (Dandona et al., 2020). Despite repeated bans and public campaigns, crop burning persists, underscoring deep challenges in governing environmental externalities.

Controlling environmental externalities requires government intervention. We formalize the key logic of our argument by developing a simple model that captures the dual effects of administrative fragmentation on environmental control. The model features a central regulator who balances the benefits of economic activity against the local and transboundary damages from pollution. We outline a fundamental tradeoff: jurisdictional fragmentation simultaneously reduces coordination, since smaller jurisdictions internalize only a fraction of the pollution they produce, and increases administrative capacity, since enforcement becomes less costly in smaller, more local units. Starting from a completely centralized scenario, fragmentation initially improves capacity more than the deterioration in coordination. However, as fragmentation increases beyond an optimal point, coordination losses trump any further improvements in governing capacity, thereby producing a U-shaped relationship between fragmentation and environmental outcomes.

Empirically, identifying the impact of institutional design on environmental outcomes is complicated. First, institutional arrangements are rarely random: they are typically introduced where governance, political, or environmental pressures already differ, such that variation in environmental performance may reflect these underlying factors rather than institutional design itself. We use a staggered difference-in-differences design that compares similar sub-districts before and after district fragmentation in Indian and Pakistani states affected by the problem of crop burning. We code all instances of administrative reorganizations, affecting 260 sub-districts located in 25 districts from 2000 to 2025, and record their timing and detailed shapefiles delineating the

geography of both newly created and defunct borders.

Second, separately observing the forces behind coordination and capacity demands a level of spatial precision in outcomes that is generally missing from previous research, which has largely relied on jurisdiction-level data. Aggregation at this scale blurs the distributional consequences of administrative reorganization, which produces both gains and losses. We break this barrier by combining newly digitized administrative maps with high-resolution satellite data to look inside jurisdictions. Using geo-referenced measures of crop residue burning from the VIIRS and MODIS satellites, covering 103,020 five squared km grid-cells over 25 years (for a total of 2,575,500 observations), we can study how district fragmentation reshape the spatial distribution of state capacity in the management of environmental externalities.

We begin our analysis by investigating how administrative fragmentation affects the production of environmental pollution. In the ten years leading up to a district fragmentation, which forms new districts by splitting off parts of old districts, we observe no differential change in crop burning between areas that will eventually be split and those that will not. However, right after fragmentation, we find a substantial increase in crop burning in the splitting jurisdiction: on average, there are 0.77 more fires per grid-year after a split, an almost 3-fold increase with respect to baseline, and an effect which does not attenuate over time. These findings show that administrative fragmentation, a reform typically aiming to improve capacity, leads to an overall larger production of pollution. What explains this effect?

In the next two sections of the paper, we provide evidence consistent with the fact that the overall increase in fires following district reorganization is the result of two opposing forces: a decrease in cross-jurisdictional coordination caused by the creation of new borders, and an improvement in capacity in areas that experience gains in administrative proximity and jurisdictional size reduction.

First, we document that fragmentation reduces administrative coordination: district splits create new jurisdictional borders, strengthening incentives for bureaucrats to free-ride on enforcement where pollution can be offloaded onto neighboring districts. Consistent with this expectation of coordination failure, we find that the increase in fires concentrates around borders,

where free riding incentives are the sharpest. We further show that coordination losses are larger in places where bureaucrats must answer to multiple elected politicians, a setting in which coordination is weaker to begin with. Areas with multiple political principals are where the increase in fires due to district fragmentation is concentrated, while areas with a single political principal experience no additional pollution than before

Second, we document how fragmentation improves administrative capacity. District reorganizations reduce the average size of districts and, for some areas, shorten their distance to administrative headquarters, thereby strengthening local capacity for governance. In line with this intuition, we find that areas that experience the largest reductions in district size or become closer to newly created headquarters exhibit smaller increases in fires, implying that improvements in local oversight can partially offset coordination losses. The contrast between parent and child districts, the original and the newly carved jurisdiction, reinforces this pattern: while both experience higher pollution overall, the rise is smaller in child districts, those that benefit most from enhanced proximity and smaller jurisdictional scale.

Finally, we consider how these two forces interact along the same spatial dimension. We examine how the effect of changes in distance to administrative headquarters varies with distance to district borders, with both measures expressed in kilometers. This common metric allows us to directly compare coordination losses and capacity gains within the same locations. We find that capacity improvements reduce fires primarily in interior areas, far from borders, whereas near administrative boundaries coordination failures dominate and pollution increases. Fragmentation therefore reshapes environmental outcomes through a spatial reallocation of governance effectiveness, creating local winners and losers.

Taken together, these results show that administrative fragmentation weakens the state's collective ability to manage environmental externalities, but its impact is uneven, revealing how gains in local capacity can offset the environmental costs of fragmentation.

Our study bridges two major strands of research. The first, in political science, examines the effects of administrative fragmentation on governance and service delivery. Beginning with Grossman, Pierskalla and Dean (2017), studies have shown that smaller jurisdictions enhance

local accountability and state responsiveness, improving economic growth and public goods provision (Alesina, Gennaioli and Lovo, 2019; Dahis and Szerman, 2021; Rajan and Malghan, 2022; Narasimhan and Weaver, 2024).[1] The second, in environmental economics, highlights the opposite concern: the creation of new borders accompanying fragmentation can exacerbate "polluting your neighbor" dynamics (Sigman, 2002; Lipscomb and Mobarak, 2017; Wang and Wang, 2021; Buntaine et al., 2025).

Theoretically, we link the two literatures by formalizing the trade-offs induced by coordination and capacity in environmental control, and we bring the model's intuition to the data using quasi-experimental variation in government fragmentation. First, our key contribution to the government fragmentation literature is to show that in the presence of externalities, such as with environmental outcomes, that this literature has not examined, the institutional designer will overestimate the optimal number of jurisdictions, thereby sacrificing net grains from the process. Second, the contribution to the environmental governance literature is to show that improved government capacity to manage the environment can actually ameliorate the 'pollute thy neighbor' effect.

Finally, beyond the theoretical contributions, illustrating this tradeoff in government fragmentation is also important because many development institutions have promoted more locally empowered administration as a key governance reform to improve service delivery (World Bank, 2004; Altmann et al., 2000). This prescription, however, might not travel well to contexts in which there is a substantial potential for spillovers, and therefore a need for coordination across jurisdictions, as with environmental outcomes. In this sense, our study provides new evidence on when and how smaller jurisdictions improve local governance and when they worsen collective outcomes. Taken together, our results underscore a fundamental institutional tension at the heart of environmental governance: centralization enhances coordination but weakens capacity, while decentralization does the reverse. Designing institutions that balance these forces is central to achieving effective state action on shared environmental challenges.

[1] Although, Blom-Hansen et al. (2016); Bazzi and Gudgeon (2016); Billing (2019) find null or mixed effects.

2 Theory

Summary: We develop a simple model of environmental control to formalize how administrative fragmentation shapes regulatory outcomes. We consider a region divided into multiple jurisdictions, each responsible for regulating local pollution that generates both private economic benefits and cross-border environmental damages. Fragmentation affects two core dimensions of governance: it weakens coordination across jurisdictions, reducing the extent to which local regulators internalize spillovers, but strengthens administrative capacity by lowering monitoring costs and improving enforcement. The model captures this fundamental tradeoff between coordination and capacity, showing how the equilibrium level of pollution depends on the number of jurisdictions and how an institutional designer would optimally balance these countervailing forces.

Setup: A region is divided into $J \in \{1, 2, \dots\}$ administrative jurisdictions (districts). Each jurisdiction regulates a representative polluting source (a representative farmer) that emits $e \geq 0$ units of pollution. Emissions generate economic benefits for the polluter but also create environmental damages that may spill across jurisdictions.

Private benefits and damages. The polluter's private benefit is quadratic:

$$B(e) = a\, e - \frac{1}{2}e^2, \qquad a > 0. \tag{T.1}$$

Here a measures the private value of emissions, for example, how profitable an extra unit of burning is, while quadratic term $-\frac{1}{2}e^2$ imposes diminishing marginal benefits.

Pollution also creates quadratic damages:

$$D(e) = \frac{d}{2}e^2, \qquad d > 0, \tag{T.2}$$

where d measures the intensity of marginal environmental harm. Convex damages ($\propto e^2$) reflect that environmental degradation tends to accelerate as emissions rise.

Partial internalization. Each jurisdiction internalizes only a fraction $\theta(J) \in (0, 1]$ of the total damages it causes. The remainder spills across borders and affects neighboring areas. We assume:

$$\theta'(J) < 0 \quad \text{(fragmentation reduces internalization)}. \tag{T.3}$$

As the number of jurisdictions J increases and the region becomes more fragmented, each regulator internalizes a smaller share of the overall damage. This assumption captures how fragmentation erodes coordination and the internalization of spillovers: when decision-making authority is dispersed among many small units, each has less incentive to account for cross-border externalities.

Monitoring capacity and enforcement costs. Each jurisdictional regulator imposes a per-unit emissions tax $t \geq 0$. Enforcing this tax is costly: higher taxes require more administrative effort to monitor and penalize violators. Let $\mu(J) > 0$ denote the jurisdiction's monitoring capacity, with enforcement cost:

$$C(t; J) = \frac{t^2}{2\,\mu(J)}, \qquad \mu'(J) > 0 \quad \text{(fragmentation raises capacity)}. \tag{T.4}$$

The parameter $\mu(J)$ scales inversely with enforcement cost: higher μ implies cheaper enforcement. The assumption $\mu'(J) > 0$ formalizes that smaller jurisdictions (larger J) can monitor more effectively, for example because they are closer to local emitters, have to control a smaller area, or have more precise information.

Hence fragmentation has two countervailing consequences: it *reduces internalization*, but *improves enforcement capacity*.

Polluter. Taking the tax rate t as given, the representative polluter solves:

$$\max_{e \geq 0} \; ae - \frac{1}{2}e^2 - te.$$

The first-order condition gives a linear best response:

$$e(t) = a - t. \tag{T.5}$$

Emissions thus decrease proportionally with the increase in tax rate.

Local regulator. Each jurisdiction chooses t to maximize internal welfare, which is a function of local economic benefit, internalized environmental cost, and enforcement cost:

$$W(t; J) = B(e(t)) - \theta(J)D(e(t)) - C(t; J). \tag{T.6}$$

Substituting (T.1)–(T.5) yields:

$$W(t; J) = ae - \frac{1}{2}(1 + \theta(J)d)e^2 - \frac{t^2}{2\mu(J)}, \qquad e = a - t.$$

The first-order condition with respect to t for an interior optimum yields the optimal tax and emissions as follows:

$$t^*(J) = \frac{a\,\theta(J)d}{1 + \theta(J)d + 1/\mu(J)}, \tag{T.7}$$

$$e^*(J) = a - t^*(J) = a\,\frac{1 + 1/\mu(J)}{1 + \theta(J)d + 1/\mu(J)}. \tag{T.8}$$

A higher internalization rate $\theta(J)$ or damage coefficient d increases the optimal tax, while higher enforcement capacity $\mu(J)$ (lower cost) also allows higher taxation. Instead, emissions move positively with how valuable they are economically (a), and negatively with how much of the damage they cause is internalized by the administrator ($\theta(J)$), and on the administrator's monitoring capacity ($\mu(J)$).

Two countervailing effects of fragmentation. Differentiating (T.8) with respect to θ and μ clarifies the tradeoff between coordination and capacity. Let $s(J) = 1/\mu(J)$ for notational brevity.

$$\frac{\partial e^*}{\partial \theta} = -\,a\,\frac{d(1+s)}{(1+\theta d+s)^2} < 0, \tag{T.9}$$

The negative sign of this derivative implies that when jurisdictions internalize more of the damage (higher θ), they reduce emissions.

$$\frac{\partial e^*}{\partial \mu} = \frac{\partial e^*}{\partial s}\cdot\frac{\partial s}{\partial \mu} = a\,\frac{\theta d}{(1+\theta d+s)^2}\cdot\left(-\frac{1}{\mu^2}\right) < 0. \tag{T.10}$$

As for internalization, an increase in government monitoring capacity μ reduces emissions.

Finally, we consider the combination of the two forces when fragmentation takes place by considering the total derivative $\frac{de}{dJ}$:

$$\frac{de^*}{dJ} = \underbrace{\Big[\frac{\partial e^*}{\partial \theta}\,\theta'(J)\Big]}_{\text{coordination effect}} + \underbrace{\Big[\frac{\partial e^*}{\partial \mu}\,\mu'(J)\Big]}_{\text{capacity effect}}. \tag{T.11}$$

- *Coordination effect:* As $(\partial e^*/\partial\theta)\theta'(J) > 0$, an increase in the number of jurisdictions reduces the internalization of damage, leading to higher emissions.
- *Capacity effect:* As $de^*/dJ|_{\text{capacity}} = (\partial e^*/\partial\mu)\mu'(J) < 0$, an increase in the number of jurisdictions bolsters governance capacity, leading to lower emissions.

The total derivative de^*/dJ is, therefore, ambiguous, indicating that the overall effect of fragmentation on emissions is unclear ex-ante and reflects the competition between these two forces.

3 Environmental Externalities and Government Fragmentation in India and Pakistan

In this section we introduce the problem of crop burning in South Asia, discuss the key role districts play in managing it, and how administrative fragmentation can affect this management, as well as what determines the adoption of this institutional reform.

3.1 The Institutional Origins of Crop Burning in South Asia

While low air quality is a problem everywhere, nowhere is this issue more severe than in South Asia, where pollution is a striking 52 percent higher than in the second-most polluted region (AQLI, 2025). A key difference from other contexts is the prevalence of agricultural residue or crop burning, a practice where the crop stubble left after a harvest is cleared using fire, instead of expensive mechanized tools or manual labor. This is a leading driver of seasonal smog accounting for 40-60% of fine-particle emissions during the peak smog season (Bikkina et al., 2019; Lan et al., 2022).

Crop burning has become widespread in this region due to the combination of historical and structural factors: starting with the Green Revolution, the intensification of the rice–wheat cropping systems in northern India and Pakistan has compressed the time from harvest to the next sowing, creating pressure for rapid clearing. Additionally, regulatory interventions aimed at conserving groundwater (for example delaying rice planting) have the unintended effect of synchronising harvests, which leads to peaks in crop burning episodes. To clear crop residue fast, farmers could rely on mechanized methods, but those are expensive, and produce leftover biomass which requires removal. Farmers could also rely on rural labor, but the cost of labor has been driven up by out-migration (Garg, Jagnani and Pullabhotla, 2024). In light of these conditions, burning remains the quickest and cheapest way to clear fields after harvest for farmers.

Indian states such as Punjab, Haryana, and Uttar Pradesh enacted explicit anti-burning measures in 2015, and Pakistan's Punjab adopted restrictions in 2018 under Section 144 of the Code of Criminal Procedure. Judicial directives have repeatedly ordered governments to curb crop

burning, most prominently in M.C. Mehta v. Union of India and the 2019 Supreme Court order declaring agricultural burning unlawful (Supreme Court of India, 2019). Nonetheless, despite being illegal and the threat of fines and jail, farmers continue burning crops every year, indicating a profound governance challenge that is under the aegis of the district bureaucracy.

3.2 The Governance of Crop Burning

District officers face multiple, sometimes conflicting, pressures. They oversee policy domains as wide-ranging as agriculture, revenue, policing, infrastructure, welfare. The enforcement of crop-burning bans is among those tasks, but it competes for resources and attention (Dasgupta and Kapur, 2020; Xu, Bertrand and Burgess, 2023).

Nonetheless, the pressure to act on this issue has been increasing from both hierarchical oversight and public scrutiny. Senior officials issue instructions and can censure district leadership for poor control of crop burning, including formal notices and threatened sanctions (The Wire, 2024). Civil-society and media attention intensify in winter months, amplifying pressure on administrators to act (Bikkina et al., 2019; Lan et al., 2022).

District-level bureaucrats wield a diverse tool-kit to influence crop residue burning across both the pre-season and during-season phases. Before the major harvest and clearance window, administrators coordinate with Agriculture and Revenue departments to deploy preventive instruments: they manage information campaigns for farmers about the harms of crop burning; they oversee the rollout of subsidies or rental access to machines (mulchers, balers, zero-till drills) that enable non-burning options.[2] Once the burning window opens, district administrators are in charge of enforcement: they coordinate with pollution-control boards and law-enforcement agencies to detect crop burning via satellite fire counts (Dasgupta and Kapur, 2020) and field visits;[3] they collect complaints about burning and visit the locations where they have been filed

[2]For instance, the central government's scheme supports farmers with up to 50% of machinery cost and up to 80% for farmer collectives, and by 2021 over 39,000 custom-hiring centres and nearly 195,000 machines had been supplied in Punjab, Haryana, Uttar Pradesh and NCT Delhi (Press Release Ministry of Environment, 2021).

[3]For example, Punjab led a large-scale mobilization of over 8,000 nodal officers to check stubble

(Times of India, 2025); they mobilize revenue or police staff to issue notices or forward cases for fines or prosecution; they also operate monitoring dashboards or control rooms in hotspot districts that enable rapid response. Because crop burning is temporally concentrated, enforcement and punishment of even a few farmers by bureaucrats can deter future burning, increasing compliance through the season (Dipoppa and Gulzar, 2024).

District-level bureaucrats have a menu of tools to crack down on crop burning. The effectiveness of these tools depends on their timely deployment and on how much local capacity bureaucrats have to deploy these tools across the territory under their supervision. However, the global production of fires depends also on inter-jurisdictional coordination to reduce the production of fires in areas that would not impact the district itself, but their neighbor. Both these forces – capacity and coordination – are impacted by the administrative reorganization of jurisdictions.

3.3 The Drivers of Jurisdictional Reorganization

The reorganization of administrative jurisdictions is a widespread institutional reform across countries. It represents a key component of decentralization strategies that aim to improve administrative efficiency and service delivery by bringing government closer to citizens. Typically, these reforms involve the creation of smaller subnational units such as districts, provinces, or municipalities, accompanied by the establishment of new administrative offices.

Across different contexts, governments have periodically expanded their administrative maps, resulting in a steady increase in the number of subnational units over time. Examples include Uganda, where the number of districts increased by 42 percent between 2009 and 2011 (Cohen, 2024), and post-communist Czechoslovakia and Hungary, which both doubled the number of their municipalities between 1989 and 1993 (Illner, 1999). Similar processes have unfolded in South Asia and largely at the district level: in India, the number of districts has increased from 310 after Independence to 785 today (India Times, 2024).

To better understand the drivers of district reorganization in our context (for a broader analysis, see Grossman and Lewis (2014)), we examine three illustrative case studies presented

fires in 2023 (Hindustan Times, 2023).

in detail in Appendix A. In each case, the official rationale emphasized improved governance and proximity to citizens in response to oversized districts. For example, in Rajasthan, former Chief Minister Ashok Gehlot publicly framed the carving out of new districts as an effort to "increase administrative capacity and improve service delivery" (Indian Express, 2024). In Haryana, the committee reviewing proposals for new districts creation explicitly mentioned "population above 10 lakh, distance from district headquarters more than 50 kms, and presence of three to four tehsils among others" as criteria for the creation of new districts (Indian Express, 2025).

Yet the timing and nature of these reforms were also clearly influenced by political considerations: the appointment of a sympathetic leader (as in Bhiwani), the use of symbolic naming for partisan purposes (as in Kasganj), and the proximity of competitive elections (as in Fazilka). Together, these cases illustrate how jurisdictions reorganizations can simultaneously pursue administrative efficiency and objectives linked to political opportunism, as also concluded in a recent report in India (Flame University, 2024).

3.4 How Districts Fragmentation Unfolds

When districts are fragmented, both routine service delivery and operational structures can be transformed. The most immediate consequence of a district split is that all core offices are duplicated: a new district headquarter is created, with a new district collector in charge; a new police leadership is nominated and headquarters are opened; similarly, a district court, and other sectoral departments are created. Together with the duplication of core offices and leaders, new staff positions are also opened to run them (Civilsdaily, 2023; ForumIAS, 2020). Districts become operational on the official split date: states typically set up posts and allocate personnel in advance and assign them to temporary premises, such as schools or unused government buildings, while permanent infrastructure is constructed later.[4] While district institutions are profoundly modified,

[4]For example, ahead of the 2016 district reorganization in Telangana, the state issued procedural and financial guidelines on the allocation of posts and personnel prior to the effective date of the split (Government of Telangana, 2016). Similarly, the newly created Markapuram district in Andhra Pradesh became operational immediately after notification, with offices

sub-district units (tehsils, blocks, and their associated administrative machinery) remain the same (IIKD, 2024; Rang De, 2023), limiting the potential for disruption during the transition phase.

These structural changes can bear directly on the governance of crop-residue burning. First, fragmentation can strengthen monitoring and enforcement by enabling each new district administration to hire and deploy new nodal officers, task forces, and control rooms across a reduced territorial span. Second, new districts overseeing a territory particularly affected by crop burning can decide to create specialized units in charge of handling the problem. This was the case, for example, for the new district Mohali, which created the "Parali Protection Force", a crop-burning control-room dashboard designed to coordinate real-time responses across agriculture, police, and pollution-control authorities (Times of India, 2025; Times of India, 2025).

Finally, smaller districts could also expand their engagement with civil society: reports from Haryana highlight that district administrations routinely run village-level meetings on the harms of burning and registration for machinery subsidies (Haryana Day Night, 2025; Abhinav Pahal, 2025). With fewer villages to cover after the split, district collectors and additional deputy commissioners can potentially visit these sites more frequently.

District fragmentation multiplies decision centers, reduces the geographic span of administrative authority, and can enhance the state's ability to monitor and deter crop-residue burning. But it also generates new borders, potentially creating the scope for externalities to spill over across jurisdictions. As a result, this is an ideal setting to bring the predictions from our model to the empirics.

4 Data

Our analysis combines a variety of administrative and satellite data at a fine-grained geographic level ($5km^2$ grid-cell) for northern India and Pakistan. We restrict our focus to rural areas in states where agriculture is prevalent and crop stubble burning is consequently a problem: Punjab and Sindh in Pakistan, and Punjab, Haryana, Uttar Pradesh, and Bihar in India.

functioning from school buildings until permanent buildings were developed (Times of India, 2023).

District Fragmentation: Each district in India and Pakistan consists of one or more subdistricts, also called tehsils (or subdivisions in Bihar). We define a sub-district as treated if it undergoes an administrative reorganization. Reorganizations involve assigning one or more tehsils from existing districts to newly created districts. Two types of reorganization occur in our sample: (1) district splits, when tehsils are separated from a district to establish a new one (as in Figure **??**), and (2) merges, when tehsils carved from two or more districts are combined to form a new district entity (as in Figure **??**). We classify as the *parent* the subdistricts belonging to the pre-existing district and as the *child* those assigned to the new entity, which receives a new administrative headquarter.

We identified all district reorganizations by combining spatial analysis of district and sub-district shapefiles with documentary evidence. For India, we compared district boundary shapefiles from 1990 onward to the most recent version available and cross-checked all identified changes against the India State Stories website which documents districts evolution from 1872. For Pakistan, we conducted systematic manual searches of news reports to identify district splits and related changes. All sources are listed in Appendix G.

We identify 76 district reorganizations occurring between 1990 and 2024 in our sample. Figure B.2 shows the location of these reorganizations. Our analysis starts in 2000. To avoid misclassifying districts that underwent reorganization before 2000 as control, we exclude districts treated before 2000. We end up with 25 districts subject to reorganizations, of which 22 district splits and 3 district merges. We show robustness to inclusion of districts that were split before 2000 in Table C.3.

Fires: Our main outcome of interest is the presence and extent of crop stubble burning. We measure crop burning using fire detection data from NASA satellites: the Moderate Resolution Imaging Spectroradiometer (MODIS) at 1km×1km resolution (January 2000 to December 2024) and the Visible Infrared Imaging Radiometer Suite (VIIRS) at 375m×375m resolution (January 2012 to December 2024). For the period 2000 to 2012, MODIS is the only source available, while from 2012 we can rely on the combined detection of VIIRS and MODIS satellites, increasing both the geographic precision and the number of recorded fires detected, as illustrated in Figure B.4.

The satellite records fires from thermal signatures, such that the presence of cloud cover or smoke in the atmosphere does not prevent its detection. The absence of forests in the area of India and Pakistan we study and our focus on rural areas means that we can safely attribute fires to crop burning activity rather than to forest fires.

Crops: Rice is the crop responsible for the largest share of stubble burning. To focus on areas most affected by crop burning, we collect data on average crop area and production in 2000, the latest year with micro-level crop data available before the start of our analysis period. The data is sourced from the FAO maps, it has a resolution of 5×5 arc/min, corresponding to approximately the size of a grid in the final database, and is plotted in Figure B.3.

Combined data: We combine all data in a $5km^2$ grid-year level database observed in each year from 2000 to 2024. Our main sample includes 103,020 grids located in 976 subdistricts and 112 districts for 24 years for a total of 2,575,500 observations.

5 Impact of District Reorganization on Crop Burning

5.1 Empirical Strategy

Causally evaluating the consequences of district reorganization on environmental outcomes is challenging. First, the location at which farmers choose to pollute is endogenous. A simple comparison of areas with and without a district reorganization will likely reflect factors linked with the decision to redraw borders itself, such as political and administrative considerations which might themselves affect environmental outcomes. Second, even within the same district, farmers located in different areas of the district might be fundamentally different. For example, those close to bordering areas might be more deprived of services and disconnected than those close to district centers, and this might in itself affect whether or not they burn.

We address these concerns in three ways. First, we examine polluting behavior within the same unit and before and after a district reorganization, netting out inherent location and time characteristics like remoteness and year-specific effects. Second, we account for the possibility that

splits are driven by pre-existing environmental differences in treated areas by comparing units that would have likely evolved similarly in absence of a split (e.g., units that follow parallel pre-trends). We also directly partial out the decision to split or not by exploiting only variation in the timing of district changes, restricting attention to the split districts only. Finally, unlike previous work on government fragmentation, we observe outcomes at a highly fine-grained geographic scale, which allows us to look inside the district to examine the distributional consequences of government fragmentation, thereby enabling an analysis of the tradeoffs between coordination and capacity.

Concretely, we use a difference-in-differences (DiD) strategy to estimate the effect of district fragmentation on crop-related fires. We consider the difference in fires in grids subject and not subject to fragmentation, before and after subdistricts are subject to reorganization. For grid i in subdistrict s year t, we estimate:

$$\text{Fires}_{ist} = \beta \text{AfterSplit}_{st} + \alpha_i + \gamma_t + \epsilon_{ist} \tag{1}$$

where the main outcome variable is the total number of fires in a grid-year and the treatment variable, $AfterSplit_{st}$, is a dummy taking value one for all the sub-districts subject to fragmentation, from the year of reorganization until the end of the period, and zero otherwise, such that the coefficient of interest, β, captures the average effect of administrative fragmentation on the number of fires. We include grid-cell fixed effects (α_i), absorbing time-invariant differences across locations at a fine-grained geographic level for the 123,187 grid-cells in our data. We also include year fixed effects (γ_t) accounting for time-varying shocks, such as election years, or years with high demand for agricultural products. Standard errors are clustered at the subdistrict level, since fragmentation strictly occurs along pre-treatment subdistrict lines. We show robustness to alternative clustering choices in Appendix (Table C.4) . Our empirical strategy for the overall impact of government fragmentation is illustrated in Figure 1, panel a.

Identifying assumptions: The central identifying assumption is that districts that reorganized and that did not would have displayed similar crop-burning patterns if the split had not occurred. We assess the plausibility of this assumption by examining pre-treatment trends through an

event-study specification. Second, when treatment effects are heterogeneous across groups or time, the standard two-way fixed effects estimator may produce biased estimates due to negative weighting and biased comparisons between the already-treated groups and the later-treated groups (Goodman-Bacon, 2021; De Chaisemartin and d'Haultfoeuille, 2020). We relax this assumption by replicating all results using the Callaway and Sant'Anna (2021) estimator[5].

Event-Study: To trace the dynamic effect on the number of fires around the year in which grids become treated, we implement an event study version of Equation 1:

$$\text{Fires}_{ist} = \sum_{k=-10}^{10} \beta RelativeTime_{iskt} + \alpha_i + \gamma_t + \epsilon_{it} \tag{2}$$

where our coefficients of interest, β, represents the effect of treatment in each period before and after treatment, relative to the year preceding the split (the omitted category). The variable $RelativeTime_k$ is a dummy equal to 1 in the k-th year before or after treatment, and 0 otherwise. For example, if a district is split in 2012, $RelativeTime_0 = 1$ in 2012, $RelativeTime_1 = 1$ in 2013, $RelativeTime_{-1} = 1$ in 2011, and so on. The control group includes never treated grids (Callaway and Sant'Anna, 2021). While in the main analysis we include all available observations, in the event-study specification we restrict the sample to a window of 10 years before and after the district reorganization, to have a sufficient density of observations in each relative time period (see Figure B.5 for density by relative time period).

[5]A key limitation of the Callaway and Sant'Anna (2021) estimator, as implemented in the *csdid* command (Rios-Avila, Sant'Anna and Callaway, 2021), is its inability to allow for interaction terms between treatment and covariates. Subgroup analyses is not always a viable solution in our context as the covariates include both multi-category classifications and continuous measures, making the stratification impractical. For this reason, we show all results using the standard OLS and, when possible, we show robustness to the Callaway and Sant'Anna (2021) estimator in Appendix.

5.2 Total Impact of District Fragmentation

Our first objective is to evaluate the overall impact of district reorganization on crop burning that includes both the forces of coordination and capacity. We plot the event-study coefficients of the difference in fires in grids subject to reorganization in Figure 1b. The flat and insignificant pre-period indicates no difference in fires between treated and control grids before the split. We observe a positive jump in the number of fires in the first year after the district reorganization, an effect that is lasting and sustained over time, becoming larger from the fifth year onward.

The pre- and post-average coefficients summarise these results. While the pre-average coefficient is small and insignificant, the post-average shows a 2-fold increase in fires in the split areas compared to the average of the same areas before the split.

We show table-form full-sample results in Figure 1, panel c. In the most demanding specification (column 3), the number of fires increase by 0.847 per grid-year (s.e.= 0.217), a 3-fold increase from the mean of the dependent variable in the treated group before the split. The effect is largest in areas with high rice production, where we observe a 5.3-fold increase in fires with respect to baseline (column 4, $\beta = 2.439$, s.e.= 0.482).

This result shows that reorganization leads to a significant increase in crop-burning fires. In light of our model, this indicates that the impact of the loss in coordination is larger than the gains from improved capacity. This result on an environmental outcome is therefore in contrast to the standard finding in the literature, which shows a positive impact on the provision of public goods involving minimal cross-jurisdictional spillovers after reorganization.

We conduct several robustness checks to assess the sensitivity of our main finding. First, we restrict the sample to a window of ± 10 years around treatment, as in the event-study specification (Table C.1, columns 1 and 2). Second, we replicate the main result using the Callaway and Sant'Anna (2021) estimator (Table C.1, column 3). Third, we restrict our sample to the ever-treated units (Table C.2). Fourth, we include districts in the sample that were split between 1990 and 1999 (Table C.3, column 1). Fifth, we restrict the sample to simple splits by dropping the rare complicated type 2 splits, as illustrated in Figure B.1, (Table C.3, column 2). Sixth, we vary the level of clustering, replacing tehsil with district (we show results using both existing and new

districts for clustering) to assess the sensitivity of our findings to different structures of spatial correlation (Table C.4). Finally, we consider alternative definitions of the outcome variable in Table C.5 – log transformation, winsorization, and the average monthly number of fires in the year. Across all exercises, results remain robust in both direction and statistical significance.

6 Mechanism

Having established the total impact of district fragmentation, we now examine the mechanisms underlying this effect. In particular, we analyze how changes in coordination and administrative capacity contribute to the observed increase in fires.

6.1 Coordination

District fragmentation alters the strategic framework within which environmental management takes place. When a district is split, responsibilities that were previously internal to a single administration become divided across jurisdictions. This change affects incentives to coordinate over pollution control, as actions taken in one jurisdiction generate spillovers in neighboring areas. We refer to adjacent administrations' joint exertion (or absence) of effort and planning in the presence of spillovers as *coordination*.

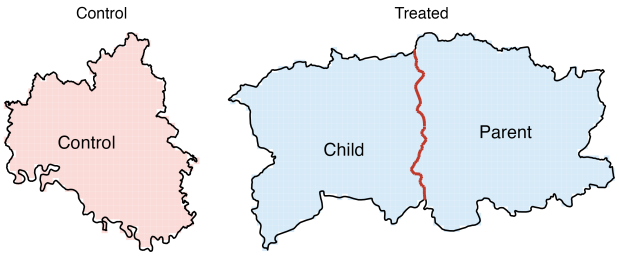
Fragmentation mechanically increases the number of administrative units and of shared borders. Table B.1 documents this transformation. During our study period, 30 new districts are created from an initial set of 192, increasing the number of neighbors and borders by 16.2%, from 537 to 624.[6]

Empirically, we analyze losses in coordination in two ways. First, we postulate that the incentive to coordinate is weakest when a district manager can offload pollution to their neighbor. This is most likely to happen at border compared to internal areas. Second, we hypothesize that coordination failures are more likely in the presence of more principals with potentially competing

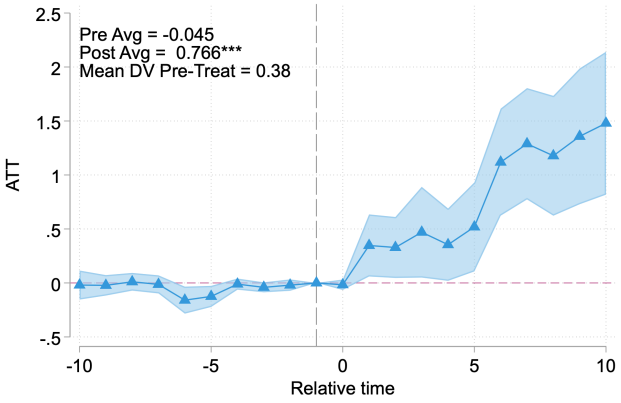
[6]As discussed, our analysis sample includes only 25 of these districts, since 5 of them were already split between 1990 and 1999.

Figure 1: Total Impact of District Fragmentation on Crop-Burning Fires

(a) District Fragmentation, Illustration



(b) District Fragmentation, Event Study



(c) Effect of District Fragmentation on Fires (DID)

	(1)	(2)	(3)	(4)
	Number of Fires			
AfterSplit	1.177***	1.393***	0.847***	
	(0.244)	(0.221)	(0.217)	
AfterSplit × HighRice				2.439***
				(0.482)
AfterSplit × LowRice				-0.014
				(0.108)
Linear Combinations:				
High Rice - Low Rice				2.453***
				(0.492)
Observations	2,575,500	2,575,500	2,575,500	2,575,500
Mean DV	0.28	0.28	0.28	0.28
Mean DV (High Rice)				0.46
Mean DV (Low Rice)				0.23
Grid FE	N	Y	Y	Y
Year FE	N	N	Y	Y

Notes: Panel (a) illustrates the empirical strategy for the total effect of district fragmentation. We compare the evolution of fires in districts that undergo a reorganization (treated, right) and those that do not (control, left) before and after the split. Panel (b) shows the event-study estimates of the effect of district fragmentation on fires using (Callaway and Sant'Anna, 2021). The dependent variable is the number of fires per grid-year. The sample includes never-treated grids and treated grids within a 10-year window around the split. Panel (c) reports the results from Equation 1. Column (4) includes the additional interactions for constituency agricultural characteristics: *HighRice* (*LowRice*) is a dummy equal to one if the average rice production in the subdistrict in year 2000 is above (below) median. Standard errors are clustered at the tehsil level. The table reports the mean of the dependent variable in the treated group before treatment.

interests.

6.1.1 Pollution Increases at Borders

We start by considering whether coordination is most likely to erode at jurisdictional borders versus internal areas. If coordination across districts deteriorates with fragmentation, locations close to a district border should experience larger increases in crop burning than locations that are internal to a district.

We estimate the impact of being close to a border versus an internal part of the district in a difference-in-differences framework. For grid i in year t, we estimate:

$$\text{Number of Fires}_{it} = \beta_1(\text{AfterSplit}_{it} \times \text{Internal}_i) + \beta_2(\text{AfterSplit}_{it} \times \text{Border}_i) + \alpha_i + \gamma_t + \epsilon_{it} \quad (3)$$

where $Border_i$ is a dummy equal to 1 if grid i is within 5 km distance to the closest post-reorganization district border, and $Internal_i$ is a dummy equal to 1 if grid i is located more than 5 km away from its nearest border – in the internal part of the district. In robustness tests, we vary the 5km threshold to be larger or smaller. All specifications include grid and year fixed effects. Since here treatment is defined by proximity to borders and varies at the grid level, we cluster standard errors at the grid-cell level. We illustrate this empirical strategy in Figure 2, panel a.

We find that the increase in fires following district reorganization is larger at border than at the internal areas of the district, though both exhibit an increase. Table 1, Panel A shows that areas located near a border experience a substantially larger increase in fires (1.105 fires per grid-year, s.e.=0.033), than internal areas, which see an increase of 0.638 fires per grid-year (s.e.=0.022). Relative to baseline levels, this corresponds to roughly a 3.5-fold increase at borders and a 2.7-fold increase in internal areas. This suggests that coordination losses matter everywhere in the district. However, the difference between border and internal areas is substantive and statistically significant, as indicated by the t-test in Panel C. This pattern is consistent with a coordination mechanism: the concentration of fires near borders suggests stronger free-riding incentives, as jurisdictions can increase polluting activity while shifting part of the pollution damage onto neighboring districts.

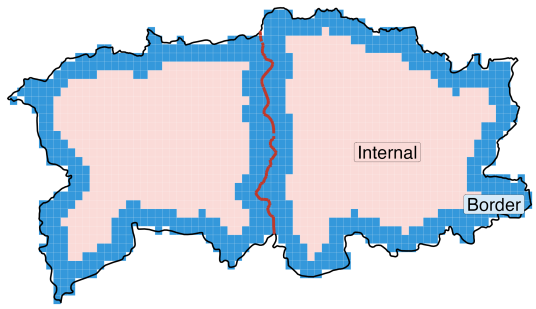
Table 1: Effect of District Fragmentation on Fires, Coordination

	(1)	(2)	(3)
	Number of Fires		
Panel A: Border Proximity			
AfterSplit × Internal	0.638***		
	(0.022)		
AfterSplit × Border	1.105***		
	(0.033)		
Panel B: Assembly Constituencies			
Multiple ACs		0.497***	
		(0.162)	
AfterSplit × Single AC			0.943*
			(0.519)
AfterSplit × Multiple ACs			2.110***
			(0.514)
Panel C: Linear Combinations			
Border - Internal	0.467***		
	(0.039)		
Multiple ACs - Single AC			1.166*
			(0.647)
Observations	2,575,500	1,100,075	1,100,075
Mean DV (Internal / Single AC)	0.24	0.18	0.18
Mean DV (Border / Multiple ACs)	0.32	0.44	0.44
Grid FE	Y	N	Y
Year FE	Y	Y	Y

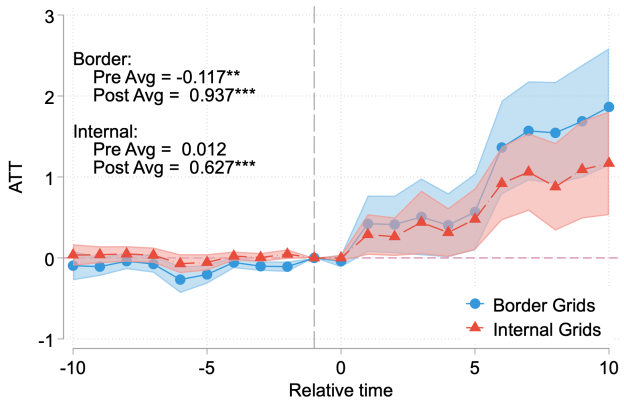
Notes: (Panel a) Results from Equation 3 of the effect of fragmentation on fires by location. $Border_i$ is a dummy equal to 1 if grid i is closest to a border (new or existing) by less than 5km. $Internal_i$ is a dummy equal to 1 if grid i is located more than 5km away from its nearest border. The regression includes grid and year fixed effects. Standard errors are clustered at the grid level.

Figure 2: Evidence of Coordination after District Fragmentation

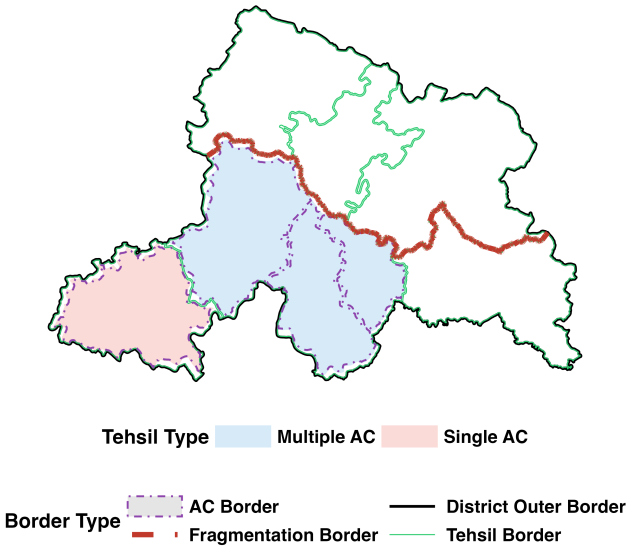
(a) Border vs internal areas



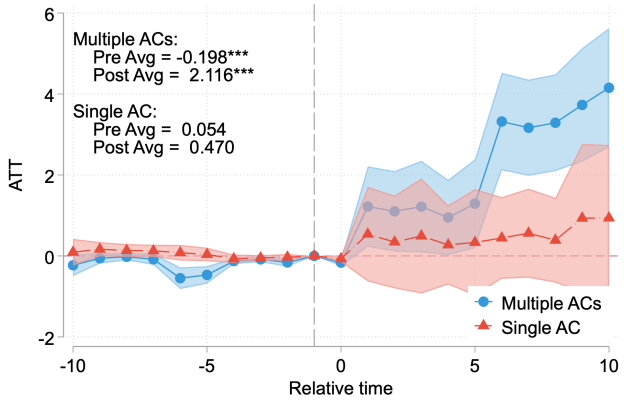
(b) District Fragmentation by Border Proximity



(c) Multiple Single Political Principals



(d) District Fragmentation by Multiple Principals



Notes: (Panel a) Empirical strategy for the border proximity analysis. Grids located within 5km of the nearest district border are classified as border grids (light blue), while grids in the interior of the district are classified as internal grids (light red). (Panel b) Event-study estimates (Callaway and Sant'Anna, 2021) of the effect of district fragmentation on fires separately for border and internal grids. (Panel c) illustrates the empirical strategy for the political principals heterogeneity analysis. Subdistricts are classified according to whether they contain a single Assembly Constituency (light red) or multiple Assembly Constituencies (light blue). (Panel d) Corresponding event-study estimates (Callaway and Sant'Anna, 2021). The classification of subdistricts with single or multiple political principals is determined as of the year of administrative fragmentation. The sample is restricted to the Indian states of Bihar, Haryana, Punjab, and Uttar Pradesh. All regressions include grid and year fixed effects. Standard errors clustered at the tehsil level in panel (b) and at the grid level in panel (d).

While in the main analyses we use a 5km bandwidth to define proximity to borders, we show robustness using alternative thresholds of 1, 2, 7 and 10 km in Table D.1. Treatment effect size

remains comparable, with effects significantly larger at the border relative to internal areas.

6.1.2 Pollution Increases with Multiple Political Principals

In India, state politicians are elected from single-member constituencies. Each administrative district contains multiple political constituencies. While the political constituency boundaries rarely cross district boundaries, they intersect unevenly with subdistrict boundaries, producing variation in how many political principals local bureaucrats answer to.

Previous work shows that governance is weaker in the presence of multiple political principals (Gulzar and Pasquale, 2017). Bureaucrats regularly meet with politicians in the context of the 'District Development Coordination and Monitoring Committee' (DISHA), chaired by elected politicians, and including district and subdistrict bureaucrats. In this setting, bureaucrats report progress on various governance outcomes and schemes to politicians. Previous work has shown that the presence of multiple politicians lowers public goods provision (Gulzar and Pasquale, 2017). First, we replicate this finding with the production of pollution: in our setting, subdistricts responding to multiple political principals experience more than double the number of fires than at baseline (Column 2, Table 1). After accounting for year fixed effects, these areas experience 0.497 higher fires per grid-year (s.e.=0.162).

Next, we investigate if coordination worsens after a district reorganization in places with a single versus multiple political principals. We estimate a similar model as Equation 3, but consider the impact of district reorganization in a sub-district with a single political principal versus multiple ones. Specifically, all grids in a sub-district are coded as 1 for the years in which the sub-district contains multiple political constituencies.[7] All specifications include grid and year fixed effects, and we cluster standard errors at the subdistrict level. For this analysis we focus on India, where data is available in a consistent form. We illustrate this empirical strategy in

[7]The number of electoral constituencies changes in a staggered way following the 2008 delimitation reform, as the new boundaries are implemented in each state's next election, which occurs at different times across states. We include fixed effects for the post-delimitation year in each state.

Figure 2c.

Results in Table 1, panel B, show that the vast majority of the increase in fires after the reorganization is driven by places with multiple politicians: here, the number of fires in a grid-cell increases by 2.11 (s.e.=0.514) over a baseline mean of 0.44 per year. The difference between the increase in areas with multiple and single politicians is statistically significant, as shown in Panel C. We show the eventstudy specification in Figure 2, panel d.

6.2 Capacity

The adoption of district fragmentation reforms is generally motivated by the goal of increasing administrative and monitoring capacity. We focus on three mechanisms through which fragmentation can increase capacity: a reduction in the size of administrative jurisdictions, a reduction in the distance between localities and administrative headquarters, and the creation of new administrative authority.

Fragmentation affects all three mechanisms mechanically. When a district splits, the original district is divided into smaller jurisdictions, making headquarters responsible for a smaller geographic area, and increasing their capacity to monitor and enforce regulations within the district. We document this change in Figure E.1, where both parent and child districts experience reductions in size, becoming 44 and 60% smaller on average. At the same time, the creation of new headquarters reduces the distance between administrative centers and localities in the newly created districts. As shown in Figure E.2, distance to the headquarters declines by 29km on average, and up to 160 km, in child districts following a split.[8] Finally, fragmentation entails the creation of a new district administration, giving the newly formed district its own bureaucratic leadership, budget, and formal authority, which can increase oversight and enforcement relative to when it was managed from a more distant parent district.

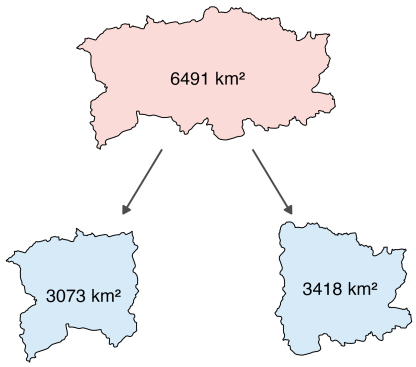
6.2.1 Pollution Increases are Offset by Smaller District Size

We start by considering how the effect of district fragmentation changes with the magnitude of the reduction in jurisdiction size. To answer this question, we estimate an augmented version of Equation 1 in which the treatment indicator $AfterSplit$ is interacted with the standardized change in district size post-fragmentation. We illustrate treatment (blue) and control units (red) in Figure 3, panel a.

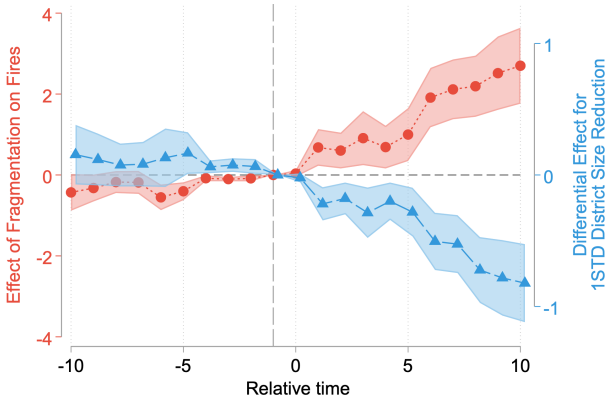
We have already documented that district splits increases fires overall. However, considering the differential effect of a one-standard deviation reduction in district size on fires, we find that

[8]Fragmentation can also increase distance for some areas, but this happens in only 1.35% of the grids, preventing us from running analyses on this sample.

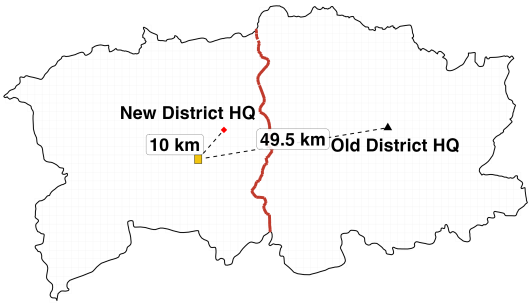
Figure 3: Evidence of Capacity after District Fragmentation



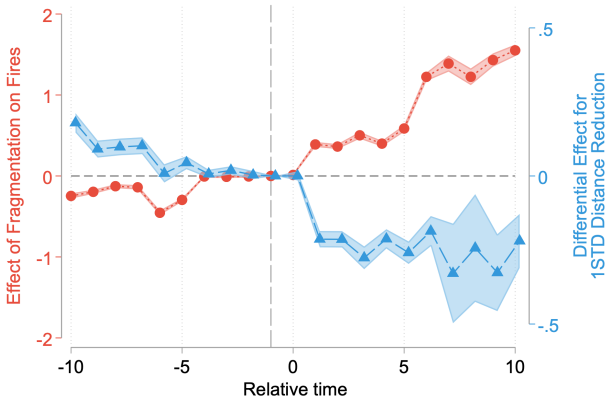
(a) Change in district size



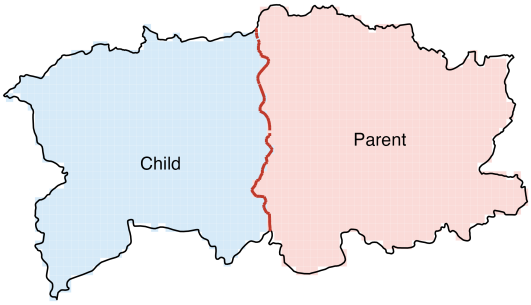
(b) Event Study for Capacity (District Size)



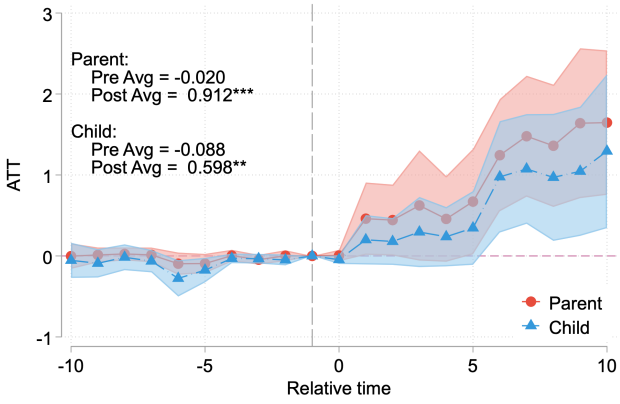
(c) Change in distance to headquarter



(d) Event Study for Capacity (Distance to HQ)



(e) Parent vs Child District



(f) Event Study for Capacity (Parent vs Child)

Notes: (Panel a) Empirical strategy for the district size heterogeneity analysis. The original pre-split district is shown in red, and the two resulting post-split districts are shown in blue. (Panel b) Event-study estimates separately for districts experiencing a change in size equal to the sample mean and districts experiencing a change one standard deviation above the mean. (Panel c) Empirical strategy for the change in distance to the district headquarter following reorganization. (Panel d) Event-study estimates. Panel (e) illustrates the empirical strategy for the parent versus child district classification. Parent tehsils that retain the existing headquarter are shown in red; child tehsils that receive a new headquarter — are shown in blue. (Panel f) Event-study estimates separately for parent and child tehsils. All regressions include grid and year fixed effects. Standard errors are clustered at the tehsil level in panels (b) and (f), and at the grid level in panel (d).

those areas experience a significant drop in fires (Figure 3b). Table 2, column 1, shows that a one–standard deviation reduction in district size, approximately 549 grid-cells corresponding to a 2,470 km^2 change, is associated with 0.542 fewer fires per grid-year (s.e.=0.110), a 35% drop in pollution with respect to never treated districts and those with average district size reduction. Consistent with a gradual increase in capacity as the district becomes fully operational, the drop in fires is gradual, becoming larger multiple years after the split (Figure 3b).

Table 2, column 2, further decomposes this effect by the extent of the decrease in size. Below-median reductions in district size experience an increase of 0.875 (s.e.=0.233) fires per grid-year, in line with the main effect of district fragmentation. However, districts with an above median size reduction, where the area bureaucrats are responsible for has shrank considerably, do not experience a statistically significant increase in fires. This finding is consistent with the hypothesis that sufficient improvements in administrative capacity can offset the overall negative impact of district fragmentation on environmental control.

6.2.2 Pollution Increases are Offset by Reduced Distance to Headquarters

Second, we examine how the effect of administrative fragmentation on fires varies with changes in a location's distance to the administrative headquarters. As illustrated in Figure 3, panel c, the average grid moves from being 49.5km to 10km away from an administrative center of power after split.[9] Reduced distance to the administrative headquarter is not a byproduct, but rather an explicit objective of district creation, as illustrated with examples in Section 3.3. We thus leverage this change in a difference-in-differences framework, interacting the dummy for $AfterSplit$ with whether a grid has experienced a change in distance to the headquarter. Since treatment is at the grid level, this is also the level of clustering in the tables.

We define changes in distance using three alternative measures: standardized distance in the full sample (Table 3, column 1), within-district standardized distance (column 2), and an indicator

[9]Instead, grids in the parent district do not change distance to the headquarter. In addition, because only 1% of the sample becomes farther, a group too small to support separate analyses, we exclude it from the main sample and show robustness to including it in Table 3.

Table 2: Effect of District Fragmentation on Fires by District Size Change (DID)

	(1)	**(2)**
	Number of Fires	
Panel A: Main Specification		
AfterSplit	1.546***	
	(0.314)	
AfterSplit × District Size Decrease (z-score)	-0.542***	
	(0.110)	
Panel B: Alternative Specification		
AfterSplit × Small Decrease		0.875***
		(0.233)
AfterSplit × Large Decrease		0.464
		(0.401)
Observations	2,538,525	733,000
Mean DV	0.29	0.29
Grid FE	Y	Y
Year FE	Y	Y

Notes: (Panel A) Results from Equation 1 with the additional interaction of the standardized reduction in district size after district fragmentation.*District Size Decrease (z-score)* is defined as the difference in the number of grid cells before and after the split, standardized with respect to the mean and standard deviation computed across all grid-year observations. One standard deviation of district size decrease is equivalent to a reduction of 546 grid-cells in the district. (Panel B) Results from Equation 1 with the additional interactions of *Small Decrease*, equal to 1 if the reduction in district size is below the sample median, and *Large Decrease*, equal to 1 if it is above the sample median. This panel restrict the sample to ever-treated observations. Standard errors are clustered at the tehsil level. The table reports the mean of the dependent variable in the treated group before treatment.

for above- versus below-median reductions in distance (column 3). When looking across the sample, we find that a 1SD reduction in distance to the headquarters does not have a statistically significant impact on fires, through the direction of the effect is correctly negative. Once we standardize distances within the district (column 2), we see that a 1SD decrease in distance, relative to places with average change, decreases fires by 0.174 per annum (s.e.=0.021). Finally, we also split the distance at the median and show, in column 3, that places with a greater than median chance exhibit a large and statistically significant decrease in fires ($\beta = -0.366$, s.e.=0.042). Overall, these patterns suggest that increased administrative proximity partially offsets the adverse effects of fragmentation on pollution outcomes.

Table 3: Effect of Administrative Fragmentation On Fires, by Change in Distance to Headquarters

	(1)	**(2)**	**(3)**
	Number of Fires		
AfterSplit	0.853***	0.593***	0.934***
	(0.020)	(0.017)	(0.027)
AfterSplit×CloserByDistance (z-score with full sample)	-0.012		
	(0.009)		
AfterSplit×CloserByDistance (z-score in each district)		-0.174***	
		(0.021)	
AfterSplit×(DistanceReduction > Median)			-0.366***
			(0.042)
AfterSplit×(DistanceReduction < Median)			-0.056
			(0.047)
Observations	2,575,500	766,750	2,575,500
Mean DV (All)	0.28	0.28	0.28
Grid FE	Y	Y	Y
Year FE	Y	Y	Y

Notes: Results from Equation 1 with additional interactions for changes in distance to the headquarter. (Column 1) $CloserByDistance$ is the standardized change in distance (in km) from each grid to its district headquarters before versus after the district re-organization, standardized with respect to the full sample. (Column 2) $CloserByDistance$ is standardized separately within each district. This analysis restrict the sample to ever treated units. (Column 3) $MostCloser$ ($LeastCloser$) is a dummy that takes value 1 for grids whose change in distance to headquarters is above (below) the sample median change, respectively, and zero otherwise. The table reports the mean of the dependent variable in treated grids before the split. Standard errors are clustered at the grid level.

Taken together, these result indicate that improvements in local capacity can partially offset coordination losses. Jurisdictions that become responsible for a substantially smaller area or grids that become closer to their headquarters, produce fewer fires, implying that increased capacity can offset the negative impact of altered incentives due to more opportunities for cross-border spillovers.

6.2.3 Pollution Increases are Offset in Child Districts

To further assess the capacity channel, we compare effects between parent and child districts following a split. While fragmentation weakens coordination in both units, our framework predicts that child districts should experience larger gains in administrative capacity, as they benefit from the creation of a new administrative headquarter. As a result, we expect the increase in pollution to attenuate in child districts relative to parent districts, as coordination losses are less offset by improvements in capacity in these areas.

We show the effect of administrative fragmentation by parent and child districts in the eventstudy in Figure 3, panel f, and results in Table 4, column 1. Fires increase significantly in both jurisdictional areas following the split, but this increase is smaller for child districts. Parents experience 0.934 more fires per grid-year (s.e.= 0.310), while child districts see an increase of 0.726 fires per grid-year (s.e. =0.288). These effects correspond to a 3.4- and 2.5-fold increases in fires respectively relative to the average level of fires in these areas before reorganization.

Table 4, Panel B further probes the capacity channel by examining heterogeneity with respect to the magnitude of the reduction in district size. We find that fire increases are concentrated in districts that experienced smaller reductions in size. In parent districts with a small size reduction, fires increase by 0.780 per grid-year (s.e. = 0.217), while the estimate for large size reductions is 0.854 but imprecisely estimated (s.e. = 0.877). In child districts, those with small size reductions experience a large increase of 1.090 (s.e. = 0.593), whereas districts with large size reductions show a much smaller and statistically insignificant increase of 0.188 (s.e. = 0.261). These results indicate that capacity gains are strongest when fragmentation meaningfully reduces jurisdiction size, and that in their absence coordination losses dominate.

6.3 Coordination vs Capacity

In this section, we bring together the two forces examined throughout the paper: coordination and capacity. Rather than providing evidence for the presence of coordination losses and capacity gains in isolation, we study how they interact within the same locations. We do so in two complementary ways. First, we provide a binary comparison that contrasts border and interior areas in parent and child districts. Second, we implement a continuous analysis that interacts distance to headquarters with distance to the border. This exercise relies on spatial distance as the common denominator, placing coordination and capacity on the same scale and allowing us a direct comparison of their relative effect.

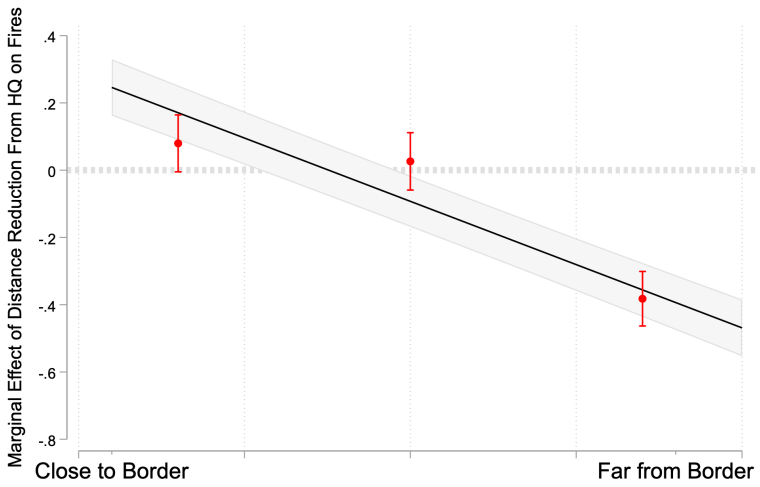
Our first approach asks whether coordination losses at borders offset the capacity gains observed in child districts. Table 4, Panel C, disaggregates the effect of district reorganization by parent versus child districts and by proximity to the district border. Consistent with earlier results, fires increase more sharply in areas close to administrative boundaries than in district interiors. Two patterns emerge. First, border areas in both parent and child districts experience systematically larger increases in fires (1.191, s.e.=0.049 and 0.991, s.e.=0.040 respectively), highlighting the importance of coordination losses. Second, child districts exhibit significantly smaller increases than parent districts, both at the border and in the interior (0.505, s.e. = 0.031 in child districts vs 0.733, s.e.=0.030 in parents), consistent with the idea that improved capacity in child districts partially mitigates the overall impact of fragmentation. All differences are statistically significant.

Our second approach examines the interaction between distance to headquarters and proximity to borders in a continuous framework. We focus on two distance-based measures: proximity to administrative borders and proximity to the district headquarters induced by fragmentation. Distance to the border captures the intensity of coordination frictions, while distance to headquarters captures the intensity of administrative capacity. This common measure allows us to assess which force dominates across space.

Figure 4 reports the marginal effect of a reduction in distance to the headquarters as a function of border proximity. Overall, as indicated by the straight black line, the average effect of proximity

to the headquarter is negative, meaning that fires drop as grids become closer to the administrative center after the split. This effect, however, varies sharply with distance to the border. In areas located deep in the district interior, far from administrative borders, a reduction in distance to the headquarters produces a sizable and statistically significant decline in fires, with marginal effects reaching approximately -0.4. By contrast, in areas closer to district borders, the effect is small and statistically indistinguishable from zero. These results indicate that the capacity gains from increased proximity to headquarters are spatially concentrated. Interior areas experience capacity gains that can offset the disruptive effects of fragmentation, winning from the overall reorganization. Instead near borders coordination losses dominate and neutralize the potential benefits of improved capacity.

Figure 4: Marginal Effect of Distance Reduction to The Headquarter, by Distance to Borders



Notes: The figure plots the marginal effect of a reduction in distance to the district headquarter on fires by distance to the closest border. The solid black line and shaded band report the linear fit for the effect of distance reduction to the headquarter and its 95% confidence interval. Coefficients in red bin this effect by terciles of distance to the border. The analysis restricts the sample to ever treated units, regressions include grid and year fixed effects, and standard errors are clustered at the grid level.

Table 4: Effect of District Fragmentation on Fires By Parent and Child District (DID)

	(1)	(2)	(3)
	Number of Fires		
Panel A: Main Specification			
AfterSplit × InParent	0.934***		
	(0.310)		
AfterSplit × InChild	0.726**		
	(0.288)		
Panel B: District Size Change			
InParent × Small Decrease		0.780***	
		(0.217)	
InParent × Large Decrease		0.854	
		(0.877)	
InChild × Small Decrease		1.090*	
		(0.593)	
InChild × Large Decrease		0.188	
		(0.261)	
Panel C: Border Proximity			
AfterSplit × Internal × InParent			0.733***
			(0.030)
AfterSplit × Border × InParent			1.191***
			(0.049)
AfterSplit × Internal × InChild			0.505***
			(0.031)
AfterSplit × Border × InChild			0.991***
			(0.040)
Linear Combinations:			
InParent - InChild	0.208		
	(0.422)		
Border×InParent - Border×InChild			0.199***
			(0.064)
Internal×InParent - Internal×InChild			0.227***
			(0.043)
Observations	2,575,500	733,000	2,575,500
Mean DV (Full Sample)	0.284	0.284	0.284
Mean DV (InParent)	0.278	0.278	0.278
Mean DV (InChild)	0.293	0.293	0.293
Grid FE	Y	Y	Y
Year FE	Y	Y	Y

Notes: Column (1) presents the overall effect heterogeneity based on the administrative unit (parent vs child). Column (2) lists the results based on reduction in size of districts. Column (3) presents the heterogeneity by border proximity (5km threshold) and administrative unit. Internal_i identifies grids more than 5km from any border; Border_i includes both new and existing borders; RemovedBorder_i identifies borders that ceased to exist post-split. Standard errors in parentheses are clustered at the tehsil level for Column (1) and (2) and grid level for Column (3).

7 Discussion: The optimal design of institutions for environmental control

This paper documents and quantifies a fundamental tradeoff in institutional design. Administrative fragmentation simultaneously increases enforcement capacity and weakens coordination across jurisdictions. Our empirical results show that both forces are quantitatively important. Fragmentation reduces fires in locations that benefit from increased proximity to headquarters and substantial reductions in jurisdiction size. At the same time, it increases fires in areas exposed to new or intensified administrative borders, where coordination frictions become salient.

Our model formalizes this tension from the perspective of a higher-level institutional designer who chooses the number of jurisdictions J to minimize emissions. The model returns the intuition that the relationship between fragmentation and pollution is U-shaped with activities that generate spillovers: when J is small, jurisdictions are large and enforcement capacity is limited (Figure 5). Monitoring is weak, and emissions remain high. As J increases, capacity improves because administrative units become smaller and closer to regulated actors. Emissions fall. However, beyond a certain point, additional fragmentation generates excessive coordination losses. Jurisdictions fail to internalize spillovers across borders, and emissions rise again. The optimal institutional design lies at an interior solution J^*, where the marginal gains in capacity are exactly offset by the marginal losses in coordination.

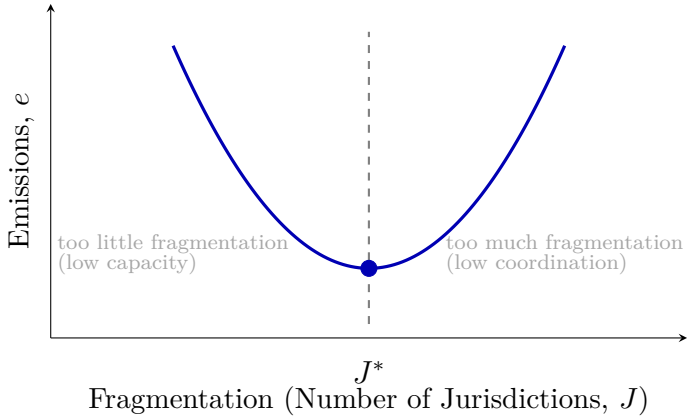


Figure 5: The Tradeoff Between Fragmentation and Emissions.

Our empirical findings provide direct support for the mechanisms embedded in the model. The border proximity results demonstrate that coordination losses are concentrated spatially where emissions can be offloaded and grow with the creation of borders. The headquarters proximity and district size results show that capacity improvements are spatially concentrated, primarily benefiting areas close to administrative centers and districts becoming smaller. By expressing both mechanisms in terms of distance, we show that they operate on the same margin and can be directly compared. In interior areas, capacity gains can dominate. Near borders, coordination losses prevail. These empirical patterns are the micro-level forces that generate the aggregate U-shape in the model.

The model also clarifies how the optimal degree of fragmentation depends on the extent of spillovers. In a benchmark without cross-jurisdictional externalities, where emissions are fully internalized ($\theta = 1$), fragmentation affects only capacity. In that case, the designer would prefer as many jurisdictions as feasible, $J^{**} \to \infty$, since additional fragmentation strictly improves enforcement. By contrast, when spillovers are present, the optimal degree of fragmentation J^* is strictly smaller. Coordination concerns impose a real constraint on institutional proliferation.

Our theoretical and empirical results yield insights for the institutional design of environmental control as well as other activities generating spillovers. Better institutions should structure administrative fragmentation in a way that maximizes capacity gains while minimizing coordination losses. Our estimates suggest several principles. First, fragmentation is more likely to improve environmental outcomes when it substantially reduces jurisdiction size. Splits that leave units only marginally smaller generate coordination costs without meaningful capacity gains. Second, the spatial placement of headquarters matters. Locating administrative centers strategically can extend the reach of capacity improvements beyond a narrow interior core. Third, minimizing the length and complexity of new borders can reduce the spatial scope of coordination failures. In practice, this implies favoring reforms that create compact and contiguous jurisdictions rather than highly interlocked boundaries.

More broadly, the framework extends beyond environmental governance. Any policy domain characterized by spillovers across administrative units, such as public health, policing, or

infrastructure provision, faces a similar tradeoff. Fragmentation enhances responsiveness and monitoring but can undermine the internalization of externalities. The optimal institutional structure depends on the relative strength of these two forces.

Taken together, the theoretical and empirical results show that fragmentation is neither inherently beneficial nor inherently harmful. Its effects depend on how it reshapes both administrative capacity and cross-jurisdictional coordination. Effective institutional design requires recognizing and balancing these competing forces.

References

Alesina, Alberto, Caterina Gennaioli and Stefania Lovo. 2019. "Public goods and ethnic diversity: Evidence from deforestation in Indonesia." *Economica* 86(341):32–66.

Altmann, J., L. Carino, R. Flaman, M. Kulessa and I. Schulz. 2000. *The UNDP Role in Decentralization and Local Governance*. New York: United Nations Development Programme.

Bazzi, Samuel and Matthew Gudgeon. 2016. *Local government proliferation, diversity, and conflict*. Boston University, Economics.

Bikkina, Srinivas, August Andersson, Elena N Kirillova, Henry Holmstrand, Suresh Tiwari, Atul K Srivastava, Deewan S Bisht and Örjan Gustafsson. 2019. "Air quality in megacity Delhi affected by countryside biomass burning." *Nature Sustainability* 2(3):200–205.

Billing, Cory R. 2019. "Size and local government policy agendas: Assessing the effect of municipal amalgamation." *Political Research Quarterly* 72(2):416–429.

Blom-Hansen, Jens, Kurt Houlberg, Søren Serritzlew and Daniel Treisman. 2016. "Jurisdiction size and local government policy expenditure: assessing the effect of municipal amalgamation." *American Political Science Review* 110(4):812–831.

Buntaine, Mark, Zhichen Huang, Gang Jin and Yanfei Yin. 2025. "Invisible Barriers to Externality Theory: Administrative Mergers, Local Favoritism, and Pollution Disparities." Unpublished manuscript.

Callaway, Brantly and Pedro HC Sant'Anna. 2021. "Difference-in-differences with multiple time periods." *Journal of econometrics* 225(2):200–230.

Cohen, Isabelle. 2024. "Documenting Decentralization: Empirical Evidence on Administrative Unit Proliferation from Uganda." *The World Bank Economic Review* 38(4):772–795.

Dahis, Ricardo and Christiane Szerman. 2021. "Development via administrative redistricting: Evidence from brazil." *Available at SSRN* .

Dandona, Rakhi, G Anil Kumar, Nathaniel J Henry, Vasna Joshua, Siddarth Ramji, Subodh S Gupta, Deepti Agrawal, Rashmi Kumar, Rakesh Lodha, Matthews Mathai et al. 2020. "Subnational mapping of under-5 and neonatal mortality trends in India: the Global Burden of Disease Study 2000–17." *The Lancet* 395(10237):1640–1658.

Dasgupta, Aditya and Devesh Kapur. 2020. "The political economy of bureaucratic overload: Evidence from rural development officials in India." *American Political Science Review* 114(4):1316–1334.

De Chaisemartin, Clément and Xavier d'Haultfoeuille. 2020. "Two-way fixed effects estimators with heterogeneous treatment effects." *American economic review* 110(9):2964–2996.

Dipoppa, Gemma and Saad Gulzar. 2024. "Bureaucrat incentives reduce crop burning and child mortality in South Asia." *Nature* 634(8036):1125–1131.

Garg, Teevrat, Maulik Jagnani and Hemant K Pullabhotla. 2024. "Rural roads, farm labor exits, and crop fires." *American Economic Journal: Economic Policy* 16(3):420–450.

Goodman-Bacon, Andrew. 2021. "Difference-in-differences with variation in treatment timing." *Journal of econometrics* 225(2):254–277.

Grossman, Guy, Jan H Pierskalla and Emma Boswell Dean. 2017. "Government fragmentation and public goods provision." *The Journal of Politics* 79(3):823–840.

Grossman, Guy and Janet I Lewis. 2014. "Administrative unit proliferation." *American Political Science Review* 108(1):196–217.

Gulzar, Saad and Benjamin J Pasquale. 2017. "Politicians, bureaucrats, and development: Evidence from India." *American Political Science Review* 111(1):162–183.

Illner, Michal. 1999. "Territorial decentralization: an obstacle to democratic reform in central and eastern Europe." *The transfer of power: decentralization in Central and Eastern Europe* pp. 7–42.

Lan, Ruoyu, Sebastian D Eastham, Tianjia Liu, Leslie K Norford and Steven RH Barrett. 2022. "Air quality impacts of crop residue burning in India and mitigation alternatives." *Nature communications* 13(1):6537.

Lipscomb, Molly and Ahmed Mushfiq Mobarak. 2017. "Decentralization and pollution spillovers: evidence from the re-drawing of county borders in Brazil." *The Review of Economic Studies* 84(1):464–502.

Narasimhan, Veda and Jeffrey Weaver. 2024. "Polity Size and Local Government Performance: Evidence from India." *American Economic Review* 114(5):1357–1395.

Rajan, Jothsna and Deepak Malghan. 2022. Administrative Proliferation and Developmental Outcomes: Evidence from India. Technical report IIMB Working Paper.

Rios-Avila, Fernando, Pedro H.C. Sant'Anna and Brantly Callaway. 2021. "CSDID: Stata module for the estimation of Difference-in-Difference models with multiple time periods." Statistical Software Components, Boston College Department of Economics.
URL: *https://ideas.repec.org/c/boc/bocode/s458976.html*

Sigman, Hilary. 2002. "International spillovers and water quality in rivers: do countries free ride?" *American Economic Review* 92(4):1152–1159.

Wang, Shaoda and Zenan Wang. 2021. "Township Merger and the Internalization of Border Pollution Spillovers." *Working Paper* .

World Bank. 2004. *World Development Report 2004: Making Services Work for Poor People*. Washington, DC: The International Bank for Reconstruction and Development / The World Bank.

Xu, Guo, Marianne Bertrand and Robin Burgess. 2023. "Organization of the state: home assignment and bureaucrat performance." *The Journal of Law, Economics, and Organization* 39(2):371–419.

A Case Studies of District Reorganizations

Stated motives behind district splits often cite administrative convenience. For example, recalling the rich history of Malerkotla, Amarinder Singh said the creation of the new district will "ease hardships of people in dealing with administrative problems" (India Today, 2021). Similarly, Uttar Pradesh chief minister Mayawati carved out three new districts in the western part of the state to "minimize hardship of the people who had to travel long distances to reach their district headquarters" (India Today, 2011). In Sindh, the cabinet approved the creation of new districts, noting that districts with "big populations and vast areas should be bifurcated into two districts for the convenience of local people" (Dawn, 2020). Bellow, we present three cases of administrative fragmentation in more detail.

A.1 Case Study: Bhiwani Split

Charkhi Dadri district was created in 2016, making it Haryana's 22nd district after splitting from the large Bhiwani district. Charkhi Dadri district comprises two administrative subdivisions (Charkhi Dadri and Badhra), two tehsils, one sub-tehsil, and covers over 170 villages with a population of over 500,000 according to the 2011 census (Government of Haryana, 2026).

The demand for this change had been present for nearly two decades, with local residents and political groups consistently highlighting the administrative difficulties caused by Bhiwani's vast size. Residents from some villages had to travel up to 40 km to reach the district headquarters in Bhiwani for official work (Singh, 2016*a*). The sarpanch (head) of one village expressed hope that the move would end their "endless problems" related to connectivity, water, and electricity, while Chief Minister Manohar Lal Khattar stated that the process would "speed up the ongoing development" in the area (Hindustan Times, 2016).

The announcement of the district during a public rally on September 18, 2016, portrays a potential motivation for competition in the elections. The Chief Minister declared, "It is a matter of pride for me to declare Charkhi Dadri as the 22nd district," and questioned why previous governments–who created districts like Panchkula and Yamunanagar–did not do the same for Dadri. The move was supported by a committee led by Agriculture Minister OP Dhankar, who

confirmed that the new district met all parameters (Singh, 2016*b*).

A.2 Formation of Kasganj from Etah

Kasganj district was carved out of Etah district on April 17, 2008, comprising the tehsils of Kasganj, Patiali, and Sahawar, with Kasganj as the district headquarters within Aligarh division (Kasganj District Administration, n.d.*a*; IndiaStat Districts, 2008). The new district was named Kanshiram Nagar after Bahujan Samaj Party founder Kanshi Ram by Chief Minister Mayawati, making it Uttar Pradesh's 71st district (India Today, 2008). Official district profiles describe the area as being organized into three tehsils and seven development blocks. (Kasganj District Administration, n.d.*b*; DCMSME, n.d.).

Soon after its creation, the naming of the new district as Kanshiram Nagar triggered protests, especially among local lawyers, who argued that it should instead honor Sant Tulsidas, traditionally associated with nearby Soron (Sukarkshetra) in the district (CSRidentity, 2008). These protests and public objections focused on the perceived politicization of the name rather than on the fact of the district's separation from Etah itself. In 2012, the Samajwadi Party government led by Akhilesh Yadav issued orders reverting the district's name from Kanshiram Nagar back to Kasganj, partially addressing those earlier symbolic grievances (Times of India, 2012).

Politically, some analysts argue that the 2008 creation and naming of Kanshiram Nagar fit into Mayawati's broader strategy of honoring Bahujan Samaj Party icons and redrawing administrative boundaries in western Uttar Pradesh, a move often interpreted as part of the BSP's social and electoral engineering (Twenty22, 2011). Later commentary on Uttar Pradesh's new districts under Mayawati describes such creations as having a strong political-symbolic component, with names chosen to consolidate party identity among targeted social groups (The New Indian Express, 2011). Subsequent developments -—such as the 2012 renaming back to Kasganj and later proposals to rename it again after BJP leader Kalyan Singh—show that the district has remained a site of name– based political contestation. (National Herald, 2021).

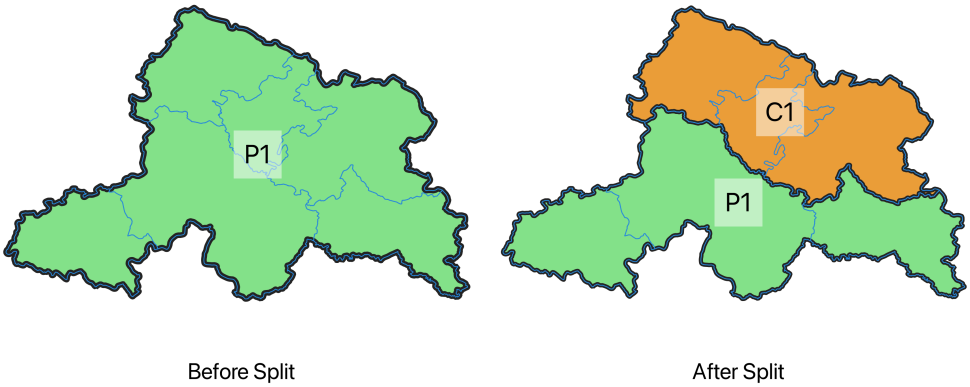
A.3 Formation of Fazilka from Firozpur

Fazilka district was carved out of Firozpur district on 27 July 2011 by the Government of Punjab through a Gazette Notification, creating a new district headquartered at Fazilka and comprising the three tehsils (subdivisions) of Fazilka, Jalalabad, and Abohar, along with the sub-tehsils Arniwala Sheikh Subhan, Sito Gunno, and Khuian Sarwar (Fazilka District & Sessions Court, n.d.; NRI Affairs Department, Government of Punjab, n.d.; Corporate Law Reporter, 2011). Official and quasi-official descriptions present the reorganization as an administrative step defining the new district's territorial and subdivision structure, while Deputy Chief Minister Sukhbir Singh Badal publicly specified the list of subdivisions and sub-tehsils when announcing the new district (Fazilka District & Sessions Court, n.d.; The Tribune, 2011).

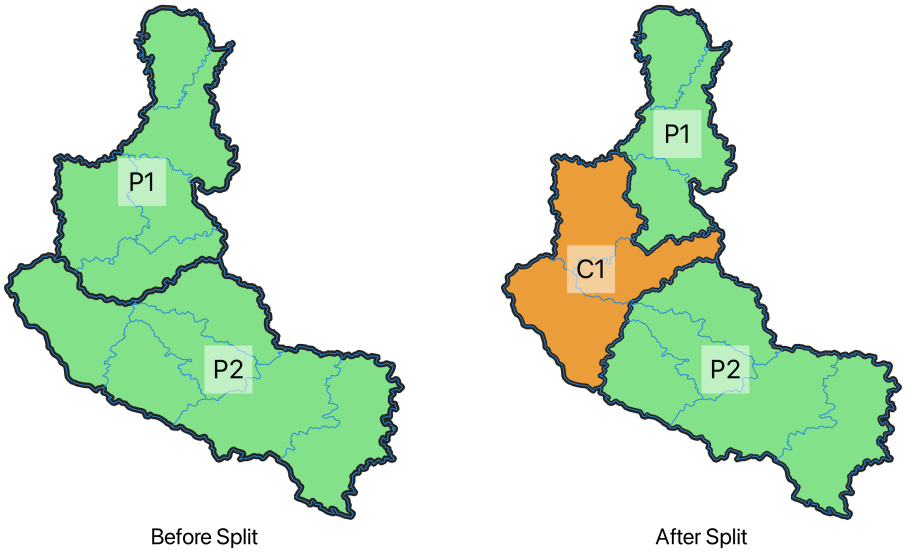
Locally, there had been sustained demand for district status before 2011, including a complete bandh and dharna in Fazilka in April 2010, during which residents, local bar association leaders, and BJP MLA Surjit Singh Jayani argued that dependence on distant Ferozepur headquarters caused delays and extra travel for administrative and policing work, and that a separate Fazilka district—also benefiting Abohar and Jalalabad—would reduce this burden (Indian Express, 2010). Political commentary around the 2011 decision notes that the creation of Fazilka and Pathankot districts under the SAD–BJP government also aligned with the home bases and interests of key BJP and alliance leaders and sparked competing demands from other towns (e.g., Batala) for similar district status, indicating an element of electoral and symbolic calculation alongside the administrative rationale (The Tribune, 2011; SikhRevolution, 2011).

B Descriptives

Figure B.1: Administrative Fragmentation Types

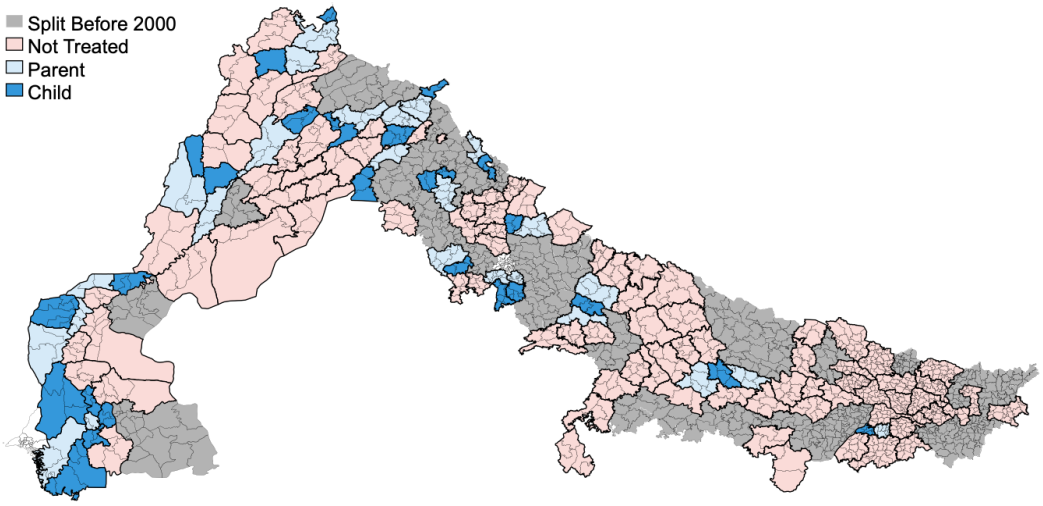


(a) Type 1: Creation of Kasganj district (Child, C1) out of Etah district (Parent, P1).



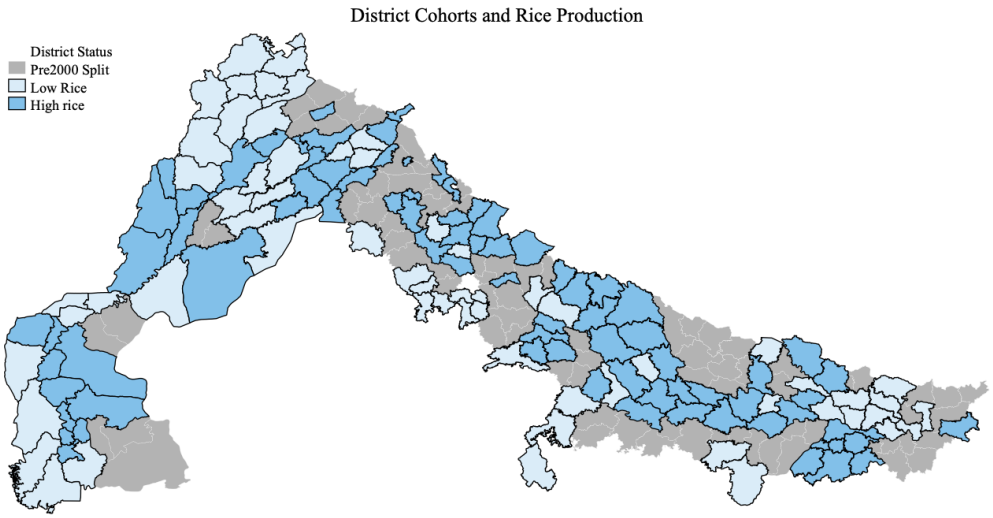
(b) Type 2: Creation of Sambhal district (Child, C1) out of Budaun (Parent, P2) and Moradabad (Parent, P1).

Figure B.2: Treatment Variation Across Space



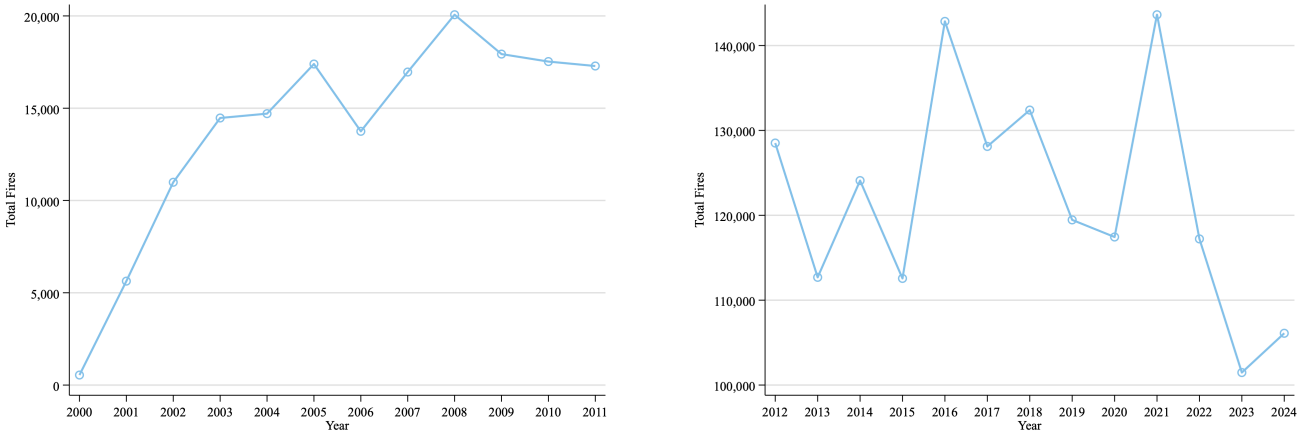
Notes: The map shows the location of administrative units that underwent a district split between 2000 and 2024. Light blue indicates parent districts — those that retained the original district headquarter following a split; dark blue indicates child districts — newly created districts assigned a new headquarter. Light red indicates districts that did not undergo any reorganization during the sample period. Gray indicates districts that experienced administrative fragmentation between 1990 and 2000 and are therefore excluded from the analysis. Bold black lines denote district boundaries as of 2024; thinner black lines denote tehsil boundaries.

Figure B.3: Distribution of Districts Based on Rice Production.



Notes: The map displays rice production in 2000 at the district level. Light blue indicates districts with below-median rice production; dark blue indicates districts with above-median rice production. Gray indicates districts that experienced administrative fragmentation between 1990 and 2000 and are therefore excluded from the analysis.

Figure B.4: Yearly Number of Fires



(a) Before 2012 (MODIS Only)

(b) From 2012 (VIIRS and MODIS Combined)

Figure B.5: Number of Observations by Relative Time (years) from Treatment

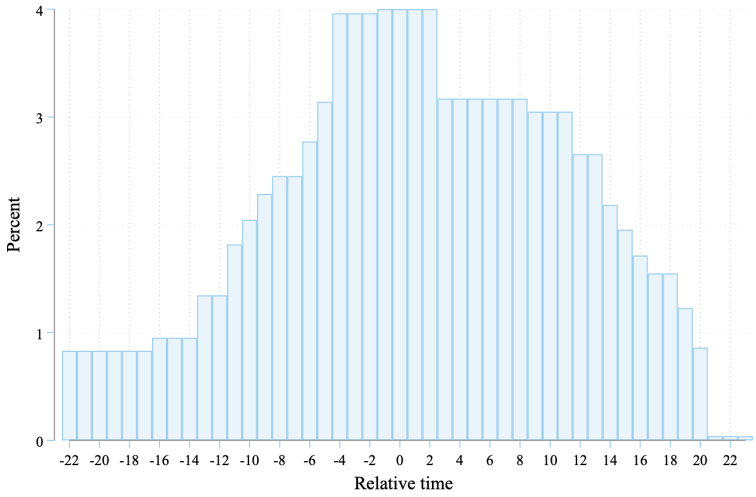


Table B.1: Administrative Fragmentation: Districts and Boundaries

	(1) **2000**	(2) **2024**	(3) **% Change**
Number of Districts	192	222	15.6%
Number of Borders	537	624	16.2%

Notes: The table reports the change in the number of districts and inter-district borders over the sample period (2000–2024). Columns 1 and 2 report the total counts at the beginning and end of the sample period, respectively. Column 3 reports the percentage change.

C Impact of District Reorganization on Crop Burning

Table C.1: Effect of Administrative Fragmentation on Fires, Event-Study Sample

	(1)	(2)	(3)
	Number of Fires		
AfterSplit	0.772***		0.765***
	(0.213)		(0.192)
AfterSplit × HighRice		2.225***	
		(0.507)	
AfterSplit × LowRice		0.007	
		(0.085)	
Linear Combinations:			
High Rice - Low Rice		2.218***	
		(0.512)	
Observations	2,324,936	2,324,936	2,324,936
Mean DV	0.38	0.38	0.38
Mean DV (High Rice)		0.48	
Mean DV (Low Rice)		0.34	
Grid FE	Y	Y	Y
Year FE	Y	Y	Y

Notes: (Column 1) Results from Equation 1 of the effect of administrative fragmentation on the number of fires. The sample is restricted to never treated grids and treated grids in a window of ± 10 years around treatment. (Column 2) Result from Equation 1 with additional interactions for constituency agricultural characteristics. *HighRice* is a dummy equal to 1 if the total rice production in the re-organized districts before the split is above median, and zero otherwise. *LowRice* is a dummy equal to 1 if the total rice production in the re-organized districts before the split is below median, and zero otherwise. Rice production variables are defined at the tehsil level, and based on the average rice production in year 2000. (Column 3) Result from Equation 1 using the **?** estimator. The table reports the mean of the dependent variable in the treated group before treatment. Standard errors clustered at the tehsil level.

Table C.2: Effect of Administrative Fragmentation on Fires, only treated units

	(1)	**(2)**
	Number of Fires	
AfterSplit	0.598***	
	(0.214)	
AfterSplit × HighRice		2.161***
		(0.486)
AfterSplit × LowRice		−0.242*
		(0.133)
Linear Combination:		
High Rice - Low Rice		2.403***
		(0.486)
Observations	766,750	766,750
Mean DV	0.28	0.28
Mean DV (High Rice)		0.46
Mean DV (Low Rice)		0.23
Grid FE	Y	Y
Year FE	Y	Y

Notes: Results as in Figure 1 of the effect of administrative fragmentation on the number of fires, restricting the sample to treated units only. Column (2) reports the result from Equation 1 with additional interactions for constituency agricultural characteristics. *HighRice* is a dummy equal to 1 if the average rice production in the re-organized subdistrict before the split is above median, and zero otherwise. *LowRice* is a dummy equal to 1 if the average rice production in the re-organized subdistrict before the split is below median, and zero otherwise. The table reports the mean of the dependent variable in the treated group before treatment. Standard errors clustered at the tehsil level.

Table C.3: Effect of Administrative Fragmentation on Fires, alternative samples

	(1)	**(2)**
	Number of Fires	
$AfterSplit$	0.569***	1.037***
	(0.184)	(0.253)
Observations	4,423,800	2,499,100
Mean DV	0.35	0.31
Grid FE	Y	Y
Year FE	Y	Y

Notes: The table reports estimates of the effect of administrative fragmentation on the number of fires across alternative samples, following the specification in Figure 1. Column (1) uses the full sample, including districts that underwent a split in the 1990s. The estimated effect is smaller than the baseline result in Figure 1, which likely reflects the fact that districts split prior to 2000 had already partially absorbed their treatment effects before the start of our sample period. Column (2) restricts the sample to our baseline specification — excluding 1990s splits — and additionally drops Type 2 splits. The table reports the mean of the dependent variable in treated grids before treatment. Standard errors are clustered at the tehsil level.

Table C.4: Effect of Administrative Fragmentation on Fires, Alternative Clustering

	(1)	(2)
Panel A		
AfterSplit	0.847	
SE by Cluster Level:		
(1) Tehsil	(0.217) ∗ ∗∗	
(2) Old District	(0.484)∗	
(3) Final District	(0.360) ∗ ∗	
(4) Old & Final Dist.	(0.360) ∗ ∗	
Panel B		
AfterSplit × **HighRice**		2.439
SE by Cluster Level:		
(1) Tehsil		(0.482) ∗ ∗∗
(2) Old District		(1.040) ∗ ∗
(3) Final District		(0.811) ∗ ∗∗
(4) Old & Final Dist.		(0.805) ∗ ∗∗
AfterSplit × **LowRice**		−0.014
SE by Cluster Level:		
(1) Tehsil		(0.108)
(2) Old District		(0.253)
(3) Final District		(0.187)
(4) Old & Final Dist.		(0.187)
Observations	2,575,500	2,575,500
Mean DV	0.36	0.36
Mean DV (High Rice)		0.47
Mean DV (Low Rice)		0.32
Grid FE	Y	Y
Year FE	Y	Y

Notes: Results from Equation 1 under alternative clustering. Panel A reports the main treatment effect (*AfterSplit*). Panel B reports the heterogeneous treatment effects for constituency agricultural characteristics. Standard errors clustered at four levels: (1) the tehsil level, which is our main specification; (2) the pre-split (old) district; (3) the post-split (final) district; and (4) both old and final districts jointly. The table reports the mean of the dependent variable in treated grids before treatment.

Table C.5: Effect of Administrative Fragmentation on Fires, alternative dependent variables

	(1) Winsorized Fires	(2) ln(Fires + 1)	(3) Avg. Monthly Fires
AfterSplit	0.165***	0.149***	0.071***
	(0.053)	(0.041)	(0.018)
Grid FE	Y	Y	Y
Year FE	Y	Y	Y
Observations	2,575,500	2,575,500	2,575,500
Mean DV	0.225	0.134	0.024

Notes: Results from Equation 1, using alternative transformations of the dependent variable. Column (1) reports results using a winsorized measure of the number of fires; column (2) uses the log-transformed number of fires; and column (3) uses the average monthly number of fires. The table reports the mean of the dependent variable in treated grids before treatment. Standard errors are clustered at the tehsil level.

D Coordination

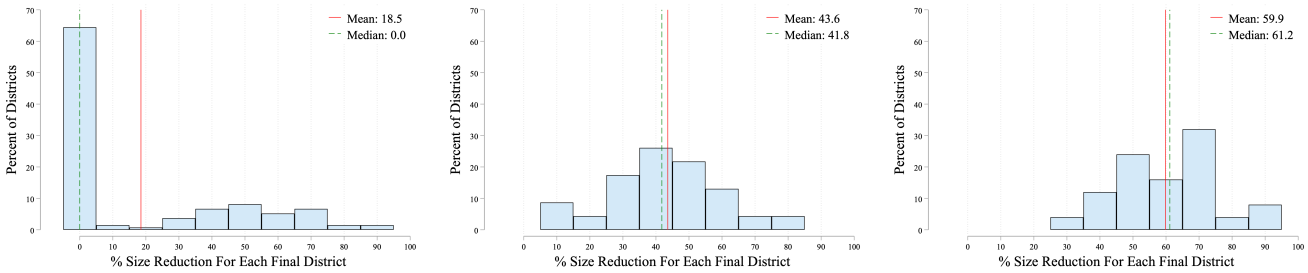
Table D.1: Effect of Administrative Fragmentation on Fires by Border Proximity, alternative thresholds

	(1)	(2)	(3)	(4)
	Number of Fires			
	1km	2km	7km	10km
AfterSplit × Internal	0.818***	0.769***	0.542***	0.371***
	(0.020)	(0.019)	(0.023)	(0.025)
AfterSplit × Border	1.078***	1.142***	1.075***	1.037***
	(0.057)	(0.053)	(0.028)	(0.024)
Linear Combinations				
Border - Internal	0.261***	0.373***	0.533***	0.667***
	(0.060)	(0.057)	(0.036)	(0.035)
Observations	2,575,500	2,575,500	2,575,500	2,575,500
Mean DV (Internal)	0.28	0.27	0.23	0.20
Mean DV (Border)	0.33	0.34	0.33	0.32
Grid FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y

Notes: Results from Equation 3. $Border_i$ is a dummy equal to 1 if grid i is within the specified threshold (1km, 2km, 7km, or 10km) from its closest border. $Internal_i$ is a dummy equal to 1 if grid i is located further than the threshold – in the internal areas. The table reports the mean of the dependent variable in treated grids before treatment. Standard errors are clustered at the grid level.

E Capacity

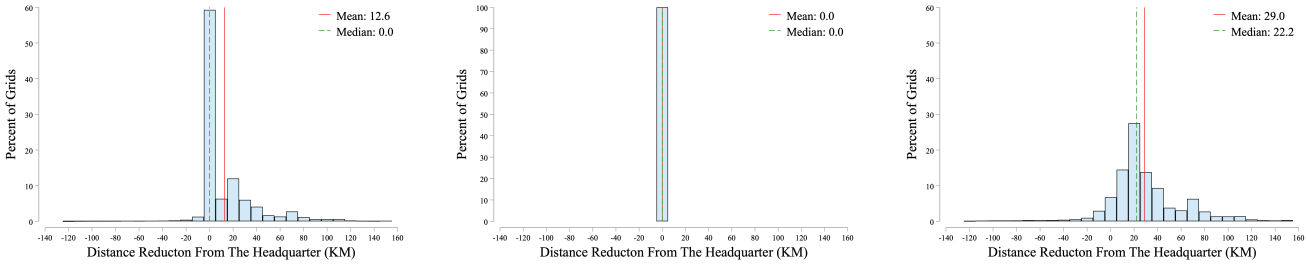
Figure E.1: District Size Reduction



(a) All districts (b) Parent districts (c) Child districts

Notes: The figure shows the distribution of district size reduction following administrative fragmentation, measured as the percentage decrease in district area. Panel (a) shows the distribution for all districts in the sample. Panel (b) restricts to the parent districts. Panel (c) restricts to child districts. Vertical solid and dashed lines indicate the mean and median of each distribution, respectively.

Figure E.2: Distance Reduction From The Headquarter



(a) All Treated Districts (b) Parent districts (c) Child districts

Notes: The figure shows the distribution of reduction in distance to the headquarter (in km) following administrative fragmentation. Panel (a) shows the distribution for all districts that undergo administrative reorganization in the sample. Panel (b) restricts to the parent districts – by construction, these districts retain their original headquarter and thus experience no change in distance. Panel (c) restricts to child districts – which are assigned a new headquarter upon reorganization. Vertical solid and dashed lines indicate the mean and median of each distribution, respectively.

F Empirical Strategy

F.1 Callaway and Sant'Anna (2021) Estimator

To control for the possible presence of treatment effect heterogeneity, we check the robustness of our main results to the **?** estimator. Their approach allows for arbitrary treatment effect heterogeneity and dynamic effects, thereby avoiding the issues of interpreting results of standard DiD regressions with staggered treatment adoption, as in Equation 1.

Formally, the estimator identifies the group × time average treatment effect (ATT), comparing municipalities first treated in period g to those never treated (or not-yet treated) at time t:

$$ATT(g,t) = \mathbb{E}[Y_t(1) - Y_t(0) \,|\, G = g] \tag{4}$$

where $Y_t(1)$ and $Y_t(0)$ denote the potential outcomes under treatment and control respectively, and $G = g$ denotes the group of districts first treated, i.e. split, in period g.

These effects can then be aggregated in different ways. We rely on the event-study aggregation that provides the average of the treatment effect in each pre- and post-treatment period. As we are interested in estimating the dynamic effect of the split over time -and to support the parallel trends assumption required for a correct interpretation of the ATT- we also look at the aggregation of group-time effects by relative time from the split into an event study plot. In this case, relative time equal to 0 represents the average effect of splitting across districts in the year when they are first treated (the instantaneous treatment effect). At relative time equal to +1, for example, it corresponds to the average effect of participating in the treatment across groups in the year after the split. At relative time equal to -1, instead, it corresponds to the average effect in the year before the split. A limitation of the event-study aggregation is that it does not address issues of unbalanced panels. Specifically, not all groups have the same number of pre- and post-treatment periods, and this compositional imbalance can complicate the interpretation of the aggregated parameters. For this reason, we restrict the event study analyses to a sample with a sufficient number of relative time periods, keeping only observations in a 10 years window around treatment. Figure B.5 shows that these relative time periods are the ones with the highest density

of observations.

G Administrative Fragmentation Sources

Below is a list of the sources used to gather iformation on the administrative fragmentation.

- (Kalra and Jolad, 2025).
- (India Local Government Directory, 2024).
- (Pakistan Bureau of Statistics, 2023).
- (Pakistan Bureau of Statistics, 1998).
- (Wikipedia contributors, 2026*a*).
- (Wikipedia contributors, 2026*b*).

Appendix References

Corporate Law Reporter. 2011. "Formation of two new districts Fazilka & Pathankot in the State of Punjab – Assignment of Lead Bank responsibility.". Accessed: 2026-02-03.

URL: *https://corporatelawreporter.com/formation-districts-fazilka-pathankot-state-punjab-assignment-lead-bank-responsibility/*

CSRidentity. 2008. "Welcome to Kasganj.". Accessed: 2026-02-03.

URL: *https://csridentity.com/districts/kasganj.asp*

Dawn. 2020. "Sindh cabinet approves creation of new districts.". Accessed: 2026-01-19.

URL: *https://www.dawn.com/news/1575499*

DCMSME. n.d. "KANSHIRAM NAGAR (KASGANJ), District Industrial Potential Survey.". Accessed: 2026-02-03.

URL: *https://dcmsme.gov.in/dips/Kanshiram%20Nagar%20(Kasganj).pdf*

Fazilka District & Sessions Court. n.d. "History.". Accessed: 2026-02-03.

URL: *https://fazilka.dcourts.gov.in/about-department/history/*

Government of Haryana. 2026. "District Profile — District Charkhi Dadri." `https://charkhidadri.gov.in/district-profile/`. Accessed: 2026-01-27.

Hindustan Times. 2016. "Dadri becomes Haryana's 22nd district.". Accessed: 2026-01-27.

URL: *https://www.hindustantimes.com/india-news/dadri-becomes-haryana-s-22nd-district/story-gmlh4idvD1rO1BjS79PrYM.html*

India Local Government Directory. 2024. "India Local Government Directory." `https://LGDirectory.gov.in`. [Online; accessed January 2025].

India Today. 2008. "CM announces creation of new district in UP.". Accessed: 2026-02-03.

URL: *https://www.indiatoday.in/latest-headlines/story/cm-announces-creation-of-new-district-in-up-24484-2008-04-16*

India Today. 2011. "Uttar Pradesh gets three new districts.". Accessed: 2026-01-19.

URL: *https://www.indiatoday.in/india/north/story/uttar-pradesh-gets-three-new-districts-142229-2011-09-28*

India Today. 2021. "Punjab CM declares state's only Muslim-majority town Malerkotla as district on Eid.". Accessed: 2026-01-19.

URL: *https://www.indiatoday.in/india/story/punjab-cm-declares-state-s-only-muslim-majority-town-malerkotla-as-district-on-eid-1802664-2021-05-14*

Indian Express. 2010. "Complete bandh in Fazilka, residents demand district status.". Accessed: 2026-02-03.

URL: *https://indianexpress.com/article/cities/chandigarh/complete-bandh-in-fazilka-residents-demand-district-status/*

IndiaStat Districts. 2008. "Kasganj (Kanshiram Nagar) – Districts of India.". Accessed: 2026-02-03.

URL: *https://www.indiastatdistricts.com/UTTARPRADESH/kasganj-kanshiramnagar-district*

Kalra, Mehr and Shivakumar Jolad. 2025. "New Districts Created in India (1951–2024).".

URL: *https://www.indiastatestory.in/datadownloads*

Kasganj District Administration. n.d.*a*. "About District — Kasganj.". Accessed: 2026-02-03.

URL: *https://kasganj.nic.in/about-district/*

Kasganj District Administration. n.d.*b*. "Administrative Setup — Kasganj.". Accessed: 2026-02-03.

URL: *https://kasganj.nic.in/administrative-setup/*

National Herald. 2021. "Now demand to change names of UP's Kasganj, Jaunpur.". Accessed: 2026-02-03.

URL: *https://www.nationalheraldindia.com/national/now-demand-to-change-names-of-ups-kasganj-jaunpur*

NRI Affairs Department, Government of Punjab. n.d. "Fazilka — Districts Profile.". Accessed: 2026-02-03.
URL: *http://nripunjab.gov.in/fazilka-district.htm*

Pakistan Bureau of Statistics. 1998. "Pakistan Census Archive." `https://www.pbs.gov.pk/censusarchive/`. [accessed 17-February-2026].

Pakistan Bureau of Statistics. 2023. "List of Administrative Districts." `https://www.pbs.gov.pk/wp-content/uploads/2020/07/List-of-Administrative-Districts-2023.pdf`. [accessed 17-February-2026].

SikhRevolution. 2011. "History of formation of new districts in Punjab.". Accessed: 2026-02-03.
URL: *https://www.youtube.com/watch?v=YKQDIcF5YSU*

Singh, Sat. 2016*a*. "Charkhi-Dadri is Haryana's 22nd district." `https://satsinghblog.wordpress.com/2016/09/18/charkhi-dadri-is-haryanas-22nd-district/`. Accessed: 2026-01-27.

Singh, Sat. 2016*b*. "Charkhi Dadri is state's 22nd district." `https://www.tribuneindia.com/news/archive/community/charkhi-dadri-is-state-s-22nd-district-297332/`. Accessed: 2026-01-27.

The New Indian Express. 2011. "New districts are Maya's latest electoral game.". Accessed: 2026-02-03.
URL: *https://www.newindianexpress.com/thesundaystandard/2011/Oct/02/new-districts-are-mayas-latest-electoral-game-296516.html*

The Tribune. 2011. "The Tribune, Chandigarh, India – Main News.". Accessed: 2026-02-03.
URL: *https://www.tribuneindia.com/2011/20110728/main4.htm*

Times of India. 2012. "Akhilesh renames UP districts named after dalits by Mayawati.". Accessed: 2026-02-03.
URL: *https://timesofindia.indiatimes.com/india/akhilesh-renames-up-districts-named-after-dalits-by-mayawati/articleshow/15114054.cms*

Twenty22. 2011. "Mayawati's poll-itics.". Accessed: 2026-02-03.

URL: *http://www.twenty22.in/2011/09/mayawatis-poll-itics.html*

Wikipedia contributors. 2026*a*. "List of districts in Punjab, Pakistan — Wikipedia, The Free Encyclopedia." `https://en.wikipedia.org/w/index.php?title=List_of_districts_in_Punjab,_Pakistan&oldid=1336350292`. [Online; accessed 17-February-2026].

Wikipedia contributors. 2026*b*. "List of districts in Sindh — Wikipedia, The Free Encyclopedia." `https://en.wikipedia.org/w/index.php?title=List_of_districts_in_Sindh&oldid=1333100662`. [Online; accessed 17-February-2026].