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September 2025

Working Paper 20250901

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Keywords: agriculture, conflict, public goods, irrigation management
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Arguments for decentralizing local public goods often emphasize productivity gains, but such reforms can also shape social cohesion, particularly in diverse communities and for high-stake resources. Exploiting the staggered roll-out of irrigation decentralization across Indian states, we show that these reforms reduce rural riots and perceived village-level conflicts. Our mechanism analysis points at reform-induced increases in the opportunity cost of conflict and highlights increased labor supply in agriculture and strengthened cooperation, which expand irrigation access and ultimately boost agricultural productivity.

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*Our thanks for valuable comments are due to Pascal Achard, Catherine Bros, Shumitro Chaterjee, Siddharth George, Lakshmi Iyer, Sriya Iyer, Veda Narasimhan, Leonid Peisakhin, Alberto Vesperoni, and Sujata Visaria. We are grateful to Peter Rongli Xue for excellent research assistance. We also thank seminar participants at Collegio Carlo Alberto, IDE-JETRO, King's College, NYU-Abu Dhabi, Oxford, Peking HSBC, Royal Holloway and Utrecht. Karol gratefully acknowledges financial support from the British Academy under the Leverhulme Small Research Grant 2021/210492. All remaining errors are our own.

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1 Introduction

Irrigation is a cornerstone of agricultural productivity and food security worldwide (Evenson and Gollin 2003), and its importance is set to grow amid climate change and increasing water scarcity (World Bank 2016). As a local common pool resource, irrigation systems rely critically on effective governance, regulation, and well-defined property rights (Ostrom 1990; Coase 1960). In many developing countries, where state capacity is limited, formal institutions often coexist—and sometimes conflict—with informal governance structures maintained by local communities.[1] Access to water[2] and food security[3] are well-documented sources of tension, and both conflict and cooperation are shaped by underlying group heterogeneity.[4] Yet we know relatively little about how the formalization of informal irrigation institutions—through administrative, fiscal, or political decentralization—affects civil conflict in socially diverse settings. We study this question in the context of India, a uniquely heterogeneous society marked by caste stratification, eight major religions, and a multitude of languages and dialects, all embedded in a long history of recurring conflict.

Historically, rulers of ancient Indian kingdoms served as custodians of water resources, operating under a highly decentralized administrative structure. This tradition was disrupted under British colonial rule, which centralized key irrigation decisions and prioritized the construction of large-scale irrigation networks to boost agricultural productivity. The legacy of centralized irrigation management persisted in post-independence India throughout much of the 20th century, contributing to inefficiencies, inequities, and conflict—largely due to weak governance, poor regulation, and incomplete property rights.

Toward the end of the 20th century, the central government of India began advocating for the decentralization of irrigation governance,[5] encouraging the formation

[1] See, for example, Wade (1988); Ostrom, Gardner, and Walker (1994); Greif (1993); McMillan and Woodruff (1999); Macchiavello and Morjaria (2015).

[2] See Devoto et al. (2012) for Morocco and Sekhri (2014) for India.

[3] See the special issue on food security and violent conflict in *World Development* (Brück and d'Errico 2019).

[4] See, e.g., Alesina and Spolaore (2005); Habyarimana et al. (2007); Arbatlı et al. (2020).

[5] The first national-level recommendations for irrigation decentralization appeared in the 2002

of *Water User Associations* (WUAs) with formal property rights to construct, operate, and maintain irrigation infrastructure. In what follows, we examine whether the transfer of these rights from central authorities to local communities through the establishment of WUAs influenced the incidence of civil conflict.

To guide our empirical analysis, we begin by developing a conceptual framework that highlights the high-stakes nature of irrigation for rural income generation. We show that decentralization reforms can reduce the incidence of civil conflict by raising the opportunity cost of engaging in violence relative to working and maintaining irrigation infrastructure. Upon assuming that local conflict generates negative productivity externalities, we also show that the direct effects are further amplified through positive income effects triggered by improvements in agricultural productivity.

In order to test implications of this framework, we construct a novel panel dataset at the state, district, village, and household levels. Our data sources include the Minor Irrigation Census (MIC), Indian Human Development Survey (IHDS), Indian Population Censuses, National Crime Records Bureau (NCRB), Reserve Bank of India, ERA5 climate data from the European Centre for Medium-Range Weather Forecasts, and remote-sensed satellite biomass imagery from NASA.

Our identification strategy leverages India's federal structure, which grants states autonomy over water governance. This institutional feature generates plausibly exogenous variation in the timing of Water User Association (WUA) reforms across states. We exploit this variation using a staggered difference-in-differences (DiD) design to compare regions that adopted decentralized irrigation management with those that did not. Moreover, we establish a strong first-stage effect of WUA laws on the share of government-managed irrigation systems, as recorded in the MIC. Using this, we further implement an instrumental variable (IV) strategy to bolster the robustness of our DiD results.

Our findings consistently indicate that the introduction of WUA reforms leads to a significant reduction in conflict incidence. First, event study estimates reveal that riot occurrence declines by one-third within the first three years following reform adoption, with longer-term effects reaching nearly two-thirds after a decade. Second,

update of the National Water Policy issued by the Indian Ministry of Water Resources.

instrumental variable (IV) estimates suggest that the reforms reduce rural riots by approximately 20%. Third, traditional difference-in-differences (DiD) estimates show substantial declines in perceived conflict: overall village-level conflict decreases by 62%, while intergroup conflict falls by 50%.

Our mechanism analysis supports the interpretation that these effects are launched by changes in the opportunity cost of conflict and operate through improvements in local cooperation and economic conditions. We document increases in subjective measures of water-related cooperation, higher agricultural labor supply and income, greater access to irrigation, and gains in agricultural productivity. Importantly, we show that these results are not driven by concurrent increases in public irrigation spending or by broader shifts in crime trends.

Our study contributes to three strands of literature. First, it contributes to research on water access and conflict—an especially salient issue in India, where socio-cultural diversity often exacerbates tensions over scarce resources. Wade (1988) offers a foundational account of the socio-economic dynamics of irrigation in Indian villages, emphasizing the role of caste networks and local institutions in managing water distribution and resolving disputes. More recent empirical work by Devoto et al. (2012) and Sekhri and Hossain (2023) documents how difficulties in accessing water can escalate into disputes and violence. Relatedly, Sekhri (2014) and Miguel, Satyanath, and Sergenti (2004) show that water scarcity—and the poverty it induces—can trigger violent conflict. In a broader context, McGurik and Nunn (2024) demonstrate that rainfall scarcity among African transhumant pastoralists undermines cooperation and increases the risk of conflict. We complement these studies by providing evidence on a scalable institutional solution to water-related conflict: the decentralization of irrigation governance through the transfer of property rights to local communities.

A related strand of literature documents wide-spread elite capture in India, i.e. discrimination in access to water or other public goods (Banerjee, Iyer, and Somanathan 2005; Shah et al. 2006; Anderson 2011; Bros and Couttenier 2015; Nambissan 2020). Our results suggest that decentralization and democratization of high stake public goods may reduce extent of such discriminatory practices.

Second, we contribute to the literature on the impacts of decentralization reforms across policy domains. Existing research often reports mixed or inconclusive results regarding the effectiveness of such reforms (Bardhan and Mookherjee 2006; Treisman 2007; Faguet and Pal 2023). Positive assessments can be found in Dahis and Szerman (2024) and Narasimhan and Weaver (2024), while others, such as Cassidy and Velayudhan (2022) and Malesky, Nguyen, and Tran (2014), report adverse outcomes. In the context of irrigation, Mazur (2023) structurally estimates a model of risk-sharing and irrigation cooperation using panel data from three Indian villages and shows that decentralization reforms enhanced outcomes by generating dynamic complementarities between these two institutional domains. We extend this literature by providing country-wide causal evidence that irrigation decentralization in India not only improves the efficiency of water resource management but also strengthens community resilience and cooperation, ultimately reducing civil conflict.

In related work on decentralization of other public goods, Chaudhary and Iyer (2024) shows that partial devolution—specifically, decentralizing administrative control over local healthcare services without corresponding fiscal authority—led to higher child mortality in India. Our findings align with their hypothesis that the success of decentralization depends on its completeness. In the case of irrigation, the reform involved the devolution of administrative, political and fiscal responsibilities, which likely contributed to positive outcomes documented by us.

Third, we contribute to the literature on conflict-reducing interventions, which often emphasize intergroup contact and leadership appeals for peace. For example, Weiss, Ran, and Halperin (2023) show that classroom debates on intergroup tensions and exposure to outgroup perspectives via televised appeals can effectively reduce prejudice among adolescents in Israel. Similarly, Blair et al. (2021) find that peace-promoting messages from trusted authorities in Nigeria decrease belligerent attitudes, while Chang and Peisakhin (2021) report comparable results from spiritual leaders in Lebanon. However, such interventions tend to be externally imposed, limited in duration, and difficult to scale.

To address these limitations, a growing body of research examines intergroup interdependencies in more organic, real-world settings. In the Indian context, Varshney (2003) provides qualitative evidence that economic interdependence fosters Hindu-

Muslim cooperation. At the international level, Lee and Pyun (2016) find that bilateral trade integration reduces the likelihood of conflict between neighboring countries, and Gartzke (2007) and Martin, Mayer, and Thoenig (2008) argue that economic development, financial integration, and shared policy interests are key drivers of peace. We complement this literature by providing micro-level causal evidence that decentralizing local irrigation infrastructure enhances cooperation and reduces conflict, by increasing the opportunity costs of non-cooperation leading to losses in agricultural productivity.

Our findings also relate to Jha and Shayo (2019), who show that incentivized participation in joint financial markets can foster peace-oriented attitudes among Israelis and Palestinians, and to Garg et al. (2024), who demonstrate that inter-village competition under Indonesia's Community Driven Development program reduces conflict by strengthening intra-village cohesion. Finally, our results resonate with Allen, Bertazzini, and Heldring (2023), who use archaeological data to show that shifting river paths in ancient Mesopotamia incentivized public irrigation and contributed to early state formation. Taken together, our findings suggest that economic interdependence and decentralized property rights can serve as scalable and sustainable mechanisms for promoting peace and cooperation in divided societies.

2 Institutional Setting

2.1 Historical Context of Irrigation in India

Irrigation has long been essential to ensuring food security and sustaining rural livelihoods in India. Historically, irrigation systems in ancient and medieval India were managed in a decentralized manner. Local communities, often operating under the trusteeship of regional kings (Siddiqui 1992; Cullet and Gupta 2008), regulated water resources according to local geographical and physical conditions (Vani 1992; Joseph 2021; Bhat, Basalalli, and Bhogse 2021). This decentralized model enabled adaptive, context-specific water management that supported sustainability.

Colonial rule, however, marked a turning point. The British administration sought centralized control over natural resources, including water, to promote agricultural productivity and extract rents. Irrigation was seen as a tool for both economic development and famine mitigation (Commission Of Inquiry On Indian Famines 1880), leading to the construction of vast canal networks by the British military—many of which remain in use today (Asher et al. 2023).

In legal terms, the British introduced a fundamental shift by redefining community water rights. Local communities were granted only usufructuary rights, allowing them to use water passing through their land but denying ownership of the resource or any specific volume (Puthucherril 2011; Jacob and Singh 1972; Cullet and Gupta 2008). This departure from customary rights was later embedded in constitutional reforms. The Government of India Act of 1919 introduced a quasi-federal structure, granting provinces authority to propose and implement irrigation projects subject to central approval (Jain 1971; Singh 2003). The 1935 Act expanded this autonomy, giving provinces control over all aspects of water management, while reserving interstate water dispute resolution for the central government (Jain 1971).

This federal structure has endured post-independence, with the Constitution preserving state autonomy over water governance in all 29 states, while granting the central government control in the eight Union Territories.[6]

2.2 Emergence of WUAs and Decentralized Irrigation Management

Several scholars have argued that under centralized irrigation management, state governments—operating through regional offices of the Ministry of Water's Irrigation Department (ID)—frequently struggled to effectively monitor, regulate, and maintain irrigation infrastructure (Wade 1982, 1988, 2000; Chambers 1988; Wade and Chambers 1980; Brewer et al. 1999; Bardhan 2000). The sources of this mismanagement range from corruption to shortages of personnel, financial resources, motivation, technical expertise, or localized information. Extending beyond the Indian context, the 2004 *World Development Report* similarly advocates for decentralizing public service

[6]The central government retains limited influence over state-level water politics through Article 282 of the Constitution, which authorizes discretionary grants for irrigation projects (Puthucherril 2022).

delivery, citing many of the same challenges inherent in centralized governance structures.

> Too often services fail poor people in access, in quality, and in affordability ... this year's World Development Report argues that services can be improved by putting poor people at the center of service. How? By enabling the poor to monitor and discipline service providers, by amplifying their voice in policy making, and by strengthening the incentives for providers to serve the poor. (World Bank 2004)

In response to persistent challenges in irrigation governance, India began gradually implementing Water User Association (WUA) laws across states and union territories in the 1990s. Andhra Pradesh and Goa were the first to adopt such laws in 1997, and to date, 16 states have established WUAs (see Table 1 in the Online Appendix for implementation timelines).

WUA reforms establish a three-tiered system of Farmers' Organizations—Project Committees, Distributory Committees, and Water User Associations—ranked from highest to lowest. At the core are the WUAs, composed of governing bodies elected by landowners typically spanning one or two villages. These associations are granted collective property rights over local water resources and are tasked with managing and improving irrigation infrastructure, regulating water distribution, levying and managing water fees, providing extension services, and resolving internal disputes.[7]

WUAs often build upon or collaborate with Panchayats, the decentralized village governments established through the 73rd and 74th Constitutional Amendments in 1993. While not direct successors of earlier informal irrigation bodies—some of which emerged independently in the 1970s and 1980s (Wade 1988; Sengupta 1991; Gandhi et al. 2020)—WUA reforms represent the first large-scale, institutionalized effort to decentralize water governance.[8] By transferring authority to local user groups,

[7] Distributory Committees coordinate across WUAs within a distributory area, while Project Committees oversee broader project areas and mediate across Distributory Committees.

[8] Ghatak and Ghatak (2002) similarly argue that although some panchayats existed before the constitutional reforms introducing formal frameworks for panchayats in 1990s, they were largely inactive and ineffective in delivering public services.

WUA reforms aim to improve the efficiency, sustainability, and equity of irrigation systems—aligning with the broader goals of the Panchayati Raj framework to foster accountability and local ownership in public service delivery.

2.3 Examples of Experiences with WUAs

We complement our conceptual framework and empirical analysis with an overview of micro-level studies that shed light on the causal mechanisms underlying the effects we observe. While the inception and diffusion of decentralized irrigation institutions in India vary across contexts, they commonly originate from farmer-led initiatives reflecting genuine local interest.[9] In some cases, these efforts were supported by NGOs through training and extension services—as documented in Gujarat by Mukherji, Verma, and Rath (2002) and Bhatt (2013). In others, local farmers initiated WUAs independently, often in response to failing infrastructure or after learning from neighboring communities' successes—as seen in Assam and Bihar (Gandhi et al. 2020).[10] Membership in WUAs is typically voluntary and obtained through the purchase of institutional shares.

From a governance perspective, WUAs generally feature elected executive committees—comprising around a dozen members (e.g., chairperson, secretary, treasurer)—who are independent of local Panchayat structures. Representatives from WUA committees may also be selected to serve on higher-tier Distributory Committees. The performance of WUAs often shapes member engagement in these democratic processes, reinforcing local ownership and accountability. Importantly, Bhatt (2013) finds no evidence of elite capture in these institutions. In states where land rights for women are recognized or gender quotas apply, women have gained representation in WUA leadership, further contributing to social cohesion by gender inclusion (e.g., Bihar in Gandhi et al. 2020; Andhra Pradesh and Madhya Pradesh in Raju, Dayal, and Chatterji 2008).

[9] An exception is Maharashtra, where the 2005 Maharashtra Management of Irrigation Systems by Farmers Act mandates that irrigation water be distributed exclusively via WUAs.

[10] Many early WUAs, established prior to formal legislation, operated informally without state support. Upon demonstrating effectiveness, they often formalized through agreements with state irrigation departments (see Mukherji, Verma, and Rath 2002).

Although some of WUA laws listed in Table 1 extend WUAs' mandates to groundwater, most associations focus on managing surface irrigation via canals. Evidence from Gujarat (Bassi, Rishi, and Choudhury 2010; Mukherji, Verma, and Rath 2002) and Andhra Pradesh (Raju, Dayal, and Chatterji 2008) shows that WUA establishment improved both water availability and equity. These improvements spurred shifts from rain-fed crops to higher-value alternatives such as wheat, pulses, groundnuts, and vegetables (Mukherji, Verma, and Rath 2002). In some cases, productivity gains also reduced seasonal migration, fostering greater village-level cohesion.

These benefits extended to both head- and tail-end villages along canals—settings particularly prone to inter-village conflict due to water scarcity at the tail. Studies by Bassi, Rishi, and Choudhury (2010) and Raju, Dayal, and Chatterji (2008) document how cooperation under WUAs enhanced water equity, particularly for tail-end users. Head-end farmers, recognizing their reliance on tail-end communities for canal maintenance, began to uphold equitable water-sharing arrangements in anticipation of future reciprocity.

While executive committees of WUAs are formally responsible for managing local irrigation, effective implementation depends on broad community participation and, often, inter-village cooperation. Gandhi et al. (2020), for example, document how WUA members regularly contribute voluntary labor under the leadership of local chairpersons to repair infrastructure.

Fiscal decentralization plays a crucial role in strengthening community ownership. Before WUAs, irrigation fees were collected by the Irrigation Department (ID), with low compliance. Following WUA implementation, collection rates improved significantly—largely due to social ties, community norms, and local enforcement mechanisms (Mukherji, Verma, and Rath 2002; Raju, Dayal, and Chatterji 2008; Bhatt 2013).[11]

WUAs are not fully independent from the ID, as they share collected fees and rely

[11] See also Wade (1988, 75, 193), who discusses "common irrigators" hired by village councils and funded by local contributions, responsible for water allocation, organizing repairs, and imposing sanctions for non-cooperation. Sengupta (1991, 104) reports a similar institution—the "neerpaichy" in Tamil Nadu.

on the department for water supply. While ID support for major repairs is inconsistent, improved fee compliance has led to more reliable water delivery and better coordination, in part due to enhanced communication and water demand forecasting (Mukherji, Verma, and Rath 2002).

Across numerous case studies, farmers report substantial reductions in water-related conflicts following WUA implementation (Gandhi et al. 2020; Raju, Dayal, and Chatterji 2008; Bhatt 2013), even in communities where WUAs underperform (Bassi, Rishi, and Choudhury 2010). Comparative studies find higher social cooperation in WUA-governed villages relative to those managed by the state ID (Wade 1988; Bardhan 2000). Meta-analyses of 21 cases across Gujarat, Maharashtra, and Tamil Nadu also show that WUAs tend to develop more effective rules for managing water and infrastructure, contributing to conflict reduction (Brewer et al. 1999; Kolavalli and Brewer 1999).

These patterns are echoed globally. A cross-country review by the Food and Agriculture Organization (FAO) finds that irrigation management transfers—including WUAs in Andhra Pradesh, Karnataka, and Madhya Pradesh—are associated with improvements in fee collection, infrastructure maintenance, water delivery, irrigated area, yields, and farmer incomes (Garces-Restrepo, Vermillion, and Munoz 2007).

3 Conceptual Framework

3.1 Static Environment

We begin with a one-period economy inhabited by 2 identical farming households with linear preferences over consumption $c \geq 0$ and a constant relative risk aversion (CRRA) preferences over leisure:

$$u\left(c_i, l_i\right) = c_i + \alpha \frac{l_i^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} \tag{1}$$

where $\epsilon > 0$ governs the Frisch elasticity. Both households $i \in \{1, 2\}$ are endowed with 1 unit of time and with resources $w_i = w$, over which they may fight. We denote by f_i the amount of time household i devotes to fighting over resources of the other household $-i$. We assume that household i takes the fighting decision of the other household as given.

Furthermore, households decide about the time devoted to working on the field n_i to produce agricultural output using the following technology:

$$y\left(n_i; f_1, f_2, \theta^j\right) = \theta^j \left(1 - \frac{1}{2}\left[f_1 + f_2\right]\right)^{(1-\gamma)\cdot\zeta} n_i^{\gamma} \tag{2}$$

where $\gamma \in (0,1)$ so that the production technology exhibits decreasing returns to scale in labor. The term $\theta^j \left(1 - \frac{1}{2}\left[f_1 + f_2\right]\right)^{(1-\gamma)\cdot\zeta}$ captures the overall productivity of irrigation in the village. We introduce common pool externalities (typical for irrigation) by assuming that the endogenous part of irrigation productivity is increasing in the village-wide time spent non-fighting. For tractability, we assume that it is taken as given by households when choosing f. As such, we also interpret increases in conflict as reductions in cooperation. We will highlight the importance of irrigation's common pool resource nature by comparing the model with ($\zeta = 1$) and without externalities ($\zeta = 0$).

The variable θ^j captures the productivity of irrigation that is exogenous to fighting time f, but endogenous to the choice of management model $j \in \{\mathbf{c}\textit{entralized}, \mathbf{d}\textit{ecentralized}\}$ (capturing the reassignment of property rights over irrigation in the sense of Coase (1960)). The centralized model assumes that the government agency external to the village is fully responsible for operations and maintenance of the irrigation infrastructure, i.e. it requires no time investment of households ($x_c = 0$). On the other hand, under the decentralized management of irrigation, villagers need to invest a fixed amount of time $x > 0$ to maintain and manage the infrastructure. We provide a dynamic extension of the model endogenizing the degree of cooperation in Section 3.2 below.

Characterization We start with making the following assumption:

Assumption 1. *The amount of resources w is large relative to the irrigation mainte-*

nance time x in the sense of:

$$1-\left(\frac{\max\{\theta^d,\theta^c\}\cdot\gamma}{w}\right)^{\frac{1}{1-\gamma}}-\left(\frac{\alpha}{w}\right)^{\epsilon}>x \tag{3}$$

Intuitively, this assumption ensures that households are not so resource-poor—or that the burden of decentralized irrigation management is not so high—that they are forced to forgo all other activities. In particular, it guarantees that after allocating time to irrigation maintenance, the amount of time devoted to fighting satisfies $f_i > 0$ and to work satisfies $n_i < 1$ (we establish this below in Proposition 1).[12]

Second, notice that the labor supply will be positive $n_i > 0$ due to the production function (2) exhibiting decreasing return to scale. This implies $l_i < 1 - 1_{j=d} \cdot x$, where $1_{j=d}$ denotes the indicator function taking value of 1 irrigation management is decentralized ($j = d$). Similarly, as the CRRA utility function of leisure satisfies Inada condition[13] at 0, $l_i > 0$. Thus, we know that endogenous choices will be interior: $0 < l_i < 1 - 1_{j=d} \cdot x$, $0 < n_i < 1 - 1_{j=d} \cdot x$ and $0 < f_i < 1 - 1_{j=d} \cdot x$. We interpret f_i as the share of household $-i$'s resources controlled by household i after fighting takes place. The symmetry implies $n_1 = n_2$ and $f_1 = f_2$.

In equilibrium with a given irrigation management model $j \in \{c, d\}$, households maximize individual utility given by (1) subject to:

1. the following budget constraint:

$$c_i \leq \theta^j \left(1-\frac{1}{2}[f_1+f_2]\right)^{(1-\gamma)\cdot\zeta} n_i^{\gamma} + w_i(1-f_{-i}) + w_{-i}f_i \ \forall i \in \{1,2\} \tag{4}$$

2. the total amount of time spent on working, fighting, leisure and irrigation maintenance (under decentralized management) satisfying the following constraint:

$$l_i + n_i + f_i + x \cdot 1_{j=d} = 1 \tag{5}$$

The following proposition characterizes optimal decisions of households:

[12]For the latter result, notice that Assumption 1 implies that $\left(\frac{\max\{\theta^d,\theta^c\}\cdot\gamma}{w}\right)^{1/(1-\gamma)} \in (0,1)$.

[13]The marginal benefit of leisure is infinity at $l_i = 0$.

Proposition 1. *Households in regime $j \in \{c, d\}$ maximizing utility function* (1) *subject to* (4) *and* (5) *devote the following amount of time to fighting and working:*

1. *with externalities* ($\zeta = 1$):

$$f^* = 1 - \frac{x \cdot 1_{j=d} + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta^j \gamma}\right)^{\frac{1}{\gamma-1}}} \tag{6}$$

$$n^* = \left(\frac{w}{\theta^j \gamma}\right)^{\frac{1}{\gamma-1}} \cdot \frac{x \cdot 1_{j=d} + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta^j \gamma}\right)^{\frac{1}{\gamma-1}}} \tag{7}$$

2. *without externalities* ($\zeta = 0$):

$$f^* = 1 - \left(\frac{w}{\alpha}\right)^{-\epsilon} - x \cdot 1_{j=d} - \left(\frac{w}{\theta^j \gamma}\right)^{\frac{1}{\gamma-1}} \tag{8}$$

$$n^* = \left(\frac{w}{\theta^j \gamma}\right)^{\frac{1}{\gamma-1}} \tag{9}$$

Proof. See Appendix A.1. □

Notice that conflict is a socially wasteful zero sum game. This and the assumption that households do not internalize the impact of conflict on productivity, imply that the the equilibrium with households maximizing individual utility is generally inefficient relative to the first best benchmark, where the planner would choose no conflict and hence generate no externalities.

In any case, comparative statics associated with optimal decisions in Proposition 1 show that utility-maximizing households fight less and work more when their agricultural productivity increases. Furthermore, they work less and fight more when the amount of resources in the village increases. Intuitively, these dynamics reflect optimal responses of households to changes in opportunity cost of their time. We summarize these comparative statics in the following proposition:

Proposition 2. *Under Assumption 1, the following hold:*

1. *Conflict f decreases with productivity θ:* $\frac{\partial f}{\partial \theta} < 0$.

2. *Conflict f decreases with time required for maintaining irrigation x:* $\frac{\partial f}{\partial x} < 0$.

3. *Conflict f increases with amount of resources w:* $\frac{\partial f}{\partial w} > 0$.

4. *Labor supply n increases with productivity θ:* $\frac{\partial n}{\partial \theta} > 0$.

5. *Labor supply n weakly increases in time cost of irrigation maintenance x:* $\frac{\partial n}{\partial x} \geq 0$:

   (a) *With externalities, this relationship is strict:* $\frac{\partial n}{\partial x} > 0$.

   (b) *Without externalities, n is independent of x:* $\frac{\partial n}{\partial x} = 0$.

6. *Labor supply n decreases with amount of resources w:* $\frac{\partial n}{\partial w} < 0$.

Proof. See Appendix A.1. □

The effect of time cost of maintaining irrigation x on conflict and labor supply in the model with externalities is akin to the effects of exogenous productivity θ. As x increases, the opportunity cost of fighting increases (since production exhibits decreasing returns to scale and the function governing share of controlled resources after fight is linear). In the model with externalities, these reductions in conflict further increase the endogenous part of productivity, translating into increased incentives for labor supply.

We now proceed to results of our main interest - the effects of decentralization on conflict and economic outcomes:

Proposition 3. *Under Assumption 1, in the economy with externalities, there exists a productivity threshold value $\bar{\theta} < \theta^c$ such that for $\theta^d \geq \bar{\theta}$, decentralization reduces conflict, and increases irrigation's productivity, output and welfare. In the economy without externalities, the threshold on θ^d for conflict reduction satisfies $\bar{\theta} < \theta^c$ and the threshold for output and welfare improvement satisfies $\tilde{\theta} > \theta^c$.*

Proof. See Appendix A.1. □

Although decentralization effectively taxes the amount of time at households' disposal, it leads to welfare improvements by reducing conflict over resources, and increasing among of output produced. These effects are particularly strong in the economy with productivity externalities as even if the local community's productivity of irrigation management is *strictly below* that of centralized authority, the decentralization improves upon all outcomes of conflict, output and welfare. Intuitively, as the pressure of time required for maintaining irrigation reduces conflict, it also increases the productivity of farmers through the externality channel. This further increases opportunity cost of fighting, generating increases in labor supply and overall output. Ultimately, the welfare, as measured by the sum of utility functions (1) for both agents, also increases.

Finally, the model generates interesting predictions about heterogeneous effects of decentralization as summarized below:[14]

Corollary 1. *In the economy with externalities under Assumption 1, there exists a threshold $\bar{\theta} < \theta^c$ such that:*

1. *If $\theta^d \geq \bar{\theta}$, the reform reduces conflict and this effect is increasing in θ^d and in the time cost of irrigation maintenance x.*
2. *If $\theta^d < \bar{\theta}$, the reform increases conflict and this effect is decreasing in θ^d and in the time cost of irrigation maintenance x.*

Proof. See Appendix A.1. □

Intuitively, this result shows that the conflict reduction triggered by reforms is larger in places where the opportunity cost of fighting is higher, which can be either due to higher irrigation management productivity θ^d or a higher time cost of maintenance x. Conversely, in relatively unproductive places where the reform increases conflict, these negative effects are smaller as that opportunity cost increases.

3.2 Dynamic Environment

We now introduce a discrete choice of the degree of cooperation in a two period extension of the static model above. The protocol of the framework is largely similar to the

[14] Analogous corollary holds form the model without externalities with corresponding adjustments for the productivity threshold.

above one with two key differences. First, households live now for two periods $t = 1, 2$ and discount future at the rate of $\beta \in [0, 1]$.

Second, if irrigation management is decentralized, households may now also choose the level of cooperation high (H) or low (L), which translates into two levels of exogenous productivity $\theta^{d,L} < \theta^{d,H}$. We normalize the cost of low cooperation to zero and assume that the cost of high cooperation is a linear function increasing at the rate of $\chi^H > 0$ in the last period's total amount of time devoted to fighting $f_{t-1} = f_{1,t-1} + f_{2,t-1}$, with initial condition $f_0 \geq 0$ being given. The last assumption captures the theoretical mechanism in Rohner, Thoenig, and Zillibotti (2013) and, more importantly, is supported by the rich evidence discussed therein suggesting that the history of conflict affects current social cohesion, generating dynamic effects on current and future cooperation patterns. For simplicity, we assume that (i) in each period households have the same endowment $w > 0$; and (ii) households take the period 2's state variable $f1$ as given.

If decentralization takes place in period 1, each household $i \in \{1, 2\}$ faces the following dynamic problem:

$$\sum_{t=1}^{2} \beta^{t-1} \max \left\{ \max_{c,f,n,l} c_{i,t}^{L} + \frac{{l_{i,t}^{L}}^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}}, \max_{c,f,n,l} c_{i,t}^{H} + \frac{{l_{i,t}^{H}}^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} - \chi^{H} \left(f_{1,t-1} + f_{2,t-1}\right) \right\} \tag{10}$$

$$s.t. \tag{11}$$

$$c_{i,t} \leq \theta^{d,l} \left(1 - \frac{1}{2}\left[f_{1,t} + f_{2,t}\right]\right)^{(1-\gamma)\cdot\zeta} n_{i,t}^{\gamma} + w_i \left(1 - f_{-i,t}\right) + w_{-i} f_{i,t} \;\forall l \in \{H, L\} \tag{12}$$

$$l_{i,t} + n_{i,t} + f_{i,t} + x \cdot 1_{j=d} = 1 \tag{13}$$

$$f_0 \; given \tag{14}$$

Characterization Upon imposing the following restriction on productivity levels under decentralization:

Assumption 2. *The productivity parameters $\theta^{d,L}$ and $\theta^{d,H}$ satisfy:*

$$\frac{1}{1 - \left(\frac{w}{\theta^{d,H}\gamma}\right)^{\frac{1}{\gamma-1}}} < \frac{2}{1 - \left(\frac{w}{\theta^{d,L}\gamma}\right)^{\frac{1}{\gamma-1}}} - \frac{x}{x + w^{-\epsilon}} \tag{15}$$

we can show that:[15]

Proposition 4. *Under Assumptions 1 and 2 in the model with externalities, there exist regions of the initial levels of conflict* $(\bar{f}_{i,0}, 1)$ $\forall i \in \{1, 2\}$ *and of the slope of the cost of high cooperation* $(\underline{\chi}^H, \bar{\chi}^H)$ *s.t. for* $f_{i,0}$ *and* χ^H *in these regions, the level of cooperation in period 1 is low (L) and in period 2 is high (H). The level of conflict in period 1 is higher than that in period 2.*

Proof. See Appendix A.1. □

Similarly as in Proposition 3, we can also find a threshold for $\theta^{d,L}$ s.t. conflict in period 1 under decentralization is lower than conflict without decentralization. In such a case, if the marginal cost of high cooperation is not too low or too high, and the level of initial conflict is high enough, beneficial effects of decentralization are not only immediate but may also propagate over time through powerful dynamic complementarities. On impact of decentralization in period 1, conflict drops relative to the level under centralization (for the very same reasons described in the static framework), which also increases output and welfare. Consequently, the period 2's state variable f_1 of the level of past conflict decreases (relative to f_0; proxying increases in social cohesion). This in turn reduces the cost of choosing high cooperation, increasing productivity and the opportunity cost of conflict even more, and so on.[16]

3.3 Discussion

Overall, the theoretical mechanism relies on reform-induced changes in the opportunity cost of time. Pre-decentralization, households rely on the external government actor to maintain the irrigation. After the reform, households need to devote a fraction of their time to maintain irrigation, which increases the relative time cost of fighting. We now summarize the testable implications of our model.

[15] Proposition 5 in Appendix A.1 proves the version of Proposition 4 under the no-externality case.

[16] This effect is a dynamic counterpart of the typical income effect studied in the conflict literature, such as Miguel, Satyanath, and Sergenti (2004), Chassang and Padró-i-Miquel (2009), Dube and Vargas (2013), and Gawande, Kapur, and Satyanath (2017).

First, Propositions 3 and 4 from the static and dynamic models predict reductions in conflict following the introduction of decentralization reforms (H1) and that these declines propagate over time (H1a).

Second, Proposition 3 implies that conflict reduction will be accompanied by increases in labor supply in agriculture (H2a) and the productivity of irrigation infrastructure (H2b). We interpret the latter as improvements in cooperation over water resources and, consequently, increases in access to irrigation. The two latter effects translate into increases in agricultural productivity and income (H2c).

Third, Corollary 1 generates non-trivial predictions about the reform's heterogeneous impact. Firstly, it suggests that the reform can both increase or decrease conflict depending on whether the community's agricultural productivity is relatively low or high, with the absolute conflict impact being increasing in the level of productivity (H3a). Secondly, it suggests that conflict reduction will be more pronounced in communities where decentralization requires higher time investment for maintaining and managing irrigation (H3b).

4 Data sources and measures

Our empirical analysis relies on a novel panel dataset that integrates information on irrigation governance, conflict and cooperation dynamics, agricultural production, socio-economic characteristics of the Indian population, government expenditures, and rainfall patterns. To construct our main outcome variables, we use two complementary measures of conflict: district-level data on riot incidence and household-level perceptions of inter-group strife and cooperation. The treatment variable is based on two indicators of irrigation decentralization: the timing of state-level decentralization legislation and district-level records on the governance structure of irrigation infrastructure. To explore mechanisms, we leverage village-level data on irrigation access and agricultural productivity. Additional socio-economic and government data are used for robustness checks and heterogeneity analyses.

In order to address the common challenge of Indian administrative units splitting

Table 1: Heterogeneous Introduction Timing of Water User Association Laws in India

State	Act name	Year
Andhra Pradesh	Andhra Pradesh Farmers Management of Irrigation Systems Act	1997
Assam	The Assam Irrigation Water Users Act	2004
Bihar	The Bihar Irrigation, Flood Management and Drainage Rules	2003
Chhattisgarh	Chhattisgarh Sinchai Prabandhan Me Krishkon Ki Bhagidari Adhiniyam	2006
Goa	Goa Command Area Development Act	1997
Gujarat	Gujarat Water Users' Participatory Irrigation Management Act	2007
Karnataka	Karnataka Irrigation (Levy of Betterment Contribution and Water Rate) Act	2000
Kerala	Kerala Irrigation and Water Conservation Act	2003
Madhya Pradesh	Madhya Pradesh Sinchai Prabandhan Me KrishkonKi Bhagidari Adhiniyam	1999
Maharashtra	Maharashtra Management of Irrigation Systems by Farmers Act	2005
Nagaland	Nagaland Farmers Participation in Management of Irrigation System Act	2014
Orissa	Orissa Pani Panchayat Act	2002
Rajasthan	Rajasthan Sinchai Pranali Ke Prabandh MeKrishkon Ki Sahabhagita Adhiniyam	2000
Sikkim	Sikkim Irrigation Water Tax Act (PIM Ammendment)	2008
Tamil Nadu	Tamil Nadu Farmers Management of Irrigation Systems Act	2000
Uttar Pradesh	Uttar Pradesh Participatory Irrigation Management Act	2009

over time, we merge newly created districts and states back into their parent units at the beginning of 1990s. By using a stable set of geographic boundaries, we ensure comparability over time and avoid biases introduced by shifting administrative lines.

Table 2 presents the data sources and summary statistics for the key variables. The number of observations varies across measures due to differences in temporal coverage and unit of analysis. As detailed in the sections below, our variables are observed at the state, district, village, or household levels. For each regression table, we specify the corresponding unit of analysis.

Decentralization measure To measure decentralization, we compile a dataset of state-level WUA reforms based on an extensive review of legal acts and legislative changes. Specifically, we identify relevant decentralization legislation by systematically searching through the PRS Legislative Research database (https://prsindia.org/acts/states) and the India Code Portal (https://www.indiacode.nic.in). Table 1 documents the states that adopted decentralization reforms and the corresponding act name and year of the associated legislation. We code a state-year observation as treated starting from the year following the passage of decentralization legislation in the states that adopted the indicated policies.

We complement our records on the timing of WUA reform introductions with a proxy measure of *effective* district-level decentralization, constructed from 2,051 district-year observations across the 2nd (1993), 3rd (2000), 4th (2006), and 5th (2013) waves of the MIC, census of minor irrigation infrastructure (defined as systems covering areas up to 2,000 hectares) conducted by the Ministry of Jal Shakti.[17] Our key indicator, *Share Decentralized Irrigation (%)*, measures the proportion of minor irrigation systems owned and managed by non-governmental entities, including individuals, farmer groups, cooperatives, and local panchayats, as opposed to government agencies.

In the absence of a direct measure, we define this proxy for district i in year t as:

$$\begin{aligned} Share\ Dec.\ Irrig_{i,t} = &\sum_j \frac{Number\ of\ j - type\ units\ non - gov\ owned_{i,t}}{Total\ number\ of\ units\ of\ type\ j} \\ &\times \frac{Irrigation\ potential\ of\ all\ units\ of\ type\ j}{Total\ irrigation\ potential\ of\ all\ irrigation\ units_{i,t}} \end{aligned} \tag{16}$$

where j indexes all MIC irrigation unit types (dugwells, shallow and deep tubewells, surface lift, and flow irrigation systems).

Since minor irrigation systems account for approximately half of India's total irrigation potential and include a disproportionately large share of privately managed groundwater wells, the national average of 81% (with a standard deviation of 25%) suggests that this variable captures both intentional decentralization and organic private investment. We address this measurement error, which is plausibly non-random (e.g., districts with higher groundwater availability may be more likely to exhibit higher decentralization), by instrumenting $Share\ Dec.\ Irrig_{i,t}$ with the heterogeneous WUA timings (the IV strategy is detailed in Section 5.2 below).

Using the same MIC data, we also measure the share of abandoned irrigation infrastructure. This measure is calculated at the district level as the irrigation potential-weighted ratio of abandoned units of a given type—wells, tubewells, or surface infrastructure (as previously defined)—to the total number of units of that type. This variable captures variation in the quality of irrigation infrastructure across districts and allows us to explore the heterogeneities implied by our conceptual model.

[17] MIC data is available only at the district level. See https://micensus.gov.in/.

Conflict and cooperation measures Our primary measure of inter-group conflict is the incidence of riots from the National Crime Records Bureau (NCRB). Since 1953, the NCRB has compiled annual district-level counts of complaints filed under various categories of the Indian Penal Code (IPC). Following prior work identifying riots as a key manifestation of communal violence in India (Wilkinson 2006, 2009; Iyer and Shrivastava 2018; Bulutgil and Prasad 2023), we define the variable *Riots* as the number of riots recorded at the district-year level between 1990 and 2016.[18] To focus on rural violence, we exclude incidents classified by the NCRB as occurring in urban areas, commercial centers, or near railway stations. Our sample of 13,571 district-year observations has a mean of 125 and a standard deviation of 216. Riots tend to be highly disruptive, involving many individuals and resulting in substantial social and economic consequences (Thomas and John Sergenti 2010; Gupte, Justino, and Tranchant 2014). For placebo tests, we use the records of *Thefts* from the same NCRB dataset.

As consistent population data are only available for the 1991, 2001, and 2011 Population Censuses,[19] we use linear interpolation to estimate annual population figures for 1991–2011. This enables us to compute riots per 100,000 population. We restrict our per capita conflict analysis to this time window. As shown in columns 1 and 2 of Table 3, this transformation does not alter our main results. For analyses using district-wave observations from the four rounds of the MIC—1993, 2000, 2006, and 2013—we instead use the per capita riot variable, given closer alignment between MIC and census years.[20]

We complement the district-level analysis with household-level measures of conflict and cooperation derived from the 2005 and 2014 waves of the IHDS, which includes approximately 40,000 household-year observations. The first variable, *Village Conflict*

[18] We end the analysis in 2016 due to changes in NCRB crime classification that limit comparability of records pre- and post-2016. Because data for 2011 is missing, we impute values using the mean of 2010 and 2012 for each district.

[19] The original data is recorded at the village level. To construct district-level measures, we sum the population of all villages in a given district.

[20] Specifically, we match the 1991 population to the 1993 MIC, the 2001 population to the 2000 MIC, the 2011 population to the 2013 MIC, and use the average of the 2001 and 2011 census data for the 2006 MIC.

(%), captures the share of households reporting the presence of conflict in their village. The second, *Intergroup Conflict (%)*, reflects the average household-level perception of inter-caste tensions. These variables provide a more granular view of local strife. With mean values of 45% and 37%, respectively, both measures indicate widespread tensions in rural India.

Finally, we use IHDS data to assess local cooperation through the variable *Village Cooperation (%)*, which measures the percentage of households reporting that their community adopts collective—rather than individualistic—approaches to solving water supply problems. With a mean of 67%, this measure suggests that despite high levels of conflict, many Indian communities maintain strong cooperative norms, especially in the critical domain of water management.

Irrigation access and agricultural productivity measures We construct the variable *Agricultural Land with Irrigation (log Ha)* to measure village-level access to irrigation, using data from the 1991, 2001, and 2011 Population Censuses as provided by the SHRUG database (Asher et al. 2021). The resulting sample includes 1,039,602 village-year observations, with a mean of 4.2 log hectares of irrigated land per village and a standard deviation of 1.7, highlighting the widespread use of irrigation infrastructure across rural India.

As village-level data on agricultural yields is not directly available, we use a satellite-derived proxy for productivity: the Enhanced Vegetation Index (EVI), a well-established indicator of biomass from NASA (Rasmussen 1997; Son et al. 2014; Asher et al. 2023). Leveraging GPS coordinates of 2011 Census villages from SHRUG, we estimate agricultural productivity as the mean of yields during the main monsoon (kharif) and winter (rabi) seasons, which run from late May to early October and from October to March, respectively (Rasmussen 1997; Labus et al. 2002). Specifically, we define *Yields* as the difference between the peak EVI value during the kharif and rabi seasons and the average EVI from the first six weeks of each season. This adjusted measure better reflects crop growth, as it filters out high-biomass non-agricultural land (e.g., forests) that exhibits minimal seasonal fluctuation. Our yield proxy spans the years 2000 to 2016, covering 8,393,334 village-year observations.

Weather shocks To construct our measure of weather shocks, we use ERA5 climate data on annual rainfall from 1950 to 2016, matched to the GPS coordinates of all 2011 Census villages. We define drought years as those in which total annual rainfall falls below the 20th percentile of the village-specific historical distribution (1950–2016).

Based on this, we construct the variable $\text{Drought}_{i,t}$ as the share of villages in district i that experienced drought in year t or $t-1$. This measure yields 16,718 district-year observations between 1990 and 2016, with a mean of 39% and a standard deviation of 30%. For village-level regressions, we use village coordinates from the SHRUG database and define a binary drought indicator that takes the value 1 if a village experienced drought in year t or $t-1$, and 0 otherwise.

While we include the drought variable as a control in our baseline district- and village-level analyses to account for the incidence and intensity of drought, our results remain robust to excluding it, as shown in Appendix A.5.

Table 2: Summary statistics

Variable	**Mean**	**Std. Dev.**	**N**	**Data source**
Riots (count)	125.445	215.928	13571	NCRB '90-'16
Riots p.c. (per 100k pop)	8.058	11.055	9967	NCRB '91-'11
Dec. Reform	0.39	0.488	21388	Own '90-'16
Share Dec. Irrig.	0.809	0.253	2051	MIC '93/'00/'06/'13
Share Abandoned Irrig.	0.011	0.064	932	MIC '00
Drought (% villages affected in district)	0.385	0.301	16718	ERA5 '90-'16
Drought (village-year, binary)	0.386	0.487	1700880	ERA5 '90-'16
Log Population	13.892	1.097	2245	Pop Census '91/'01/'11
HHI (caste)	0.666	0.115	2245	Pop Census '91/'01/'11
Theft (count)	378.62	530.843	13078	NCRB '90-'16
Total Expendit. (log NR ten lakh)	9.756	1.41	20912	RBI '90-'16
Irrig. Expendit. (log NR ten lakh)	6.086	1.561	17789	RBI '90-'16
Village Conf. (%)	0.451	0.498	40058	IHDS '05/'14
Intergroup Conf. (%)	0.372	0.483	40054	IHDS '05/'14
Village Coop. (%)	0.671	0.47	40080	IHDS '05/'14
Agric. Income (log)	9.731	1.59	24453	IHDS '05/'14
Agric. Workers in HH	1.314	1.588	211886	IHDS '05/'14
Work Hours in Agric. (log)	5.953	1.17	63575	IHDS '05/'14
Land with Irrigation (log Ha)	4.213	1.682	1039602	Pop Census '91/'01/'11
Yields (log)	-2.296	0.505	8393334	NASA '00-'16

Notes: The number of observations (N) we report below may vary across different sets of analysis, as the underlying data sources do not fully overlap and consequently some analyses require restricting the sample. For transparency, we report the mean and standard deviation of the dependent variable separately for each subsample used in a given analysis in the following tables.

Other socio-economic indicators We use data from the India Human Development Survey (IHDS) to measure agricultural activities at the household level. The first measure captures the intensive margin of agricultural labor supply using the log of average hours worked in agriculture per household member in a given year. The second measure captures the extensive margin of agricultural labor supply using the latter measure transformed as the number of household members working in agriculture at least 240 hours annually. Finally, we also use data on agricultural earnings, measured as the log of annual household agricultural income.

To address the concern that our findings might be confounded by increased irrigation subsidies following decentralization reforms, we incorporate data from Reserve Bank of India on state-level public expenditures from 1990 to 2016. Our measure, $Expenditures\ on\ Irrigation_{i,t}$, is the logged sum of total expenditures and capital disbursements in state i and year t across all categories of irrigation spending (minor, medium, and major irrigation, as well as flood control). For robustness checks, we also use an analogous measure of total expenditures on across all public domains ($Total\ Expenditures_{i,t}$).

Additionally, to assess the role of social status and the distribution of marginalized groups in shaping our outcomes, we draw on Population Censuses containing data on village-level shares of the two most disadvantaged groups in the Indian caste hierarchy: Scheduled Castes (SCs) and Scheduled Tribes (STs). Using this, we construct an average (over 3 census waves) caste fractionalization measure based on the Herfindahl-Hirschman Index (HHI), which captures the concentration of SC/ST populations at the district or village level.[21]

[21] We aggregate village-level data to the district level by weighting village-level observations by each village's population share within the respective district.

5 Empirical framework

5.1 Difference-in-Differences Approach

To estimate the impact of irrigation decentralization reforms on our outcomes of interest, we first implement a staggered difference-in-differences (DiD) design. This approach compares changes in outcomes—such as riot incidence—before and after the reform in treated units with changes in units not yet treated or never treated. Specifically, we estimate the following event-study specification:

$$\text{Outcome}_{it} = \alpha + \sum_{k \neq -1} \beta_k \cdot \text{EventTime}_{it}^{(k)} + \text{Drought}_{i,t} + \gamma_i + \delta_t + \epsilon_{it} \tag{17}$$

where Outcome_{it} denotes the dependent variable (e.g., conflict, cooperation, irrigation access, agricultural labor supply, income or productivity) for unit i in year t; γ_i and δ_t are unit and year fixed effects, respectively; and $\text{Drought}_{i,t}$ controls for the incidence of drought in unit i in year t. The variable $\text{EventTime}_{it}^{(k)}$ consists of dummies for each relative year k before or after the reform, omitting $k = -1$ as the baseline period. The treatment is defined as equal to 1 in year t if unit i is located in a state s that has enacted legislation decentralizing irrigation governance to local communities via Water User Associations (WUAs). We cluster standard errors at the district level throughout the analysis.[22]

Under the parallel trends assumption—that in the absence of reform, treated and untreated units would have followed similar trends—each coefficient β_k in Equation (17) identifies the average effect of the WUA reform on the outcome of interest in the k-th year relative to the baseline.

5.2 Instrumental Variable Approach

To assess the robustness of our results, we use the timing of WUA reform introductions as an instrumental variable (IV) for *Share Decentralized Irrigation*, our measure of

[22]For regressions using IHDS data with two years of observations, we conduct traditional DiD and omit drought controls due to anonymization of village locations.

effective irrigation decentralization. Using reform timing to instrument for variation in this measure helps address potential measurement error—for instance, arising from infrastructure deterioration or from purely private irrigation investments (as is often the case with wells).[23]

In the first stage, we estimate a fixed effects regression of the decentralization measure on WUA reform timing using OLS. In the second stage, we estimate 2SLS models with unit and time fixed effects, instrumenting the share of decentralized irrigation with a binary indicator for whether the reform was in effect in a given district-year.

We argue that reform timing is plausibly exogenous to local conflict outcomes, as its staggered adoption reflects state-level political and bureaucratic processes rather than district-level conflict trends. A detailed discussion of the exclusion restriction and alternative channels is provided in Online Appendix A.2.

6 Results

6.1 Decentralization and Conflict

The left panel of Figure 1 presents the results from the Callaway and Sant'Anna (2021) event study analysis, estimating the impact of WUA reform introductions on the annual number of riots, comparing treated districts to those not yet (or never) treated.

Supporting the parallel trends assumption, we observe no systematic differences in riot incidence between the two groups in the pre-treatment period. While the timing of reform implementation was clearly endogenous to state-level decision-making, the absence of pre-trends suggests that pre-existing levels of social cohesion or communal violence did not drive these decisions.

In terms of reform impact, we find a significant and persistent decline in riot incidence, consistent with the main prediction of our model (H1). As shown in Table 1,

[23]Expansion of private wells may itself be partially endogenous to WUA formation, as these associations also provide advisory and extension services to local farmers (see Section 3).

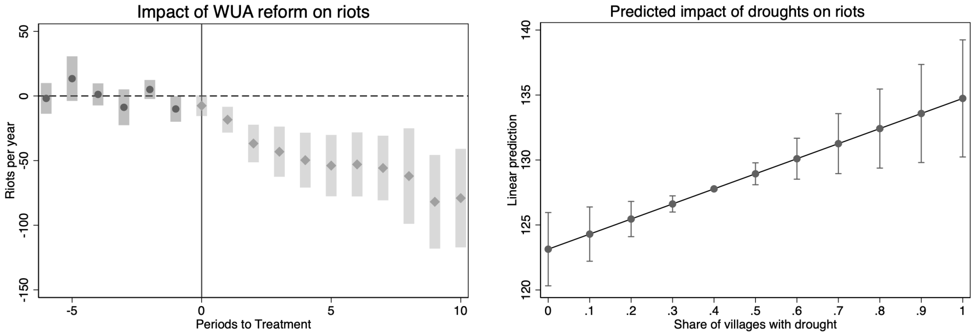
the estimated effect ten years post-reform corresponds to a 63% reduction in average riot levels—nearly twice the magnitude of the effect observed in the first two to three years after implementation. This dynamic pattern aligns with Proposition 4, which predicts compounding effects over time (H1a). In Appendix A.6, we demonstrate that these results are robust to alternative DiD estimators proposed by Chaisemartin and d'Haultfoeuille (2021) and Dube et al. (2023).

We also examine the relationship between weather shocks and conflict. Droughts, that is, events that generate excess demand for irrigation water and contribute to food scarcity, are a known trigger of unrest. The right panel of Figure 1 plots the linear relationship between our drought measure and riot incidence, controlling for district and year fixed effects. As the share of villages experiencing drought in a district rises from 0% to 100%, the number of riots increases by approximately 13—equivalent to about 10% of the long-run sample mean. This suggests that our conflict measure captures, at least in part, disputes over water access or food insecurity, both of which intensify during drought years. This result provides further support for our core hypothesis: that improved irrigation governance can *directly* reduce the likelihood of communal violence. However, the estimated effects of reform on conflict far exceeding the predicted impact of droughts suggest that the benefits of decentralization extend beyond these direct effects, consistent with unleashing dynamic income effects.

Table 3 presents additional results supporting our main findings by examining alternative conflict measures, levels of analysis, and identification strategies. Columns 1 and 2 use standard difference-in-differences at the district level to replicate the event study results. We show that expressing riots in per capita terms does not alter the qualitative interpretation. The per capita estimate of –4.27 (significant at the 1% level) implies a reduction of 0.4 standard deviations in riots per 100,000 people. Consistent results from a per capita event study are shown in Figure A2 in the Online Appendix.

One potential concern is that state-level reform adoption may not translate into actual uptake of decentralized institutions at the village level. Even if this was the case, such slippage would bias our estimates toward zero. However, in Column 3 we confirm the first-stage relationship: the introduction of WUA reforms increases the share of decentralized irrigation observed in MIC data by 0.25 standard deviations. This not

Figure 1: Event study evidence: reforms lower incidence of riots



Notes: The left panel displays the event-study estimates from Callaway and Sant'Anna (2021), along with 95% confidence intervals, obtained by regressing the annual number of riots on WUA reform implementation timing and the share of villages experiencing droughts. The control group comprises states not yet (or never) treated by the reform. As shown in Figure A2, the results are robust to alternative estimation strategies. The right panel plots the predicted effect of drought exposure—measured as the share of villages in a district experiencing drought in a given year—on riot incidence, controlling for district and year fixed effects.

only proves the reform's tangible impact on irrigation governance, but also validates instrument relevance of our IV strategy. To this end, Column 4 shows that decentralized irrigation is negatively associated with riots in an OLS framework (coefficient: –3.60, significant at the 5% level). Column 5 reports results from a 2SLS-IV model, where the instrumented share of decentralized irrigation has a substantially larger negative effect on riots (coefficient: –25.47, significant at the 5% level), reflecting attenuation bias due to measurement error in *Share Dec. Irrig* (discussed in Section 3). Column 6 provides reduced-form estimates using the IV sample; despite a smaller sample, the negative relationship is confirmed. These findings are robust to an extended set of controls (Appendix A.4), and Table A9 shows that socio-economic characteristics do not predict district-level implementation intensity, supporting instrument exogeneity.

We further corroborate these patterns using household-level data from IHDS. Column 7 shows that reform introduction reduces the likelihood that households report village-level conflict by 28 percentage points (or 62 %). Column 8 confirms this result using a second indicator—perceived conflict between *jatis* (castes), where the point estimate indicates a 19 p.p. drop (or 50%; significant at the 1% level). Both estimates come from linear probability models, as the IHDS lacks data on irrigation governance that would allow for estimating IV regressions or geographic identifiers that would

Table 3: Decentralization and conflict

	(1) Riots (count)	(2) Riots p.c.	(3) Share Dec. Irrig.	(4) Riots p.c.	(5) Riots p.c.	(6) Riots p.c.	(7) Village conflict	(8) Intergroup conflict
Dec. Reform	-35.721***	-4.266***	0.053***			-1.358***	-0.282***	-0.185***
	(9.685)	(0.652)	(0.010)			(0.510)	(0.062)	(0.063)
Share Dec. Irrig.				-3.603**	-25.465**			
				(1.646)	(10.471)			
Model	OLS	OLS	OLS	OLS	IV-2SLS	IV-Reduced	OLS	OLS
Unit of analysis	District	District	District	District	District	District	Household	Household
Unit + Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Drought control	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Mean of Dep. Var.	125.445	8.058	0.815	7.522	7.522	7.522	0.450	0.372
SD of Dep. Var.	215.928	11.053	0.251	10.039	10.039	10.039	0.498	0.483
R-squared	0.524	0.607	0.856	0.617	-0.107	0.617	0.505	0.531
Sample	'90-'16	'91-'11	'93/'00/'06/'13	'93/'00/'06/'13	'93/'00/'06/'13	'93/'00/'06/'13	'05/'14	'05/'14
N	13155	9817	1784	1784	1784	1784	39546	39546

"Riots p.c." refers to riots per 100k pop. Standard errors clustered at the district level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

allow matching to other datasets.[24]

6.2 Mechanism Analysis

The results presented above offer a consistent picture: irrigation decentralization reforms significantly reduce the incidence of communal conflict in India—a highly diverse society along ethnic and religious lines. We now turn to the question of how these reforms produce such effects.

Consistent with our theoretical model, we argue that the reforms enhance the enforcement and monitoring capacity of local communities, thereby reducing free riding and promoting cooperation. These improvements are amplified by the importance of irrigation for local food production and by the withdrawal of the state as the "maintainer of last resort." Together, these dynamics generate powerful complementarities: decentralization compels communities to cooperate, which in turn boosts agricultural productivity and incomes, further reducing conflict through an income effect. This virtuous cycle feeds back into even greater cooperation.

We provide strong support for this mechanism, consistent with hypotheses H2a and H2b, by estimating the same reduced-form models used in the previous section.[25] The results are summarized in Table 4.

[24]The staggered timing of WUA reforms makes it unlikely that our results are driven by broader reform packages. We further rule out the latter by reviewing neighboring legislative acts for each WUA reform listed in Table 1, using the PRS Legislative Research platform: https://prsindia.org/acts/states.

[25]Our mechanism analysis relies on village- and household-level sources that do not allow us to

First, household-level data from the IHDS show that the reform significantly increases reported community-level cooperation. Specifically, the likelihood that respondents report collective action to address water scarcity and related challenges rises by 9 percentage points, or approximately 20% relative to the sample mean.[26] Additionally, households in treated areas report a 16% increase in agricultural labor supply, measured by the number of household members working at least 240 hours annually (column 2), and a similar increase in hours worked per household member (column 3). The latter translates into approximately 240 additional hours—or six weeks—of agricultural labor per person. These changes are accompanied by an 11% increase in agricultural income (column 4).

Second, using village-level data from the Population Census, we examine whether improved cooperation translates into better irrigation outcomes. Consistent with H2a, column 5 shows that the reform increased the area of irrigated land by up to 32%.

Third, consistent with H2b, we find that decentralization leads to higher village-level agricultural productivity, proxied by the Enhanced Vegetation Index (EVI) from NASA satellite data. Column 6 reports an 8.2% increase in EVI during the 2000–2016 period—a magnitude comparable to Asher et al. (2023)'s estimates of the impact of canal irrigation access on agricultural productivity.

Table 4: Decentralization and local cooperation, work, irrigation, and productivity

	(1) Water Coop.	(2) Agric. Workers	(3) Work Hours in Agric. (log)	(4) Agric. Income (log)	(5) Irrig. Ha (log)	(6) Yields (log)
Dec. Reform	0.087* (0.050)	0.186*** (0.052)	0.320*** (0.063)	0.116* (0.060)	0.321*** (0.051)	0.082*** (0.014)
Model	OLS	OLS	OLS	OLS	OLS	OLS
Unit of analysis	Household	Household	HH-member	Household	Village	Village
Unit + Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Drought control	No	No	No	No	Yes	Yes
Mean of Dep. Var.	0.671	1.131	5.953	9.732	4.213	-2.296
SD of Dep. Var.	0.470	1.409	1.170	1.590	1.682	0.505
R-squared	0.534	0.742	0.524	0.733	0.862	0.569
Sample	'05/'14	'05/'14	'05/'14	'05/'14	'91/'01/'11	'00-'16
N	39686	39900	62640	18726	959182	8296909

Standard errors clustered at the district level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

observe irrigation governance, and hence not allowing for conducting IV analysis.

[26]Haseeb (2024) finds similar patterns in Pakistan, where long-term water scarcity under decentralized irrigation institutions increases cooperation. Our results are consistent, under the premise that local ownership can lead to scarcity unless communities exert effort to maintain infrastructure.

6.3 Heterogeneous Effects Implied by the Model

To empirically test the first heterogeneity prediction of our model, we construct a measure of pre-reform agricultural productivity at the district level. We begin by aggregating village-year-level EVI values to the district-year level, weighting each village by its agricultural land area as reported in the 2001 Population Census. We then conduct an AKM-style decomposition (Abowd, Kramarz, and Margolis 1999) using the following regression:

$$\log(yield_{i,t}^{pre-reform}) = \gamma_i + \gamma_t + \epsilon_{i,t} \tag{18}$$

where γ_i captures district fixed effects and γ_t year fixed effects. We interpret the estimated γ_i as the time-invariant measure of pre-reform agricultural productivity for district i.[27]

Column 1 of Table 5 shows that the reform-induced reduction in conflict is concentrated in districts with above-average productivity, and that the effect increases with productivity—supporting model prediction H3a.[28] As a robustness check, column 2 confirms that the positive reform effect on agricultural yields also holds at the aggregated district level.

Next, we test for heterogeneity with respect to the time required to maintain the local common good (H3b), using MIC data on irrigation infrastructure conditions. Specifically, we use the share of abandoned irrigation structures—available from the 1993 and 2001 MIC waves—as a proxy for pre-reform infrastructure deterioration and, by extension, time required for irrigation maintenance post-reform. Column 3 of Table 5 shows that conflict reductions are larger in districts with higher shares of abandoned infrastructure, consistent with the prediction that the reform is more effective where

[27] The regression includes observations from states that never implemented the reform, using the full EVI data range (2000–2016). States where WUA reforms were implemented before 2000 are excluded, as EVI data is unavailable for the pre-reform period. For the period 1990–1999, we assume pre-reform productivity equals the estimated district fixed effect.

[28] Estimates from regression (18) imply that the reform is associated with increased conflict in only 11.8% of districts.

Table 5: Decentralization and conflict: Heterogeneous effects implied by the model

	(1) Riots	(2) Yields (log)	(3) Riots	(4) Share Abandoned
Reform	12.857*	0.027**	-34.749***	-0.018**
	(6.613)	(0.012)	(10.072)	(0.007)
Reform x Pre-Reform Productivity	-473.969**			
	(222.247)			
Reform x Pre-Reform Abandoned			-204.246*	
			(107.887)	
Model	OLS	OLS	OLS	OLS
Unit of analysis	District	District	District	District
Unit + Time FE	Yes	Yes	Yes	Yes
Drought control	Yes	Yes	Yes	Yes
Mean of Dep. Var.	125.445	-2.311	125.445	0.011
SD of Dep. Var.	215.928	0.666	215.928	0.064
R-squared	0.788	0.910	0.512	0.504
Sample	'90-'16	'00-'16	'90-'16	'93/'00
N	4900	4700	11388	820

Standard errors clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

cooperation-intensive restoration is needed most. Supporting this interpretation, column 4 shows that, in a smaller sample of districts where reforms occurred before 2000, the share of abandoned irrigation infrastructure decreases after reform—highlighting the improvement in public goods provision under decentralized governance.

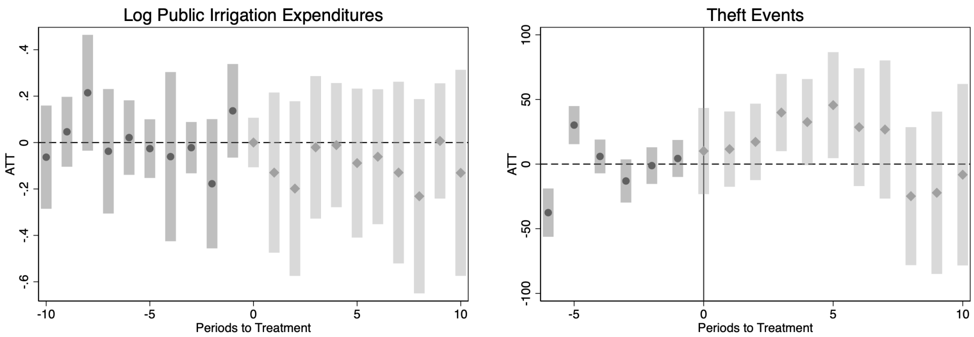
6.4 Alternative Explanations and Falsification Tests

If decentralization reforms are accompanied by increases in public spending on irrigation infrastructure, observed reductions in conflict may simply reflect income effects rather than improvements in cooperation. To test this, the left panel of Figure 2 presents estimates from the Callaway and Sant'Anna (2021) event study design, showing no evidence of increased irrigation-related public expenditures around the timing of reform implementation. This pattern also holds for total public spending by Indian states, ruling out the alternative explanation of income effects triggered by broader expansions in public welfare system (see Figure A3).

Second, despite the strong support for parallel trends in Figure 1, one might still be concerned that the reforms coincided with broader reductions in crime, unrelated to cooperation over common pool resources. To explore this, we examine the impact of WUA reforms on theft—a common and non-communal crime in India (National Crime Records Bureau 2023). The right panel of Figure 2 shows no significant change in theft incidence following reform, helping us rule out the possibility that our results are driven by general crime trends.[29]

Taken together, these findings reinforce our interpretation that irrigation decentralization reforms address deeper structural challenges—such as inefficient resource allocation, weak governance, and inequitable access to services. By enhancing efficiency and fostering more transparent and accountable local institutions, these reforms alleviate underlying tensions around resource distribution and contribute to a more durable reduction in communal conflict.

Figure 2: Decentralization reform, public expenditures and placebo crime outcome



Notes: The plot shows event-time coefficients and 95% confidence intervals constructed using the estimator by Callaway and Sant'Anna (2021).

6.5 Discussion on Other Potential Sources of Heterogeneous Effects

Existing research documents substantial disparities in access to both drinking and irrigation water for Muslims, Scheduled Castes, and Scheduled Tribes in India (Shah et al. 2006; Banerjee and Somanathan 2007; Anderson 2011; Bros and Couttenier 2015). Accordingly, the effects of irrigation decentralization may also vary depending on the social composition of local communities. Although our conceptual framework assumes homogeneous actors, we empirically explore these heterogeneities in Section A.3 of the Online Appendix through an illustrative analysis.

[29] Moreover, the absence of differential pre-trends in theft reassures us that WUA reforms were not systematically targeted at states with lower baseline crime rates.

Table A5 provides suggestive evidence that the effects of the reform differ with caste diversity, measured using the Herfindahl-Hirschman Index (HHI) of caste concentration. We find that districts with greater caste heterogeneity experience larger reductions in conflict, while more homogeneous villages tend to see greater improvements in agricultural productivity. One possible explanation is that scheduled groups tend to have lower agricultural productivity on average (Rao 2017), which may constrain yield gains of the reforms in more heterogeneous areas (with a higher share of scheduled minority groups). However, we also find suggestive evidence that decentralization improves equity in access to irrigation, thereby reducing conflict more substantially.

Since the WUA reforms were introduced relatively recently, the observed effects may also reflect the legacy of earlier efforts to address discriminatory practices—such as the constitutional ban on untouchability (Article 17) and the 73rd Amendment introducing political reservations for women and members of Scheduled Castes and Tribes in local panchayats. Given these confounding factors and the limitations of available data, we interpret these findings with caution and view them as a starting point for future research. A more granular investigation—ideally leveraging detailed micro-level data—would be needed to rigorously assess the distributional effects of irrigation decentralization across marginalized groups.

7 Conclusion

Our study provides compelling evidence that the Water User Association (WUA) reforms—introduced across multiple Indian states to decentralize irrigation management—have significantly reduced violence and conflict in rural communities. The mechanism underpinning this effect centers on the reassignment of property rights: away from state agencies plagued by weak enforcement, limited motivation, and corruption, and toward local communities. This shift has improved cooperation in managing irrigation as a common pool resource, resulting in higher agricultural productivity, enhanced local food security, and reduced economic pressures that often fuel conflict. We developed a conceptual model to formalize these dynamics and validated its predictions empirically using multiple datasets, units of analysis, and robust identification strategies.

Local management of public goods like irrigation infrastructure offers several key advantages. First, local stakeholders possess more detailed knowledge of their specific environmental and social contexts, enabling more adaptive and effective decision-making. Second, community-level institutions often have superior enforcement capacity, allowing them to resolve disputes, enforce rules on water access, and improve the reliability of supply. Third, local management is particularly valuable for high-stakes public goods like irrigation, where poor upkeep can severely depress agricultural productivity and threaten livelihoods—creating strong incentives for communities to mobilize and maintain the infrastructure. Of course, the effectiveness of decentralization depends on well-designed governance structures and an enabling policy environment—highlighting both the promise and the complexity of local public goods management.

Importantly, our results show that the conflict-reducing effects of decentralization materialize even in highly heterogeneous social contexts. This suggests that the external validity of our findings is likely to be high, particularly for other regions grappling with similar governance and development challenges. One particularly relevant case is Sub-Saharan Africa (SSA), where irrigation infrastructure remains underdeveloped but will be crucial for raising agricultural productivity. As governments in SSA look to expand irrigation, our findings offer a compelling case for integrating community-driven approaches to resource management. By fostering cooperation and reducing conflict, these approaches can contribute to broader goals of sustainable development and social stability in diverse and sometimes fragile settings.

We acknowledge that our analysis primarily captures short- to medium-term effects of decentralization. However, we argue that, over the long run, well-executed reforms in high-stakes domains like irrigation have the potential to shift communities to a more cooperative and productive equilibrium—marked by lower conflict, higher income, and reduced free riding. These gains are likely to exceed the impact of one-off subsidies or transfers, which often fail to produce lasting benefits in the absence of real changes in ownership and institutional control.

Finally, we see this paper as a first step in understanding how decentralization of essential public goods affects social cohesion. In future work, we plan to explore how these reforms shape intergroup dynamics—across religious and caste lines—through randomized evaluations, with the goal of deepening our understanding of when and how decentralization fosters inclusive and peaceful development.

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Online Appendix

A.1 Proofs

Proposition 1. *Households in regime $j \in \{c, d\}$ maximizing utility function* (1) *subject to* (4) *and* (5) *devote the following amount of time to fighting and working:*

1. *with externalities ($\zeta = 1$):*

$$f^* = 1 - \frac{x \cdot 1_{j=d} + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta^j \gamma}\right)^{\frac{1}{\gamma-1}}} > 0 \tag{1}$$

$$n^* = \left(\frac{w}{\theta^j \gamma}\right)^{\frac{1}{\gamma-1}} \cdot \frac{x \cdot 1_{j=d} + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta^j \gamma}\right)^{\frac{1}{\gamma-1}}} \tag{2}$$

2. *without externalities ($\zeta = 0$):*

$$f^* = 1 - \left(\frac{w}{\alpha}\right)^{-\epsilon} - x \cdot 1_{j=d} - \left(\frac{w}{\theta^j \gamma}\right)^{\frac{1}{\gamma-1}} \tag{3}$$

$$n^* = \left(\frac{w}{\theta^j \gamma}\right)^{\frac{1}{\gamma-1}} \tag{4}$$

Proof. Rewrite the problem of the household as:

$$V_i^j = \max_{c_i, f_i, n_i} \theta^j \left(1 - \frac{1}{2}\left(f_1 + f_2\right)\right)^{(1-\gamma)\zeta} n_i^\gamma + w\left(1 + f_i - f_{-i}\right) + \alpha \frac{\left(1 - x \cdot 1_{j=d} - n_i - f_i\right)^{1-\frac{1}{\epsilon}}}{1 - \frac{1}{\epsilon}} \tag{5}$$

For household i, given f_{-i}, the FOC for f reads:

$$\alpha(1 - f - n - x \cdot 1_{j=d})^{-\frac{1}{\epsilon}} = w \tag{6}$$

The FOC for n reads:

$$\alpha(1 - f - n - x \cdot 1_{j=d})^{-\frac{1}{\epsilon}} = \gamma\theta \left[1 - \frac{1}{2}\left(f_1 + f_2\right)\right]^{(1-\gamma)\zeta} n^{\gamma-1} \tag{7}$$

Also, in equilibrium symmetry implies that:

$$f_1 = f_2 = f > 0 \tag{8}$$

So the optimal f^* satisfies the following equation (combine (6), (7), (8)):

$$(1-f) - \left(\frac{w}{\gamma\theta}\right)^{\frac{1}{\gamma-1}} \cdot (1-f)^{\gamma_2} = x \cdot 1_{j=d} + \left(\frac{w}{\alpha}\right)^{-\epsilon} \tag{9}$$

and the optimal n^* satisfies the following equation:

$$n = \left(\frac{w}{\gamma\theta}\right)^{\frac{1}{\gamma-1}} \left[n + x + \left(\frac{w}{\alpha}\right)^{-\epsilon}\right]^{\gamma_2} \tag{10}$$

Case 1: $\zeta = 1$

Let $\zeta = 1$ in eq(9), we obtain the following optimal decisions:

$$f^* = 1 - \frac{x \cdot 1_{j=d} + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}}} > 0 \tag{11}$$

$$n^* = \left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}} \cdot \frac{x \cdot 1_{j=d} + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}}} \tag{12}$$

Case 2: $\zeta = 0$

Let $\zeta = 0$ in eq(9), then we get:

$$f^* = 1 - \left(\frac{w}{\alpha}\right)^{-\epsilon} - x \cdot 1_{j=d} - \left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}} \tag{13}$$

$$n^* = \left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}} \tag{14}$$

$\square$

Proposition 2. *Under Assumption 1, the following hold:*

1. *Conflict f decreases with productivity θ: $\frac{\partial f}{\partial \theta} < 0$.*
2. *Conflict f decreases with time required for maintaining irrigation x: $\frac{\partial f}{\partial x} < 0$.*
3. *Conflict f increases with amount of resources w: $\frac{\partial f}{\partial w} > 0$.*
4. *Labor supply n increases with productivity θ: $\frac{\partial n}{\partial \theta} > 0$.*
5. *Labor supply n weakly increases in time cost of irrigation maintenance x: $\frac{\partial n}{\partial x} \geq 0$:*
    (a) *With externalities, this relationship is strict: $\frac{\partial n}{\partial x} > 0$.*

(b) *Without externalities, n is independent of x: $\frac{\partial n}{\partial x} = 0$.*

6. *Labor supply n decreases with amount of resources w: $\frac{\partial n}{\partial w} < 0$.*

Proof. We will use the implicit function theorem on equations 9 and 10 to derive partial derivatives of f and n.

Define implicit functions:

$$G\left(f;\theta,w,x\right) = (1-f) - \left(\frac{w}{\gamma\theta}\right)^{\frac{1}{\gamma-1}} \cdot (1-f)^{\gamma_2} - x - \left(\frac{w}{\alpha}\right)^{-\epsilon} \tag{15}$$

$$K\left(n;\theta,w,x\right) = n - \left(\frac{w}{\gamma\theta}\right)^{\frac{1}{\gamma-1}} \left[n + x + \left(\frac{w}{\alpha}\right)^{-\epsilon}\right]^{\gamma_2} \tag{16}$$

Using those we can show that:

$$\frac{\partial f}{\partial \theta} = -\frac{G_\theta}{G_f} = \frac{\frac{1}{\gamma-1}\left(\frac{w}{\gamma}\right)^{\frac{1}{\gamma-1}}(1-f)^{\gamma_2}\,\theta^{\frac{\gamma}{1-\gamma}}}{1-\gamma_2\left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}}(1-f)^{\gamma_2-1}} < 0 \tag{17}$$

$$\frac{\partial f}{\partial w} = \frac{\frac{1}{1-\gamma}\left(\frac{1}{\theta\gamma}\right)^{\frac{1}{\gamma-1}}(1-f)^{\gamma_2}\,w^{\frac{2-\gamma}{\gamma-1}} + \epsilon\alpha^{\epsilon}w^{-1-\epsilon}}{1-\gamma_2\left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}}(1-f)^{\gamma_2-1}} > 0 \tag{18}$$

$$\frac{\partial f}{\partial x} = \frac{-1}{1-\gamma_2\left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}}(1-f)^{\gamma_2-1}} < 0 \tag{19}$$

$$\frac{\partial n}{\partial \theta} = -\frac{K_\theta}{K_n} = \frac{\frac{1}{1-\gamma}\left(\frac{w}{\gamma}\right)^{\frac{1}{\gamma-1}}\theta^{\frac{\gamma}{1-\gamma}}\left[n+x+\left(\frac{w}{\alpha}\right)^{-\epsilon}\right]^{\gamma_2}}{1-\gamma_2\left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}}\left[n+x+\left(\frac{w}{\alpha}\right)^{-\epsilon}\right]^{\gamma_2-1}} > 0 \tag{20}$$

$$\frac{\partial n}{\partial w} = \frac{(\theta\gamma)^{\frac{1}{1-\gamma}}\left\{\underbrace{\frac{1}{\gamma-1}w^{\frac{2-\gamma}{\gamma-1}}\left[n+x+\left(\frac{w}{\alpha}\right)^{-\epsilon}\right]^{\gamma_2}}_{<0} - \underbrace{\frac{\epsilon}{\alpha}\gamma_2 w^{\frac{1}{\gamma-1}}\left[n+x+\left(\frac{w}{\alpha}\right)^{-\epsilon}\right]^{\gamma_2-1}\left(\frac{w}{\alpha}\right)^{-1-\epsilon}}_{>0}\right\}}{1-\gamma_2\left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}}\left[n+x+\left(\frac{w}{\alpha}\right)^{-\epsilon}\right]^{\gamma_2-1}} < 0 \tag{21}$$

$$\frac{\partial n}{\partial x} = \frac{\gamma_2\left(\frac{w}{\theta\gamma}\right)^{\frac{1}{1-\gamma}}\left[n+x+\left(\frac{w}{\alpha}\right)^{-\epsilon}\right]^{\gamma_2-1}}{1-\gamma_2\left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}}\left[n+x+\left(\frac{w}{\alpha}\right)^{-\epsilon}\right]^{\gamma_2-1}} \geq 0 \tag{22}$$

□

Proposition 3. *Under Assumption 1, in the economy with externalities, there exists a productivity threshold value $\bar{\theta} < \theta^c$ such that for $\theta^d \geq \bar{\theta}$, decentralization reduces conflict, and increases irrigation's productivity, output and welfare. In the economy without externalities, the threshold on θ^d for conflict reduction satisfies $\bar{\theta} < \theta^c$ and the threshold for output and welfare improvement satisfies $\tilde{\theta} > \theta^c$.*

Proof. Our general strategy is to first compute the changes in conflict, output and welfare generated by moving from the centralized to the decentralized case. Then, we show that these changes are monotone in productivity level θ^d. This first allows us to find points at which the outcomes of decentralized and centralized management coincide, and thereby to establish the relevant thresholds.

We start with proving the proposition for the model with externalities. The optimal solutions in eq. (11) and (12) lead to:

$$y^{d*} = \theta^d \cdot (1 - f^*)^{1-\gamma} \cdot (n^*)^{\gamma} \tag{23}$$

$$= \theta^d \cdot \left[\frac{x + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta^d \gamma}\right)^{\frac{1}{\gamma-1}}} \right]^{1-\gamma} \cdot \left[\left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}} \cdot \frac{x + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta^d \gamma}\right)^{\frac{1}{\gamma-1}}} \right]^{\gamma} \tag{24}$$

$$= \theta^d \left[\frac{x + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta^d \gamma}\right)^{\frac{1}{\gamma-1}}} \right] \left(\frac{w}{\theta^d \gamma}\right)^{\frac{\gamma}{\gamma-1}} \tag{25}$$

and

$$y^{c*} = \theta^c \left[\frac{x + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta^c \gamma}\right)^{\frac{1}{\gamma-1}}} \right] \left(\frac{w}{\theta^c \gamma}\right)^{\frac{\gamma}{\gamma-1}} \tag{26}$$

Thus, the change in output is given by:

$$\Delta y = y^{d*} - y^{c*} = \theta^d \left[\frac{x + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta^d \gamma}\right)^{\frac{1}{\gamma-1}}} \right] \left(\frac{w}{\theta^d \gamma}\right)^{\frac{\gamma}{\gamma-1}} - \theta^c \left[\frac{x + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta^c \gamma}\right)^{\frac{1}{\gamma-1}}} \right] \left(\frac{w}{\theta^c \gamma}\right)^{\frac{\gamma}{\gamma-1}} \tag{27}$$

$$= \frac{\left(\theta^d\right)^{\frac{1}{1-\gamma}} \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} \left\{ x \left[1 - \left(\frac{w}{\theta^c \gamma}\right)^{\frac{1}{\gamma-1}} \right] + \left(\frac{w}{\alpha}\right)^{-\epsilon} \right\} - \left(\theta^c\right)^{\frac{1}{1-\gamma}} \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} \left(\frac{w}{\alpha}\right)^{-\epsilon}}{\left[1 - \left(\frac{w}{\theta^c \gamma}\right)^{\frac{1}{\gamma-1}} \right] \cdot \left[1 - \left(\frac{w}{\theta^d \gamma}\right)^{\frac{1}{\gamma-1}} \right]} \tag{28}$$

Because $\dfrac{\left(\theta^d\right)^{\frac{1}{1-\gamma}}}{1 - \left(\frac{w}{\theta^d \gamma}\right)^{\frac{1}{\gamma-1}}}$ is increasing in θ^d, it follows that Δy is strictly increasing in θ^d. Now, we find the threshold $\overline{\theta^d_{output}}$ at which $\Delta y = 0$:

$$0 < \left(\overline{\theta^d_{output}}\right)^{\frac{1}{1-\gamma}} = \frac{(\theta^c)^{\frac{1}{1-\gamma}} \left(\frac{w}{\alpha}\right)^{-\epsilon}}{x\left[1-\left(\frac{w}{\theta^c\gamma}\right)^{\frac{1}{\gamma-1}}\right] + \left(\frac{w}{\alpha}\right)^{-\epsilon}} < (\theta^c)^{\frac{1}{1-\gamma}} \tag{29}$$

The last inequality follows as Assumption 1 implies that $1 - \left(\frac{w}{\theta^c\gamma}\right)^{\frac{1}{\gamma-1}} > 0$. This proves that there exists $\overline{\theta^d_{output}}$ such that decentralization increases output if $\theta^d \in \left(\overline{\theta^d_{output}}, \theta^c\right)$.

Next, we compute the change in welfare from the centralized case to the decentralized case. By eq. 11 and 12, consumption is given by:

$$\begin{aligned} c^{j*} =& \theta \left(1 - f^{j*}\right)^{1-\gamma} \left(n^{j*}\right)^{\gamma} + w & (30) \\ =& \theta \left[\frac{x \cdot 1_{j=d} + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}}}\right]^{1-\gamma} \cdot \left[\left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}} \cdot \frac{x \cdot 1_{j=d} + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}}}\right]^{\gamma} + w & (31) \\ =& \theta \left[\frac{x \cdot 1_{j=d} + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}}}\right] \cdot \left(\frac{w}{\theta\gamma}\right)^{\frac{\gamma}{\gamma-1}} + w & (32) \end{aligned}$$

Therefore, utility is given by:

$$\begin{aligned} u^{j*} =& c^{j*} + \alpha \frac{\left(1 - f^{j*} - n^{j*} - x \cdot 1_{j=d}\right)^{1-\frac{1}{\epsilon}}}{1 - \frac{1}{\epsilon}} & (33) \\ =& \theta \left[\frac{x \cdot 1_{j=d} + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta\gamma}\right)^{\frac{1}{\gamma-1}}}\right] \cdot \left(\frac{w}{\theta\gamma}\right)^{\frac{\gamma}{\gamma-1}} + w + \alpha \frac{\left[\left(\frac{w}{\alpha}\right)^{-\epsilon}\right]^{1-\frac{1}{\epsilon}}}{1 - \frac{1}{\epsilon}} & (34) \end{aligned}$$

Thus, the welfare change induced by moving from centralized to decentralized management is given by:

$$\Delta u = u^{d*} - u^{c*} = \Delta y \tag{35}$$

As such, Δu is also increasing in θ^d and the threshold satisfies $\overline{\theta^d_{output}} = \overline{\theta^d_{welfare}}$.

We now proceed to the analysis of decentralization's impact on conflict. By eq. 11, the change in conflicts reads:

$$\Delta f = f^{c*} - f^{d*} = \frac{x + \left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta^d \gamma}\right)^{\frac{1}{\gamma-1}}} - \frac{\left(\frac{w}{\alpha}\right)^{-\epsilon}}{1 - \left(\frac{w}{\theta^c \gamma}\right)^{\frac{1}{\gamma-1}}} \tag{36}$$

$$= \frac{\left(\frac{w}{\alpha}\right)^{-\epsilon} \cdot \left(\frac{w}{\gamma}\right)^{\frac{1}{\gamma-1}} \left[\left(\theta^d\right)^{\frac{1}{1-\gamma}} - \left(\theta^c\right)^{\frac{1}{1-\gamma}}\right] + x \cdot \left[1 - \left(\frac{w}{\theta^c \gamma}\right)^{\frac{1}{\gamma-1}}\right]}{\left[1 - \left(\frac{w}{\theta^d \gamma}\right)^{\frac{1}{\gamma-1}}\right] \cdot \left[1 - \left(\frac{w}{\theta^c \gamma}\right)^{\frac{1}{\gamma-1}}\right]} \tag{37}$$

Since $\frac{\left(\theta^d\right)^{\frac{1}{1-\gamma}}}{1-\left(\frac{w}{\theta^d\gamma}\right)^{\frac{1}{\gamma-1}}}$ is increasing in θ^d, this establishes that Δf is increasing in θ^d. By setting $\Delta f = 0$, we can obtain the relevant threshold:

$$\left(\overline{\theta^d_{conflict}}\right)^{\frac{1}{1-\gamma}} = \frac{\left[\left(\frac{w}{\alpha}\right)^{-\epsilon} + x\right] \left(\frac{w}{\gamma}\right)^{\frac{1}{\gamma-1}} \left(\theta^c\right)^{\frac{1}{1-\gamma}} - x}{\left(\frac{w}{\gamma}\right)^{\frac{1}{\gamma-1}} \left(\frac{w}{\alpha}\right)^{-\epsilon}} < \left(\theta^c\right)^{\frac{1}{1-\gamma}} \tag{38}$$

where the inequality follows by Assumption 1.

For compactness of notation, let $A = \left(\frac{w}{\gamma}\right)^{\frac{1}{\gamma-1}}$, $B = \left(\frac{w}{\alpha}\right)^{-\epsilon}$, $C = \left(\theta^c\right)^{\frac{1}{1-\gamma}}$. Then:

$$\left(\overline{\theta^d_{conflict}}\right)^{\frac{1}{1-\gamma}} - \left(\overline{\theta^d_{welfare}}\right)^{\frac{1}{1-\gamma}} = \frac{Bx\left[2AC - (AC)^2 - 1\right] + x^2\left[2AC - (AC)^2 - 1\right]}{AB\left\{B + x\left[1 - AC\right]\right\}} \tag{39}$$

$$= \frac{-x\left(1 - AC\right)^2 \left(B + x\right)}{AB\left\{B + x\left[1 - AC\right]\right\}} < 0 \tag{40}$$

The last inequality exploits that $A > 0$, $B > 0$, $AC \in (0,1)$, $x > 0$. This establishes that $\overline{\theta^d_{conflict}} < \overline{\theta^d_{welfare}}$. Thus, the latter threshold is relevant for our proposition and concludes the proof for the case with externalities.

Proceeding to the model without externalities, by eq. (13) and (14), we know that

$$y^* = \theta^{\frac{1}{1-\gamma}} \cdot \left(\frac{w}{\gamma}\right)^{\frac{1}{\gamma-1}} \tag{41}$$

$$u^* = \theta^{\frac{1}{1-\gamma}} \cdot \left(\frac{w}{\gamma}\right)^{\frac{1}{\gamma-1}} + w + \alpha\frac{\left[\left(\frac{w}{\alpha}\right)^{-\epsilon}\right]^{1-\frac{1}{\epsilon}}}{1 - \frac{1}{\epsilon}} \tag{42}$$

So the changes in conflict, output and welfare read:

$$\Delta f = f^{c*} - f^{d*} = x + \left[\left(\theta^d\right)^{\frac{1}{1-\gamma}} - \left(\theta^c\right)^{\frac{1}{1-\gamma}}\right] \cdot \left(\frac{w}{\gamma}\right)^{\frac{1}{\gamma-1}} \tag{43}$$

$$\Delta y = y^{d*} - y^{c*} = \left[\left(\theta^d\right)^{\frac{1}{1-\gamma}} - \left(\theta^c\right)^{\frac{1}{1-\gamma}} \right] \cdot \left(\frac{w}{\gamma}\right)^{\frac{1}{\gamma-1}} \tag{44}$$

$$\Delta u = u^{d*} - u^{c*} = \left[\left(\theta^d\right)^{\frac{1}{1-\gamma}} - \left(\theta^c\right)^{\frac{1}{1-\gamma}} \right] \cdot \left(\frac{w}{\gamma}\right)^{\frac{1}{\gamma-1}} \tag{45}$$

It follows that although in the no-externality case there exists a threshold $\overline{\theta^d_{conflict}} < \theta^c$, it is also the case that $\overline{\theta^d_{output}} = \overline{\theta^d_{welfare}} = \theta^c$, which concludes the proof. □

Corollary 1. *In the economy with externalities under Assumption 1, there exists a threshold $\bar{\theta} < \theta^c$ such that:*

1. *If $\theta^d \geq \bar{\theta}$, the reform reduces conflict and this effect is increasing in θ^d and in the time cost of irrigation maintenance x.*
2. *If $\theta^d < \bar{\theta}$, the reform increases conflict and this effect is decreasing in θ^d and in the time cost of irrigation maintenance x.*

Proof. The result follows immediately from Proposition 3 as a consequence of Proposition 1 showing that $\frac{\partial f}{\partial \theta} < 0$ and $\frac{\partial f}{\partial x} < 0$. One caveat is that in this case the threshold satisfies $\bar{\theta} = \overline{\theta^d_{conflict}}$. □

Proposition 4. *Under Assumptions 1 and 2 in the model with externalities, there exist regions of the initial levels of conflict $(\bar{f}_{i,0}, 1)$ $\forall i \in \{1, 2\}$ and of the slope of the cost of high cooperation $(\underline{\chi}^H, \bar{\chi}^H)$ s.t. for $f_{i,0}$ and χ^H in these regions, the level of cooperation in period 1 is low (L) and in period 2 is high (H). The level of conflict in period 1 is higher than that in period 2.*

Proof. Our general strategy is to consider all combinations of low and high co-operation in periods 1 and 2, derive the associated utility levels, and to derive conditions under which agents prefer profile (L,H), i.e. low co-operation in period 1 and high in period 2, to any other alternative.

In period 1, the household i can choose H or L, and the optimal level of conflict and labor supply are given by eq.(11) and (12), respectively. Notice that $\alpha = 1$. For compactness of notation, we will omit i and denote $v_{i,t}$ as v_t where v stands for endogenous or exogenous variables.

If it chooses L, the period-1 utility is given by:

$$u_1^L = c_1^L + \frac{\left(l_1^L\right)^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} \tag{46}$$

$$= \theta^L \left(1 - f^*\right)^{1-\gamma} n^\gamma + w \tag{47}$$

$$= \left(\theta^L\right)^{\frac{1}{1-\gamma}} \left[\frac{x + w^{-\epsilon}}{1 - \left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}} \right] \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} + u_0 \tag{48}$$

where

$$u_0 = w + \frac{\left(w^{-\epsilon}\right)^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} \tag{49}$$

If it chooses H, the optimal f and n is still the same as before; however, there will be cost of high cooperation that leads to decrease in utility. Therefore, the utility is given by:

$$u_1^H = c_1^H + \frac{\left(l_1^H\right)^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} - 2\chi^H f_0 \tag{50}$$

$$= \left(\theta^H\right)^{\frac{1}{1-\gamma}} \left[\frac{x + w^{-\epsilon}}{1-\left(\frac{w}{\theta^H\gamma}\right)^{\frac{1}{\gamma-1}}}\right] \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} + u_0 - 2\chi^H f_0 \tag{51}$$

where f_0 is the initial level of conflict.

In period 2, the household faces the same static problem as period 1.

If it chooses L, the period-2 utility is given by:

$$u_2^L = c_2^L + \frac{\left(l_2^L\right)^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} = \left(\theta^L\right)^{\frac{1}{1-\gamma}} \left[\frac{x + w^{-\epsilon}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}}\right] \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} + u_0 \tag{52}$$

If it chooses H, there will be the cost of high cooperation that leads to decrease in utility. So the period-2 utility is given by:

$$u_2^H = \begin{cases} u_2^H\left(f_1^H\right), & \text{if } d = H \text{ at } t = 1 \\ u_2^H\left(f_1^L\right), & \text{if } d = L \text{ at } t = 1 \end{cases} \tag{53}$$

where

$$u_2^H\left(f_1^H\right) = c_2^H + \frac{\left(l_2^H\right)^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} - 2\chi^H f_1^H \tag{54}$$

$$= \left(\theta^H\right)^{\frac{1}{1-\gamma}} \left[\frac{x + w^{-\epsilon}}{1-\left(\frac{w}{\theta^H\gamma}\right)^{\frac{1}{\gamma-1}}}\right] \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} + u_0 - 2\chi^H \left[1 - \frac{x + w^{-\epsilon}}{1-\left(\frac{w}{\theta^H\gamma}\right)^{\frac{1}{\gamma-1}}}\right] \tag{55}$$

$$= \left[\left(\theta^H\right)^{\frac{1}{1-\gamma}} \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} + 2\chi^H\right] \left[\frac{x + w^{-\epsilon}}{1-\left(\frac{w}{\theta^H\gamma}\right)^{\frac{1}{\gamma-1}}}\right] + u_0 - 2\chi^H \tag{56}$$

and:

$$u_2^H\left(f_1^L\right) = c_2^H + \frac{\left(l_2^H\right)^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} - 2\chi^H f_1^L \tag{57}$$

$$= \left(\theta^H\right)^{\frac{1}{1-\gamma}}\left[\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^H\gamma}\right)^{\frac{1}{\gamma-1}}}\right]\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} + u_0 - 2\chi^H\left[1-\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}}\right] \tag{58}$$

The household then solves:

$$u = \max\left\{u_1^L, u_1^H\right\} + \beta\max\left\{u_2^L, u_2^H\right\} \tag{59}$$

$$= \max\left\{u\left(L,H\right), u\left(L,L\right), u\left(H,L\right), u\left(H,H\right)\right\} \tag{60}$$

$$= \max_{k,j}\left\{u\left(k,j\right)\right\} \tag{61}$$

where $u\left(k,j\right)$ stands for the overall welfare induced by the cooperation level k in period 1 and cooperation level j in period 2. Specifically,

$$u\left(L,H\right) = u_1^L + \beta u_2^H\left(f_1^L\right) \tag{62}$$

$$= \left(\theta^L\right)^{\frac{1}{1-\gamma}}\left[\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}}\right]\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} + u_0 \tag{63}$$

$$+\beta\left\{\left(\theta^H\right)^{\frac{1}{1-\gamma}}\left[\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^H\gamma}\right)^{\frac{1}{\gamma-1}}}\right]\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} + u_0 - 2\chi^H\left[1-\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}}\right]\right\} \tag{64}$$

$$= \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}\left(x+w^{-\epsilon}\right)\left[\frac{\left(\theta^L\right)^{\frac{1}{1-\gamma}}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}} + \beta\frac{\left(\theta^H\right)^{\frac{1}{1-\gamma}}}{1-\left(\frac{w}{\theta^H\gamma}\right)^{\frac{1}{\gamma-1}}}\right] + \left(1+\beta\right)u_0 - 2\beta\chi^H \tag{65}$$

$$+ 2\beta\chi^H\left[\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}}\right] \tag{66}$$

$$u\left(L,L\right)=u_1^L+\beta u_2^L \tag{67}$$

$$=\left(\theta^L\right)^{\frac{1}{1-\gamma}}\left[\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}}\right]\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}+u_0+\beta\left\{\left(\theta^L\right)^{\frac{1}{1-\gamma}}\left[\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}}\right]\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}+u_0\right\} \tag{68}$$

$$=\left(1+\beta\right)\left(\theta^L\right)^{\frac{1}{1-\gamma}}\left[\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}}\right]\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}+\left(1+\beta\right)u_0 \tag{69}$$

$$u\left(H,L\right)=u_1^H+\beta u_2^L \tag{70}$$

$$=\left(\theta^H\right)^{\frac{1}{1-\gamma}}\left[\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^H\gamma}\right)^{\frac{1}{\gamma-1}}}\right]\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}+u_0-2\chi^H f_0 \tag{71}$$

$$+\beta\left\{\left(\theta^L\right)^{\frac{1}{1-\gamma}}\left[\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}}\right]\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}+u_0\right\} \tag{72}$$

$$=\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}\left(x+w^{-\epsilon}\right)\left[\frac{\left(\theta^L\right)^{\frac{1}{1-\gamma}}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}}+\beta\frac{\left(\theta^H\right)^{\frac{1}{1-\gamma}}}{1-\left(\frac{w}{\theta^H\gamma}\right)^{\frac{1}{\gamma-1}}}\right]+\left(1+\beta\right)u_0-2\chi^H f_0 \tag{73}$$

$$u\left(H,H\right)=u_1^H+\beta u_2^H\left(f_1^H\right) \tag{74}$$

$$=\left(\theta^H\right)^{\frac{1}{1-\gamma}}\left[\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^H\gamma}\right)^{\frac{1}{\gamma-1}}}\right]\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}+u_0-2\chi^H f_0 \tag{75}$$

$$+\beta\left\{\left[\left(\theta^H\right)^{\frac{1}{1-\gamma}}\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}+2\chi^H\right]\left[\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^H\gamma}\right)^{\frac{1}{\gamma-1}}}\right]+u_0-2\chi^H\right\} \tag{76}$$

$$=\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^H\gamma}\right)^{\frac{1}{\gamma-1}}}\left\{\left(1+\beta\right)\left(\theta^H\right)^{\frac{1}{1-\gamma}}\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}+2\beta\chi^H\right\}+\left(1+\beta\right)u_0-2\chi^H f_0-2\beta\chi^H \tag{77}$$

Therefore, we can compute:

$$\Delta u_A = u(L,H) - u(L,L) \tag{78}$$

$$= \beta \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} \left(x + w^{-\epsilon}\right) \left[\underbrace{\frac{\left(\theta^H\right)^{\frac{1}{1-\gamma}}}{1-\left(\frac{w}{\theta^H \gamma}\right)^{\frac{1}{\gamma-1}}} - \frac{\left(\theta^L\right)^{\frac{1}{1-\gamma}}}{1-\left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}}}_{>0}\right] + 2\beta\chi^H \left[\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}} - 1\right] \tag{79}$$

First, $\frac{\partial \Delta u_A}{\partial \chi^H} < 0$ because $f^* > 0$ implies that $\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}} - 1 < 0$. Hence, χ^H should not be too large so that $\Delta u_A > 0$.

Set $\Delta u_A = 0$ and solve for the upper bound threshold $\bar{\chi}^H$, we have:

$$\bar{\chi}^H = \frac{\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} \left(x + w^{-\epsilon}\right) \left[\frac{\left(\theta^H\right)^{\frac{1}{1-\gamma}}}{1-\left(\frac{w}{\theta^H \gamma}\right)^{\frac{1}{\gamma-1}}} - \frac{\left(\theta^L\right)^{\frac{1}{1-\gamma}}}{1-\left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}}\right]}{2\left[1 - \frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}}\right]} > 0 \tag{80}$$

When $\chi^H \in \left(0, \bar{\chi}^H\right)$, $\Delta u_A > 0$.

Second,

$$\frac{\partial \Delta u_A}{\partial \beta} = \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} \left(x + w^{-\epsilon}\right) \left[\frac{\left(\theta^H\right)^{\frac{1}{1-\gamma}}}{1-\left(\frac{w}{\theta^H \gamma}\right)^{\frac{1}{\gamma-1}}} - \frac{\left(\theta^L\right)^{\frac{1}{1-\gamma}}}{1-\left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}}\right] + 2\chi^H \left[\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}} - 1\right] \tag{81}$$

If $\chi^H \in \left(0, \bar{\chi}^H\right)$, then $\frac{\partial \Delta u_A}{\partial \beta} > 0$.

Third,

$$\frac{\partial \Delta u_A}{\partial f_0} = 0. \tag{82}$$

$$\Delta u_B = u(L,H) - u(H,L) = 2\beta\chi^H \left[\underbrace{\frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}} - 1}_{<0}\right] + 2\chi^H f_0 \tag{83}$$

First, $\frac{\partial \Delta u_B}{\partial f_0} = 2\chi^H > 0$. Hence, f_0 should not be too small so that $\Delta u_B > 0$. Set $\Delta u_B = 0$ and solve for the lower bound threshold $\bar{f}_0$, we have:

$$\bar{f}_0 = \beta \left[1 - \frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}}\right] > 0 \tag{84}$$

When $f_0 > \bar{f}_0$, $\Delta u_B > 0$.

Second, $\frac{\partial \Delta u_B}{\partial \beta} < 0$. Therefore, we can solve for the threshold $\bar{\beta}$ by setting $\Delta u_B = 0$.

$$\beta < \bar{\beta} = \frac{f_0}{1 - \frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}}} \tag{85}$$

When $\beta < \bar{\beta}$, $\Delta u_B > 0$.

Third, if we set $\Delta u_B = 0$, χ^H drops out. Hence, only f_0 and β matter for case B. At the end of this proof we show that our parametric assumptions deliver $\Delta u_B > 0$

$$\Delta u_C = u\left(L, H\right) - u\left(H, H\right) \tag{86}$$

$$= \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} \left(x + w^{-\epsilon}\right) \left[\underbrace{\frac{\left(\theta^L\right)^{\frac{1}{1-\gamma}}}{1 - \left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}} - \frac{\left(\theta^H\right)^{\frac{1}{1-\gamma}}}{1 - \left(\frac{w}{\theta^H \gamma}\right)^{\frac{1}{\gamma-1}}}}_{<0}\right] \tag{87}$$

$$- 2\beta\chi^H \left(x + w^{-\epsilon}\right) \left[\underbrace{\frac{1}{1 - \left(\frac{w}{\theta^H \gamma}\right)^{\frac{1}{\gamma-1}}} - \frac{1}{1 - \left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}}}_{>0}\right] + 2\chi^H f_0 \tag{88}$$

First, notice that

$$\frac{\partial \Delta u_C}{\partial \beta} = -2\chi^H \left(x + w^{-\epsilon}\right) \left[\underbrace{\frac{1}{1 - \left(\frac{w}{\theta^H \gamma}\right)^{\frac{1}{\gamma-1}}} - \frac{1}{1 - \left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}}}_{>0}\right] < 0 \tag{89}$$

Therefore, β should not be too large so that $\Delta u_C > 0$. We solve for the threshold β by setting $\Delta u_C = 0$.

$$\bar{\beta} = \frac{K}{2\chi^H} + \frac{f_0}{Q} \tag{90}$$

where

$$K = \frac{\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} \left[\frac{\left(\theta^L\right)^{\frac{1}{1-\gamma}}}{1-\left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}} - \frac{\left(\theta^H\right)^{\frac{1}{1-\gamma}}}{1-\left(\frac{w}{\theta^H \gamma}\right)^{\frac{1}{\gamma-1}}}\right]}{\frac{1}{1-\left(\frac{w}{\theta^H \gamma}\right)^{\frac{1}{\gamma-1}}} - \frac{1}{1-\left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}}} < 0 \tag{91}$$

and

$$Q = \left(x + w^{-\epsilon}\right) \left[\frac{1}{1 - \left(\frac{w}{\theta^H \gamma}\right)^{\frac{1}{\gamma-1}}} - \frac{1}{1 - \left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}}\right] > 0 \tag{92}$$

Second,

$$\frac{\partial \Delta u_C}{\partial \chi^H} = -2\beta\left(x + w^{-\epsilon}\right)\underbrace{\left[\frac{1}{1-\left(\frac{w}{\theta^H \gamma}\right)^{\frac{1}{\gamma-1}}} - \frac{1}{1-\left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}}\right]}_{>0} + 2f_0 \tag{93}$$

The sign of $\frac{\partial \Delta u_C}{\partial \chi^H}$ is uncertain. It depends on the value of β and f_0.

Third, $\frac{\partial \Delta u_C}{\partial f_0} = 2\chi^H > 0$. Hence, f_0 should not be too small so that $\Delta u_C > 0$. Set $\Delta u_C = 0$ and solve for the lower bound threshold $\bar{f}_0$, we have:

$$\bar{f}_0 = \beta Q - \frac{KQ}{2\chi^H} \tag{94}$$

Table below presents summary of the intermediate conclusions on threshold conditions (final ones are summarized at the end of this proof):

Table A1: Summary of threshold conditions

	initial level of conflict	cost of high cooperation	discount parameter
$u(L,H) - u(L,L)$	$\frac{\partial \Delta u_A}{\partial f_0} = 0$	$\frac{\partial \Delta u_A}{\partial \chi^H} < 0$	$\frac{\partial \Delta u_A}{\partial \beta}$ uncertain
$u(L,H) - u(H,L)$	$\frac{\partial \Delta u_B}{\partial f_0} > 0$	$\frac{\partial \Delta u_B}{\partial \chi^H}$ uncertain	$\frac{\partial \Delta u_B}{\partial \beta} < 0$
$u(L,H) - u(H,H)$	$\frac{\partial \Delta u_C}{\partial f_0} > 0$	$\frac{\partial \Delta u_C}{\partial \chi^H}$ uncertain	$\frac{\partial \Delta u_C}{\partial \beta} < 0$
Conclusion	$f_0 > \bar{f}_0$	$\chi^H < \bar{\chi}^H$	$\beta < \bar{\beta}$

Finally, we solve for these thresholds:

$$\bar{\chi}^H = \frac{-KQ}{2P} > 0 \tag{95}$$

$$\bar{f}_0 = \frac{\beta Q}{2} \tag{96}$$

$$\bar{\beta} = \frac{2f_0}{Q} \tag{97}$$

$$\bar{\beta} = \frac{K}{2\chi^H} + \frac{f_0}{Q} \tag{98}$$

$$\bar{f}_0 = \beta Q - \frac{KQ}{2\chi^H} \tag{99}$$

where

$$P = 1 - \frac{x + w^{-\epsilon}}{1-\left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}} > 0 \tag{100}$$

Let $\chi^H = \bar{\chi}^H$ and we have four unknowns $\beta, \bar{\beta}, f_0, \bar{f}_0$.

$$\begin{pmatrix} -P & 0 & 1 & 0 \\ 0 & P & -1 & 0 \\ 0 & Q & -1 & 0 \\ Q & 0 & 0 & -1 \end{pmatrix} \begin{pmatrix} \beta \\ \bar{\beta} \\ f_0 \\ \bar{f}_0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ -P \\ -P \end{pmatrix} \tag{101}$$

$$\begin{pmatrix} \beta \\ \bar{\beta} \\ f_0 \\ \bar{f}_0 \end{pmatrix} = \begin{pmatrix} \frac{P}{P-Q} \\ \frac{P}{P-Q} \\ \frac{P^2}{P-Q} \\ \frac{P^2}{P-Q} \end{pmatrix} \tag{102}$$

The solution is invalid because $\beta > 1$.[30]

So we decrease $\beta = 1$ and substitute the new solution

$$\begin{cases} \bar{\beta} = 1 \\ \bar{f}_0 = P + Q \\ \bar{\chi}^H = \frac{-KQ}{2P} \end{cases} \tag{103}$$

into equations (78),(83), and (86). We can verify that :

$$\Delta u_A = \beta \left(-KQ - 2\chi^H P\right) = 0 \tag{104}$$

$$\Delta u_B = 2\chi^H \left(-\beta P + f_0\right) > 0 \tag{105}$$

$$\Delta u_C = KQ - 2\chi^H \left(\beta Q - f_0\right) = 0 \tag{106}$$

$P + Q < 1 - x$ requires that

$$\frac{1}{1 - \left(\frac{w}{\theta^H \gamma}\right)^{\frac{1}{\gamma-1}}} < \frac{2}{1 - \left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}} - \frac{x}{x + w^{-\epsilon}} \tag{107}$$

From equation (94), we know that $\Delta u_c > 0$ as long as $f_0 > \bar{f}_0$, holding other parameters fixed. Then we look at equation (93). Note that the sign of $\frac{\partial \Delta u_C}{\partial \chi^H}$ is uncertain. If we set equation (93)=0, then we can get $f_0 = \beta Q$. When $f_0 > \beta Q$, $\frac{\partial \Delta u_C}{\partial \chi^H} > 0$. When $f_0 < \beta Q$, $\frac{\partial \Delta u_C}{\partial \chi^H} < 0$. But we have the condition $f_0 > P + Q > \beta Q$. So $\frac{\partial \Delta u_C}{\partial \chi^H} > 0$.

Therefore, $f_0 > \bar{f}_0$ implies that $\frac{\partial \Delta u_C}{\partial \chi^H} > 0$, which means χ^H cannot be too small.

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[30] Notice that $Q-P = (x + w^{-\epsilon}) \left[\frac{1}{1-\left(\frac{w}{\theta^H \gamma}\right)^{\frac{1}{\gamma-1}}} - \frac{1}{1-\left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}} \right] - 1 + \frac{x+w^{-\epsilon}}{1-\left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}} = \left[\frac{\left(x+w^{-\epsilon}\right)}{1-\left(\frac{w}{\theta^H \gamma}\right)^{\frac{1}{\gamma-1}}} \right] - 1 < 0$. So $0 < Q < P < 1$.

We now want to find conditions ensuring that $\Delta u_c > 0$ when:

$$\begin{cases} 0 < \beta < \bar{\beta} = 1 \\ 1 > f_0 > \bar{f}_0 \\ \underline{\chi}^H < \chi^H < \bar{\chi}^H \end{cases} \tag{108}$$

By equation (106), the underbar of χ^H is $\underline{\chi}^H = \frac{KQ}{2(\beta Q - f_0)}$. Since $KQ < 0$ and $f_0 > P + Q > \beta Q$, and from equation (95) $\bar{\chi}^H = \frac{-KQ}{2P} > 0$, so $\beta Q - f_0 < -P$ (we need $\underline{\chi}^H < \bar{\chi}^H$). This also holds because $f_0 > \bar{f}_0 > P + Q > P + \beta Q$.
Therefore, given f_0 and β,

$$\frac{-KQ}{2\left(f_0 - \beta Q\right)} < \chi^H < \frac{-KQ}{2P}. \tag{109}$$

We can verify that $\frac{\partial \Delta u_B}{\partial \chi^H} > 0$ under these threshold conditions.

By equation (105) and the threshold solutions, we know that $\left(\Delta u_B\right)_{\min} = 2\chi^H\left(\bar{f}_0 - \bar{\beta} P\right) = 2\chi^H\left[(P+Q) - P\right] = 2\chi^H Q > 0$. So Δu_B is always > 0 as we increase f_0 and decrease β.

Since $\frac{\partial \Delta u_B}{\partial \chi^H} = 2\left(f_0 - \beta P\right)$ and $f_0 > \bar{f}_0 = P + Q > \beta P$, $\frac{\partial \Delta u_B}{\partial \chi^H} > 0$.

Finally, from equation (104) and equation (106), we can verify that under these threshold conditions $\Delta u_A > 0$ and $\Delta u_C > 0$.

Table below provides the final summary of threshold conditions derived.

The level of conflict in period 1 is higher than that in period 2 because at the optimal level the household chooses (L,H) and we have shown in Proposition 1(a) that $\frac{\partial f}{\partial \theta} < 0$. □

In order to prove the version of above proposition in the model without externalities, we need the following assumption:

Assumption 3. *The productivity parameters θ^L and θ^H satisfy:*

$$\begin{cases} 0 < 1 - \left(\frac{w}{\gamma}\right)^{\frac{1}{\gamma-1}}\left[\left(\theta^H\right)^{\frac{1}{1-\gamma}} - \left(\theta^L\right)^{\frac{1}{1-\gamma}}\right] < \frac{\gamma}{w} f^*\left(\theta^L\right) \\ 0 < \left(\frac{w}{\gamma}\right)^{\frac{1}{\gamma-1}}\left[\left(\theta^H\right)^{\frac{1}{1-\gamma}} - \left(\theta^L\right)^{\frac{1}{1-\gamma}}\right] < f^*\left(\theta^L\right) < 1 \end{cases} \tag{110}$$

where $f^*\left(\theta^L\right)$ is the optimal level of conflict with low cooperation level in equation (13).

This assumption ensures that $\bar{\beta} < 1$ and $\bar{f}_0 < 1$ (See the proof below for details).

Proposition 5. *(no-externality case) Under Assumptions 1 and 3, there exists a region of the initial level of conflict $(\bar{f}_0, 1)$, the slope of the cost of high cooperation $[\underline{\chi}^H, \bar{\chi}^H]$, and the discounter parameter $(0, \bar{\beta})$ s.t. the level of cooperation in period 1 is low (L) and in period 2 is high (H). The level of conflict in period 1 is higher than that in period 2.*

Proof. In the no-externality case, the optimal level of conflict and labor supply are given by eq.(13) and eq.(14), respectively. Thus, we can compute the welfare with low or high cooperation level in the two periods, which are:

$$u_1^L = c_1^L + \frac{\left(l_1^L\right)^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} \tag{111}$$

$$= \theta^L n^\gamma + \frac{\left(w^{-\epsilon}\right)^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} \tag{112}$$

$$= \left(\theta^L\right)^{\frac{1}{1-\gamma}} \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} + u_{00} \tag{113}$$

where

$$u_{00} = \frac{\left(w^{-\epsilon}\right)^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}}. \tag{114}$$

$$u_1^H = c_1^H + \frac{\left(l_1^H\right)^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} - 2\chi^H f_0 \tag{115}$$

$$= \left(\theta^H\right)^{\frac{1}{1-\gamma}} \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} + u_{00} - 2\chi^H f_0 \tag{116}$$

$$u_2^L = c_2^L + \frac{\left(l_2^L\right)^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} = \left(\theta^L\right)^{\frac{1}{1-\gamma}} \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} + u_{00} \tag{117}$$

$$u_2^H = \begin{cases} u_2^H\left(f_1^H\right), & \text{if } d = H \text{ at } t = 1 \\ u_2^H\left(f_1^L\right), & \text{if } d = L \text{ at } t = 1 \end{cases} \tag{118}$$

where

$$u_2^H\left(f_1^H\right) = c_2^H + \frac{\left(l_2^H\right)^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} - 2\chi^H f_1^H \tag{119}$$

$$= \left(\theta^H\right)^{\frac{1}{1-\gamma}} \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} + u_{00} - 2\chi^H \left[1 - w^{-\epsilon} - x - \left(\frac{w}{\theta^H \gamma}\right)^{\frac{1}{\gamma-1}}\right] \tag{120}$$

and

$$u_2^H\left(f_1^L\right) = c_2^H + \frac{\left(l_2^H\right)^{1-\frac{1}{\epsilon}}}{1-\frac{1}{\epsilon}} - 2\chi^H f_1^L \tag{121}$$

$$= \left(\theta^H\right)^{\frac{1}{1-\gamma}} \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} + u_{00} - 2\chi^H \left[1 - w^{-\epsilon} - x - \left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}}\right] \tag{122}$$

Therefore, we can compute the overall welfare:

$$u\left(L,H\right)=u_1^L+\beta u_2^H\left(f_1^L\right) \tag{123}$$
$$=\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}\left[\left(\theta^L\right)^{\frac{1}{1-\gamma}}+\beta\left(\theta^H\right)^{\frac{1}{1-\gamma}}\right]+\left(1+\beta\right)u_{00}-2\beta\chi^H\left[1-w^{-\epsilon}-x-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}\right] \tag{124}$$

$$u\left(L,L\right)=u_1^L+\beta u_2^L \tag{125}$$
$$=\left(1+\beta\right)\left(\theta^L\right)^{\frac{1}{1-\gamma}}\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}+\left(1+\beta\right)u_{00} \tag{126}$$

$$u\left(H,L\right)=u_1^H+\beta u_2^L \tag{127}$$
$$=\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}\left[\left(\theta^H\right)^{\frac{1}{1-\gamma}}+\beta\left(\theta^L\right)^{\frac{1}{1-\gamma}}\right]+\left(1+\beta\right)u_{00}-2\chi^H f_0 \tag{128}$$

$$u\left(H,H\right)=u_1^H+\beta u_2^H\left(f_1^H\right) \tag{129}$$
$$=\left(1+\beta\right)\left(\theta^H\right)^{\frac{1}{1-\gamma}}\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}+\left(1+\beta\right)u_{00}-2\chi^H f_0-2\beta\chi^H\left[1-w^{-\epsilon}-x-\left(\frac{w}{\theta^H\gamma}\right)^{\frac{1}{\gamma-1}}\right] \tag{130}$$

Therefore, we can compute:

$$\Delta u_A=u\left(L,H\right)-u\left(L,L\right) \tag{131}$$
$$=\beta\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}\left[\underbrace{\left(\theta^H\right)^{\frac{1}{1-\gamma}}-\left(\theta^L\right)^{\frac{1}{1-\gamma}}}_{>0}\right]-2\beta\chi^H\left[1-w^{-\epsilon}-x-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}\right] \tag{132}$$

$$\Delta u_B=u\left(L,H\right)-u\left(H,L\right) \tag{133}$$
$$=\left(1-\beta\right)\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}\left[\underbrace{\left(\theta^L\right)^{\frac{1}{1-\gamma}}-\left(\theta^H\right)^{\frac{1}{1-\gamma}}}_{<0}\right]-2\beta\chi^H\left[1-w^{-\epsilon}-x-\left(\frac{w}{\theta^L\gamma}\right)^{\frac{1}{\gamma-1}}\right]+2\chi^H f_0 \tag{134}$$

$$\Delta u_C=u\left(L,H\right)-u\left(H,H\right) \tag{135}$$
$$=\left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}\left[\underbrace{\left(\theta^L\right)^{\frac{1}{1-\gamma}}-\left(\theta^H\right)^{\frac{1}{1-\gamma}}}_{<0}\right]-2\beta\chi^H\left[\left(\frac{w}{\gamma}\right)^{\frac{1}{\gamma-1}}\left[\left(\theta^H\right)^{\frac{1}{1-\gamma}}-\left(\theta^L\right)^{\frac{1}{1-\gamma}}\right]\right]+2\chi^H f_0 \tag{136}$$

We can further simplify them into:

$$\Delta u_A = \beta M - 2\beta\chi^H N \tag{137}$$

$$\Delta u_B = -\left(1-\beta\right) M + 2\chi^H \left(f_0 - \beta N\right) \tag{138}$$

$$\Delta u_C = -M + 2\chi^H \left(f_0 - \beta S\right) \tag{139}$$

where

$$M = \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} \left[\left(\theta^H\right)^{\frac{1}{1-\gamma}} - \left(\theta^L\right)^{\frac{1}{1-\gamma}}\right] \tag{140}$$

$$N = 1 - w^{-\epsilon} - x - \left(\frac{w}{\theta^L \gamma}\right)^{\frac{1}{\gamma-1}} \tag{141}$$

,and

$$S = M \cdot \frac{\gamma}{w}. \tag{142}$$

Therefore, we have the following: To solve for the threshold χ^H, we set $\Delta u_A = 0$ and obtain:

$$\bar{\chi}^H = \frac{M}{2N} \tag{143}$$

To solve for the threshold β, we set $\Delta u_C = 0$ and obtain:

$$\bar{\beta} = \frac{f_0}{S} - \frac{1}{2\chi^H} \tag{144}$$

To solve for the threshold f_0, we set $\Delta u_B = 0$ and obtain:

$$\bar{f_0} = \beta N + \frac{\left(1-\beta\right) M}{2\chi^H} \tag{145}$$

Let $\bar{\chi^H} = \chi^H$ and we have:

$$\begin{cases} \bar{\chi}^H = \frac{M}{2N} \\ \bar{\beta} = \frac{\frac{w}{\gamma} f_0 - N}{M} \\ \bar{f_0} = N \end{cases} \tag{146}$$

Note that Assumption 3 is equivalent to the following:

$$\begin{cases} 0 < \left(1-S\right) \frac{w}{\gamma} < N \\ 0 < S < N < 1 \end{cases} \Rightarrow \begin{cases} 0 < \frac{w}{\gamma} < M + N \\ 0 < S < N < 1 \end{cases} \Rightarrow \begin{cases} \left(\bar{\beta}\right)_{\max} = \frac{\frac{w}{\gamma} \cdot 1 - N}{M} < 1 \\ 0 < S < N < 1 \end{cases} \tag{147}$$

Given the solution above in expression (146), we can establish that:

$$\frac{\partial \Delta u_A}{\partial \beta} = M - 2\chi^H N > M - M = 0 \tag{148}$$

$$\frac{\partial \Delta u_B}{\partial \beta} = M - 2\chi^H N > M - M = 0 \tag{149}$$

$$\frac{\partial \Delta u_B}{\partial \chi^H} = 2\left(f_0 - \beta N\right) > 2\left(1-\beta\right) N > 0 \tag{150}$$

We can verify that $\Delta u_A > 0$ when $\chi^H < \frac{M}{2N}$.

We also want:

$$\Delta u_B = -(1-\beta) M + 2\chi^H (f_0 - \beta N) > 0 \tag{151}$$

and

$$\Delta u_C = -M + 2\chi^H (f_0 - \beta S) > 0 \tag{152}$$

Now we impose $\Delta u_C > \Delta u_B > 0$.

$\Delta u_C > \Delta u_B$ gives us

$$\chi^H > \frac{M}{2(N-S)} \tag{153}$$

$\Delta u_B > 0$ and $\beta = 0$ give us

$$\chi^H > \frac{M}{2f_0} \tag{154}$$

Note that $f_0 > N > N - S > 0$, so the under bar of χ^H is:

$$\underline{\chi}^H = \frac{M}{2(N-S)} \tag{155}$$

So finally we have: The level of conflict in period 1 is higher than that in period 2 because at the optimal level the household chooses (L,H) and we have shown in Question 1(a) that $\frac{\partial f}{\partial \theta} < 0$. $\square$

Table A2: Summary of threshold conditions

	initial level of conflict	cost of high cooperation	discount parameter
$u(L,H)-u(L,L)$	$\frac{\partial \Delta u_A}{\partial f_0}=0$	$\frac{\partial \Delta u_A}{\partial \chi^H}<0$	$\frac{\partial \Delta u_A}{\partial \beta}>0$ if $\underline{\chi}^H<\chi^H<\bar{\chi}^H$
$u(L,H)-u(H,L)$	$\frac{\partial \Delta u_B}{\partial f_0}>0$	$\frac{\partial \Delta u_B}{\partial \chi^H}>0$	$\frac{\partial \Delta u_B}{\partial \beta}<0$
$u(L,H)-u(H,H)$	$\frac{\partial \Delta u_C}{\partial f_0}>0$	$\frac{\partial \Delta u_C}{\partial \chi^H}>0$	$\frac{\partial \Delta u_C}{\partial \beta}<0$
Conclusion	$1>f_0>\bar{f}_0$	$\underline{\chi}^H<\chi^H<\bar{\chi}^H$	$0<\beta<\bar{\beta}=1$

Table A3: Summary of threshold conditions

	initial level of conflict	cost of high cooperation	discount parameter
$u(L,H)-u(L,L)$	$\frac{\partial \Delta u_A}{\partial f_0}=0$	$\frac{\partial \Delta u_A}{\partial \chi^H}<0$	$\frac{\partial \Delta u_A}{\partial \beta}$ uncertain
$u(L,H)-u(H,L)$	$\frac{\partial \Delta u_B}{\partial f_0}>0$	$\frac{\partial \Delta u_B}{\partial \chi^H}$ uncertain	$\frac{\partial \Delta u_B}{\partial \beta}$ uncertain
$u(L,H)-u(H,H)$	$\frac{\partial \Delta u_C}{\partial f_0}>0$	$\frac{\partial \Delta u_C}{\partial \chi^H}$ uncertain	$\frac{\partial \Delta u_C}{\partial \beta}<0$
Conclusion	$f_0>\bar{f}_0$	$\chi^H<\bar{\chi}^H$	$\beta<\bar{\beta}$

Table A4: Summary of threshold conditions (no-externality)

	initial level of conflict	cost of high cooperation	discount parameter
$u(L,H)-u(L,L)$	$\frac{\partial \Delta u_A}{\partial f_0}=0$	$\frac{\partial \Delta u_A}{\partial \chi^H}<0$	$\frac{\partial \Delta u_A}{\partial \beta}>0$
$u(L,H)-u(H,L)$	$\frac{\partial \Delta u_B}{\partial f_0}>0$	$\frac{\partial \Delta u_B}{\partial \chi^H}>0$	$\frac{\partial \Delta u_B}{\partial \beta}>0$
$u(L,H)-u(H,H)$	$\frac{\partial \Delta u_C}{\partial f_0}>0$	$\frac{\partial \Delta u_C}{\partial \chi^H}>0$	$\frac{\partial \Delta u_C}{\partial \beta}<0$
Conclusion	$1>f_0>\bar{f}_0$	$\underline{\chi}^H<\chi^H<\bar{\chi}^H$	$0<\beta<\bar{\beta}$

A.2 IV assumptions

We rely on four key assumptions to justify the use of the decentralization reform as an instrumental variable in our analyses:

1. **First-Stage Relevance**: The instrument (decentralization reform) must be strongly correlated with the endogenous explanatory variable (share of decentralized irrigation). This condition is satisfied: as shown in Table 3, column 3, the reform is significantly associated with an increase in decentralized irrigation, confirming the strength of the first-stage relationship.

2. **Monotonicity and Stable Unit Treatment Value Assumption (SUTVA)**: Monotonicity requires that the reform either increases or does not change the level of decentralization across all units, while SUTVA assumes no interference between units. Potential violations—such as non-compliance or spillovers—would bias estimates toward zero. For example, if some areas failed to implement the reform (non-compliance), or if treated areas influenced neighboring untreated districts (positive spillovers), the estimated effects would be conservative rather than overstated.

3. **Ignorability (Exogeneity)**: This assumption requires that the timing of WUA reform implementation is uncorrelated with unobserved determinants of the outcome (e.g., riots). The absence of pre-trends in conflict prior to the reform, as shown in the event-study plot in Figure 1 (left panel), supports this assumption. The flat pre-treatment trajectory suggests that reforms were not systematically timed in response to pre-existing changes in communal violence.

4. **Exclusion Restriction**: The reform should affect the outcome (riots) only through its impact on irrigation decentralization and not through other channels. A plausible concern is that reforms may have been accompanied by increased irrigation subsidies, which could reduce conflict through income effects. However, as documented in Section 6.4, we find no evidence that the reform altered public irrigation expenditures, suggesting that the exclusion restriction holds. Additionally, the staggered rollout of WUA reforms and our review of the legislative acts surrounding them—via the PRS Legislative Research platform—indicate that these reforms were not part of broader reform packages, further supporting the plausibility of the exclusion restriction.

A.3 Heterogeneous treatment effects

To further understand the effects of decentralization reforms, we explore whether their impact is moderated by local social structure. In socially stratified settings, or during periods of acute resource scarcity, reforms may inadvertently heighten tensions if perceived as inequitable or if they disproportionately benefit already privileged groups. It is therefore essential to assess not only the aggregate effects of decentralization, but also how these effects vary across different social contexts.

The caste composition of a region plays a particularly salient role in shaping both the implementation and outcomes of decentralization. In areas with greater caste diversity, reforms could risk reinforcing existing inequalities if marginalized groups lack access to the newly privatized systems. Systematic exclusion of Scheduled Castes (SCs) and Scheduled Tribes (STs) from decentralized governance or irrigation infrastructure could, in such cases, exacerbate tensions rather than mitigate them (see Bros and Couttenier 2015).

To examine this possibility, we interact the decentralization reform indicator with a caste fractionalization index based on the Herfindahl-Hirschman Index (HHI), where higher values reflect greater caste homogeneity and lower values indicate greater diversity. Columns 1–3 of Table A5 present the results of these interactions. In column 1, we find a statistically significant positive interaction between caste fractionalization and the reform at the 10% level, suggesting that the conflict-reducing effects of decentralization are stronger in more caste-diverse areas. This finding runs counter to concerns about exclusion (Bros and Couttenier 2015) and may reflect a reduction in institutional discrimination, whereby marginalized groups gain more equitable access under decentralized governance.

Consistent with this interpretation, column 4 shows that decentralization reforms reduce the irrigation access gap between non-scheduled and scheduled castes. We construct a variable capturing the irrigation premium of non-scheduled groups, defined as the difference in the share of irrigated land owned by non-scheduled versus scheduled castes and tribes, divided by the share for scheduled groups (based on Population Census data; see Table A10 for descriptive statistics). A negative coefficient on the reform indicator suggests that decentralization narrows this gap, disproportionately benefiting scheduled castes and tribes.

Interestingly, we observe the opposite pattern for agricultural productivity. In column 3, we find that the productivity gains from reform—as measured by EVI-based yields—are stronger in more homogeneous villages. This result is consistent with Rao (2017), who documents that SCs and STs tend to achieve lower agricultural yields, potentially due to differences in access to technology, inputs, or agronomic knowledge. Thus, while heterogeneous areas experience smaller productivity gains, they benefit more from conflict reduction, plausibly due to improved equity in access to irrigation.

Finally, we find no significant heterogeneity in the reform's effect on the area of irrigated land (column 2), suggesting that improvements in irrigation coverage are relatively uniform across caste contexts, even if the distributional outcomes and downstream effects on productivity and conflict vary.

Table A5: Decentralization, conflict, and cooperation: Interactions with Caste Status

	(1) Riots	(2) Irrig. Ha (log)	(3) Yields (log)	(4) Non-Sched. Irrig. Premium
Dec. Reform	-177.806***	0.243**	-0.118**	-0.173*
	(66.169)	(0.120)	(0.047)	(0.102)
Reform x HHI (caste)	209.068**	0.112	0.203***	
	(93.810)	(0.138)	(0.048)	
Model	OLS	OLS	OLS	OLS
Unit of analysis	District	Village	Village	District
Unit + Time FE	Yes	Yes	Yes	Yes
Drought control	No	No	No	No
Mean of Dep. Var.	125.445	4.213	-2.600	0.449
SD of Dep. Var.	215.928	1.682	0.854	1.552
R-squared	0.642	0.862	0.737	0.514
Sample	'90-'16	'01/'11	'01/'11	'93/'00/'06/'13
N	12943	964833	964156	2389

Standard errors clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

A.4 IV: Robustness tests

We extend our instrumental variable (IV) regression analysis by incorporating a set of potentially time-varying control variables (see Table A10 for descriptive statistics). These controls include: population size (log), the share of the population residing in rural areas, literacy rate (%), primary school penetration (% of population with primary school education), the agricultural sector's share of the local economy, luminosity (as a proxy for wealth), the share of villages affected by droughts in a given year, the Herfindahl-Hirschman Index (HHI) capturing caste and religious fractionalization (separately), and the share of Scheduled Caste and Tribe members in the local population. All control variables are derived from the Population Census.

Since the timing of the Population Census (PC) and the Minor Irrigation Census (MIC) do not align perfectly, we match each MIC round to the closest available PC year. Specifically, we assign the 1991 PC to the 1993 MIC, the 2001 PC to the 2000 MIC, and the 2011 PC to the 2013 MIC. For the 2006 MIC, we use the average of the 2001 and 2011 PC data to approximate mid-decade values.

As shown in Table A6, the inclusion of these controls does not materially affect our results, which remain robust and statistically significant.

Table A6: Decentralization and conflict: IV with controls

	(1) Riots p.c.	(2) Riots p.c.	(3) Riots p.c.
Share Dec. Irrig.	-1.873	-22.749*	
	(1.500)	(11.659)	
Dec. Reform			-1.127**
			(0.513)
Controls	Yes	Yes	Yes
Model	OLS	IV-2SLS	IV-Reduced
Unit of analysis	District	District	District
District + Time FE	Yes	Yes	Yes
Mean of Dep. Var.	7.522	7.522	7.522
SD of Dep. Var.	10.039	10.039	10.039
R-squared	0.635	-0.075	0.636
Sample	'93/'00/'06/'13	'93/'00/'06/'13	'93/'00/'06/'13
N	1744	1744	1744

'Riots p.c." refers to riots per 100k pop. Standard errors clustered at the district level.
*** p<0.01, ** p<0.05, * p<0.1

A.5 Main results without controlling for drought

Table A7: Decentralization and conflict

	(1) Riots	(2) Riots p.c.	(3) Share Dec. Irrig.	(4) Riots p.c.	(5) Riots p.c.	(6) Riots p.c.
Dec. Reform	-34.898***	-4.188***	0.051***			-1.202**
	(9.495)	(0.638)	(0.010)			(0.498)
Share Dec. Irrig.				-3.559**	-23.429**	
				(1.630)	(10.482)	
Model	OLS	OLS	OLS	OLS	IV-2SLS	IV-Reduced
Unit of analysis	District	District	District	District	District	District
Unit + Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Drought control	No	No	No	No	No	No
Mean of Dep. Var.	125.445	8.058	0.815	7.522	7.522	7.522
SD of Dep. Var.	215.928	11.053	0.251	10.039	10.039	10.039
R-squared	0.526	0.604	0.856	0.617	-0.089	0.617
Sample	'90-'16	'91-'11	'93/'00/'06/'13	'93/'00/'06/'13	'93/'00/'06/'13	'93/'00/'06/'13
N	13561	9964	1803	1803	1803	1803

'Riots p.c." refers to riots per 100k pop. Standard errors clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

Table A8: Decentralization and local cooperation, public goods provision, and yields

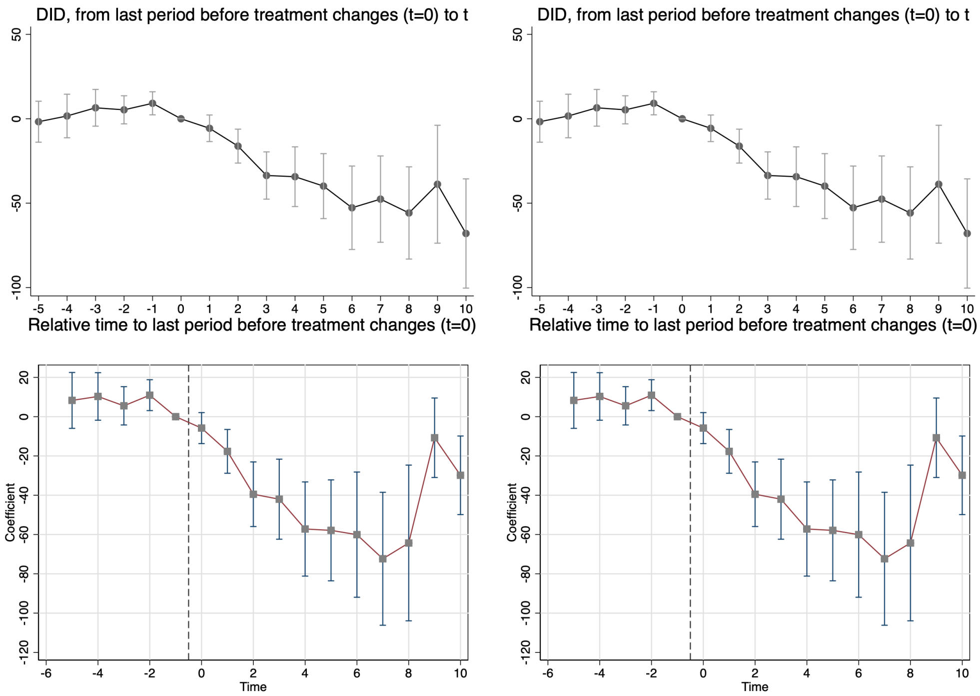
	(1) Irrig. Ha (log)	(2) Yields (log)
Dec. Reform	0.323***	0.082***
	(0.051)	(0.014)
Model	OLS	OLS
Unit of analysis	Village	Village
Unit + Time FE	Yes	Yes
Drought control	No	No
Mean of Dep. Var.	4.213	-2.296
SD of Dep. Var.	1.682	0.505
R-squared	0.862	0.570
Sample	'91/'01/'11	'00-'16
N	965414	8320212

Standard errors clustered at the district level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

A.6 Alternative DiD estimators

In Figure A1 (upper panel), we report our results using the difference-in-differences estimator developed by Chaisemartin and d'Haultfoeuille (2021). The estimator aggregates weighted difference-in-differences across cohorts and periods, delivering event-time specific average treatment effects that are more reliable under treatment effect heterogeneity. In Figure A1 (lower panel), we report results using the LP-DID estimator by Dube et al. (2023). The LP-DID method estimates event-time-specific effects by running a series of separate regressions for each event time (lead or lag). This approach avoids common issues with extrapolation and negative weighting in staggered adoption designs.

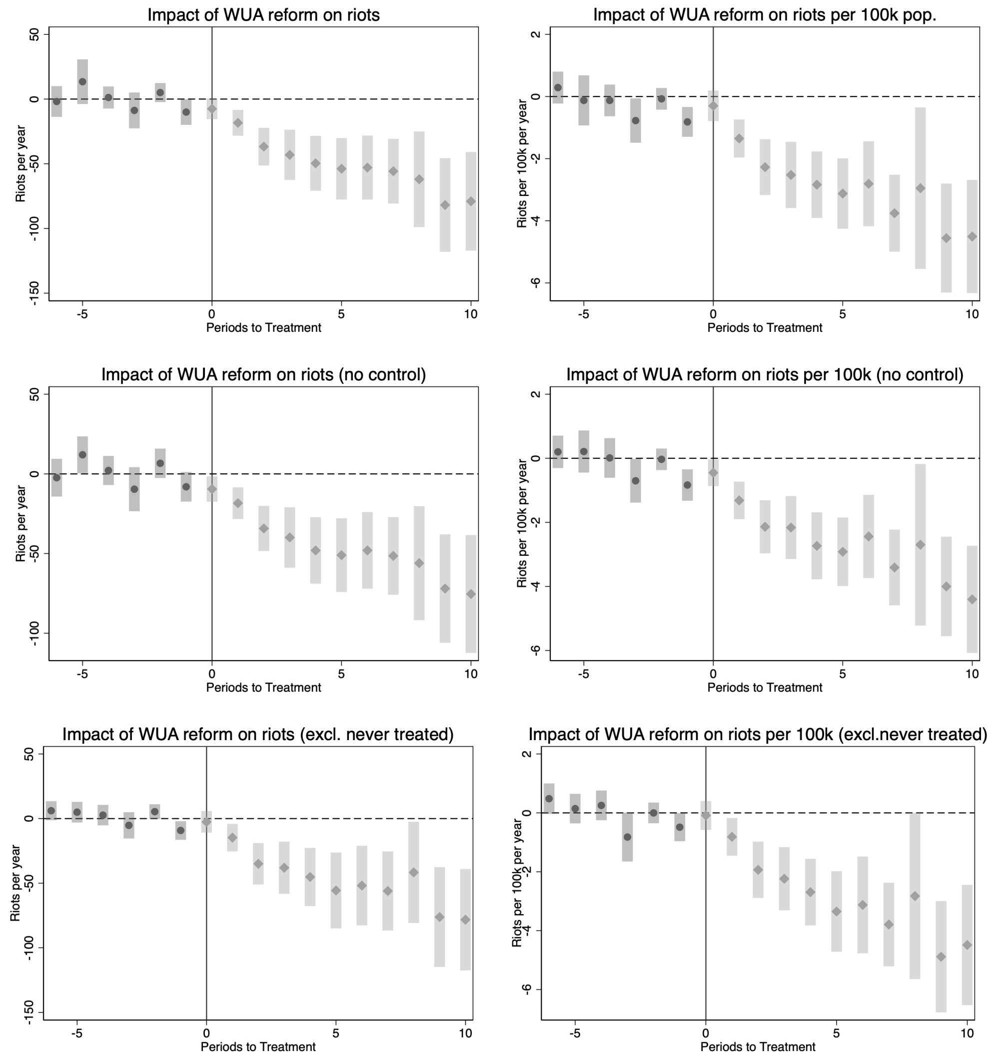
Figure A1: Event study evidence: reforms lower incidence of riots: CHD (upper panel) and LP-DID (lower panel) estimators



Notes: The figure displays event-study estimates with 95% confidence intervals from regressions of annual riot counts on WUA reform implementation years and the share of villages experiencing droughts. The left panel uses as a control group states not yet or never treated by the reform, while the right panel restricts the control group to states not yet treated. The upper panel presents estimates based on the estimator proposed by Chaisemartin and d'Haultfoeuille (2021), while the lower panel uses the estimator developed by Dube et al. (2023).

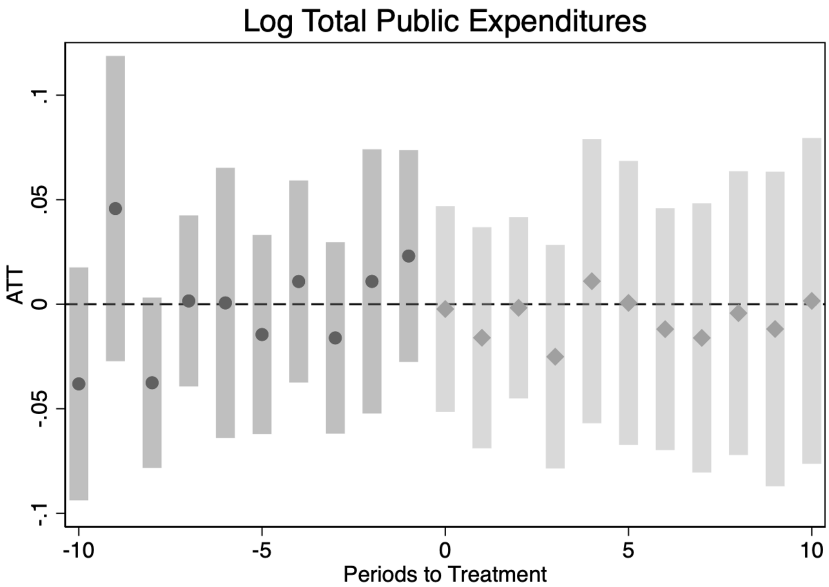
A.7 Additional tables and figures

Figure A2: Event study evidence: reforms lower incidence of riots (different specifications)



Notes: The figure presents event-study estimates following Callaway and Sant'Anna (2021), with 95% confidence intervals, from regressions of annual riot incidence on WUA reform implementation years and the share of villages experiencing droughts (except in the middle panel, where drought is omitted, as noted). The control group consists of states not yet (or never) treated by the reform. The left panel displays estimates using the raw count of riots, while the right panel shows results using riots normalized per 100,000 population. Estimates that include the drought control use the doubly robust DiD estimator based on stabilized inverse probability weighting combined with ordinary least squares (Sant'Anna and Zhao 2020). Estimates without the drought control are based on the outcome regression DiD estimator using ordinary least squares.

Figure A3: Decentralization reform and total public expenditures



Notes: The plot shows event-time coefficients and 95% confidence intervals constructed using the estimator by Callaway and Sant'Anna (2021).

Table A9 examines the determinants of effective decentralization uptake at the district level by regressing the share of decentralized irrigation infrastructure on a comprehensive set of covariates. These include measures of economic development and wealth, economic structure, education, and social fractionalization. The specification uses the same control variables introduced in Section A.4, with descriptive statistics provided in Table A10. The results indicate that population size is the only statistically significant predictor of decentralization uptake: districts with smaller populations are more likely to implement decentralized irrigation. To account for this pattern and ensure comparability across districts, we normalize our key outcome variables by population size in all relevant analyses.

Table A9: Predictors of Effective Decentralization

	(1) Share Dec. Irrig.
Share Literate	0.138
	(0.149)
Share Primary Educ.	3.119
	(47.331)
Av. Nighttime Luminosity	-0.003
	(0.003)
Share Scheduled Caste/Tribe	-0.353
	(0.445)
Share Drought Villages	0.006
	(0.007)
Population (log)	-0.135*
	(0.073)
HHI (castes)	-0.073
	(0.388)
HHI (religious groups)	0.187
	(0.185)
Share Agriculture	-0.043
	(0.207)
Power Access	-0.010*
	(0.006)
Model	OLS
Unit of analysis	District
Unit + Time FE	Yes
Control	N/A
Mean of Dep. Var.	0.809
SD of Dep. Var.	0.253
R-squared	0.829
Sample	'93/'00/'06/'13
N	1470

Standard errors clustered at the district level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A10: Additional summary statistics

Variable	**Mean**	**Std. Dev.**	**N**	**Data source**
Non-Sched. Irrig. Premium	0.449	1.552	2463	Pop Census '91/'01/'11
Share Literate	0.535	0.142	2245	Pop Census '91/'01/'11
Share Primary Educ.	0.001	0.001	2245	Pop Census '91/'01/'11
Av. Luminosity	4.27	5.125	2267	Pop Census '91/'01/'11
Share Sched. Caste	0.322	0.226	2245	Pop Census '91/'01/'11
HHI (relig.)	0.74	0.159	2001	Pop Census '91/'01/'11
Share Agric.	0.942	0.038	2192	Pop Census '91/'01/'11
Share Power Access	0.003	0.075	1842	Pop Census '91/'01/'11