SUPPLEMENTARY MATERIAL

DECENTRALIZATION WITHOUT DEMOCRACY

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Appendix A Theoretical Framework

This model reflects how public services provision is carried out under decentralization and centralization within a framework of autocracy, i.e. where electoral calculations do not drive resource allocation decisions. Under centralization, investment choices are made by the central government. Under decentralization, they are made by local governments.

Government can provide public goods in two sectors, $n \in \{1, 2\}$. Public spending in sector 1 is solely geared toward increasing citizens' production, while spending in sector 2 generates social services, which increase human capital, like healthcare. Health, in addition to being directly welfare-enhancing, in turn also affects production in the long-run—for example, by increasing labor productivity. In any given sector, government must select which of many alternative projects to carry out. Projects may be of low quality and thus produce no or few services, or they can be of good quality and thus result in high levels of service delivery. There is a set budget, which is normalized to 1 and can be distributed across sectors and, within sectors, across projects.

A government $g \in \{A, B\}$ (central government and local government, respectively) selects the budget share $0 \leq \phi_g \leq 1$ to spend on productive services, spending the rest on social services. There exists asymmetric information between central and local government on a given local jurisdiction's conditions: The local government of a jurisdiction has better information than the central government, making it more efficient in project selection and thus service provision. Specifically, γ_g constitutes an efficiency parameter in delivery of services, with $0 \leq \gamma_A < \gamma_B \leq 1$. Productive services provided thus amount to $S_{1g} = \phi_g \gamma_g$ and social services to $S_{2g} = (1 - \phi_g)\gamma_g$.

Consider the government's problem. In an autocratic setting, citizens' preferences do not directly influence government behavior (irrespective of whether there is centralized or decentralized service delivery). Instead, government's utility depends on rents extracted at the rate of $\delta \in (0, 1)$ from individuals' production, or output, O.[25] Citizens' production is a function of their utilization of productive services provided by government, and of being in good health, H, which increases labor productivity: $O(S_{1g}, H(S_{2g}))$. For simplicity, we let $O(S_{1g}, H) = b_1 S_{1g} + H^{\alpha}$ and $H(S_{2g}) = b_2 S_{2g}$, where $b_n > 0$ for $n \in 1, 2$ represent factors of conversion of public services into private production and improved health, respectively. Citizens' production as a function of public services becomes:

$$O(S_{1g}, S_{1g}) = b_1 S_{1g} + (b_2 S_{2g})^{\alpha} \tag{S1}$$

where $\alpha \in (0, 1)$ such that provision of productive services (in sector 1) contributes more to output than does provision of social services (in sector 2). The central government keeps all rents under centralization, whereas the central and local governments share the rents

[25] A dictator's public goods provision has been formally modelled variously. For example, Fearon (2011) represents the rents of an autocratic ruler as a choice variable, which is a share of the budget, with the remainder allocated to public goods; citizens' ability to protest based on noisy signals they receive of government's performance in producing public goods prevents all of the budget going to rents. Egorov, Guriev, and Sonin (2009) similarly include a noisy signal going to citizens, and additionally the autocrat's rents are in part derived as an exogenous share of citizens' production, which in turn depends on the quality of public goods provided. The latter model element is similar to ours.

under decentralization, with the share $a \in (0,1)$ of the rents going to local government. Government's utility is then:

$$U_g = R_g\{b_1\phi\gamma_g + [b_2(1-\phi)\gamma_g]^\alpha\} \tag{S2}$$

where $R_g = \delta$ for $g = A$ (central government) and $R_g = \delta a$ for $g = B$ (local government). The resulting first-order condition for a government of type g is:

$$R_g b_1 \gamma_g = \frac{R_g \alpha (b_2\gamma_g)^\alpha}{(1-\phi_g^*)^{1-\alpha}} \tag{S3}$$

This optimization problem results in the same rule for the budget share spent on productive services ϕ_g^* for both central and local governments:

$$\phi_g^* = 1 - \frac{1}{\gamma_g}\left(\frac{\alpha(b_2)^\alpha}{b_1}\right)^{\frac{1}{1-\alpha}} \tag{S4}$$

Inspection of this optimization rule reveals that the extent to which the government—central or local—invests in the productive sector instead of the social sector is decreasing in the degree to which provision of social services tends to raise output (that is, as α increases).

The utility of citizens on a continuum, represented by i, depends both on i's production O, and on i's health H. We bring together core elements from two large bodies of literature in this regard: health as a form of human capital increases output (Smith, 1999), and health is also directly an element in the citizen's utility function for any given level of output or wealth (Viscusi and Evans, 1990; Levy and Nir, 2012).[26] Utility is then formulated as $U_i(O(H), H)$. We use a Cobb-Douglas function for utility with strict concavity in the elements and with equal elasticities for O and H, after accounting for the reduction in output by the amount government extracts in the form of rents, i.e. $U_i = ((1-\delta)O)^\beta H^\beta$. The citizen's utility is then expressed as:

$$U_i = \{[b_1\phi\gamma_g + (b_2(1-\phi)\gamma_g)^\alpha](1-\delta)\}^\beta (b_2(1-\phi)\gamma_g)^\beta \tag{S5}$$

when ruled by government-type g (decentralized or centralized). The citizen's optimal budget share that it would like government to spend on productive services is:

$$\begin{aligned}\Big[b_1(1-2\phi_i^*) - (1+\alpha)\gamma_g^{\alpha-1}(b_2(1-\phi_i^*))^\alpha\Big]\cdot \\ \cdot\Big\{\beta(b_2(1-\delta))^\beta(1-\phi_i^*)^{\beta-1}\gamma_g^{2\beta}[b_1\phi_i^* + \gamma_g^{\alpha-1}(b_2(1-\phi_i^*))^\alpha]^{\beta-1}\Big\} = 0\end{aligned} \tag{S6}$$

The model yields three main predictions regarding the impacts of decentralization in an autocratic context.

[26] This notion has been motivated in various ways in the literature, including the decline in utility due to pain and suffering (and in the extreme case, death) that ill-health causes, or the decline in utility due to the fact that expenses to reduce sickness crowd out other forms of consumption.

*P*1. *The government—whether central or local—will allocate a larger proportion of the budget to productive services than would the citizen.*

To see this, recall that the characteristic of any standard maximization problem applies also to that of the citizen's: the first derivative of the utility function with respect to the choice variable (budget share allocated to productive services) is zero at the citizen's optimal budget share, it is positive at a lower-than-optimal budget share, and it is negative at a higher-than-optimal budget share: $\frac{\partial U_i}{\partial \phi} = 0$ at $\phi = \phi_i^*$, $\frac{\partial U_i}{\partial \phi} > 0 \,\forall\, \phi < \phi_i^*$, and $\frac{\partial U_i}{\partial \phi} < 0 \,\forall\, \phi > \phi_i^*$. Given that in Eq. (S6), the second left-hand side multiplicative expression (in curly braces) is positive for any value of the parameters, then if $\phi_g^* > \phi_i^*$, inserting the government's optimal budget share into the first multiplicative term in Eq. (S6) would result in a negative expression, or:

$$b_1(1 - 2\phi_g^*) - (1 + \alpha)\gamma_g^{\alpha-1}(b_2(1 - \phi_g^*))^\alpha < 0 \tag{S7}$$

To show that this is the case, we insert Eq. (S4) into (S7), which becomes:

$$-b_1 + \frac{2b_1}{\gamma_g}\left(\frac{\alpha(b_2)^\alpha}{b_1}\right)^{\frac{1}{1-\alpha}} - \frac{1+\alpha}{\gamma_g^{1-\alpha}}\left[\frac{b_2}{\gamma_g}\left(\frac{\alpha(b_2)^\alpha}{b_1}\right)^{\frac{1}{1-\alpha}}\right]^\alpha < 0 \tag{S8}$$

Rearranging the left-hand side into two additive terms, we get:

$$-\frac{1}{\gamma_g}\left(\frac{\alpha b_2}{b_1}\right)^{\frac{\alpha}{1-\alpha}}(1-\alpha) - b_1 < 0 \tag{S9}$$

Since each of the two summands on the left-hand side are negative $\forall\ \gamma$, α, b_1 and b_2, the inequality in Eq. (S9) holds. Thus, $\phi_g^* > \phi_i^*\ \forall\ g \in \{A, B\}$, proving prediction *P1*.

*P*2. *Under decentralization, the local government will invest a larger proportion of its budget in productive services and a smaller proportion in social services than would the central government under centralization.*

Since ϕ_g^* is increasing in γ_g in Eq. (S4), and given that $\gamma_B > \gamma_A$, this implies that $\phi_B^* > \phi_A^*$, and that therefore *P*2 holds.

*P*3. *The level of productive services delivery under decentralization is higher than under centralization. However, under both regimes, the level of social services is the same.*

Since $\phi_B^* > \phi_A^*$ and $\gamma_B > \gamma_A$, it follows that $S_{1B}^* > S_{1A}^*$. The equality in social service provision is shown by initially assuming this holds, i.e. $S_{2A}^* = S_{2B}^*$. Setting equal the social services provision by central and local government gives $(1 - \phi_A^*)\gamma_A = (1 - \phi_B^*)\gamma_B$. Substituting in Eq. (S4) for the optimal choice of each government yields:

$$\left\{1 - \left[1 - \frac{1}{\gamma_A}\left(\frac{\alpha(b_2)^\alpha}{b_1}\right)^{\frac{1}{1-\alpha}}\right]\right\}\gamma_A = \left\{1 - \left[1 - \frac{1}{\gamma_B}\left(\frac{\alpha(b_2)^\alpha}{b_1}\right)^{\frac{1}{1-\alpha}}\right]\right\}\gamma_B \tag{S10}$$

This holds for any value of α, b_1, and b_2. Prediction *P*3 is thus validated.

Appendix B Systematic Literature Review

We conducted a systematic review of empirical studies that examine the impact of decentralization on public service provision, published in some of the top political science, economics, and interdisciplinary journals in the last 20 years. Search terms included a combination of terms related to, and used in the context of, our independent variable of interest ("decentralization," "devolution," "fragmentation," and/or "recentralization") alongside terms related to our outcome variable of interest ("public services," "public investment," "public expenditures" and/or "government expenditures"). We did not include studies that involved decentralization of the delivery of a single service to lower tiers of government, to maintain a focus on a broader restructuring of government.

Targeted political science journals included the *American Journal of Political Science, American Political Science Review, British Journal of Political Science, Comparative Political Studies, Electoral Studies, Political Behavior, Quarterly Journal of Political Science, Journal of Politics*, and *World Politics*. Targeted economics and interdisciplinary journals included *American Economic Journal (AEJ): Economic Policy, American Economic Review, Economic Development and Cultural Change, Journal of Development Economics, Journal of Political Economy, Journal of Public Economics, Quarterly Journal of Economics, Proceedings of the National Academy of Sciences, Review of Economics and Statistics, Review of Economic Studies, Science, Social Science Quarterly, Economic Journal*, and *World Development*.

For each study, we documented the country or regional context, Polity IV score of the country/region (taking an average in the case of multi-country studies), GDP per capita of the country/region (taking an average in the case of multi-country studies), primary empirical method used (e.g., case study, observational study, quasi-experiment, or experiment), key independent variable(s), dependent variable(s) employed, service type (social services, productive services, both, or total spending), and the effect of decentralization on public service provision (positive, meaning better public goods provision and/or higher government expenditures/investments; negative; mixed; or null). The Polity IV score and GDP per capita (in constant, 2010 U.S. dollars) are taken from the closest available year that predates the first year of the study, and are based on Polity IV (2018) and World Bank (2019). For studies involving multiple countries, we took the averages (unweighted) of all countries with available data. The effect of decentralization is determined based on the overall tone in the paper—with particular attention to its abstract. We identified a total of 20 studies. It is very possible that we have omitted important studies, possibly because their abstracts did not use the specific search terms utilized above, or because of researcher oversight. However, we consider these to be a central set of studies capturing most of what was published in the last 20 years in this subset of journals on this research question.

Several patterns emerge. First, the studies consider countries with a vast range of Polity IV scores. Exactly half of studies have a negative Polity IV score and half have a positive score; five studies consider autocracies, six consider democracies, and the remaining nine consider hybrid regimes ("anocracies," with a Polity IV score between -5 and 5). Second, the methods employed are generally quasi-experimental (in 13 of the 20 studies), as in this study, though there are three observational studies and four case studies. However, only one of these quasi-experimental studies employs a regression discontinuity design; the

rest employ either difference-in-differences, instrumental variables, or some variant of a fixed effects model. Third, the majority of studies focus solely on social services. Only 30 percent of studies consider either productive services or both social and productive services. Fourth, the evidence is highly mixed. While seven studies identify positive impacts of decentralization, three identify negative impacts, eight identify mixed impacts, and two identify largely null effects. Finally, focusing on those studies that consider social services (either solely or in combination with productive services), we observe distinct impacts of decentralization depending on the Polity IV score. Among seven social services studies with negative Polity IV scores, only one identified a positive impact of decentralization. In contrast, among the nine social services studies with positive Polity IV scores, the majority identified a positive impact of decentralization. Thus, improvements in social services due to decentralization appear to be most heavily concentrated in relatively more democratic study contexts. Further, the paucity of studies considering productive services suggests the difficulty of drawing firm conclusions from existing literature on how decentralization impacts their delivery under different regime types (democracy, anocracy, or autocracy).

Our study contributes to the literature on the effects of decentralization in autocratic contexts and hybrid regimes. Studies from our systematic review on regimes with negative Polity IV scores (10 total) have largely focused on China (Li, Lu, and Wang, 2016; Su, Li, and Tao, 2019; Wang, Zheng, and Zhao, 2011; Wong et al., 2013), but also consider Vietnam (Malesky, Nguyen, and Tran, 2014), Uganda (Francis and James, 2003), Bolivia (Faguet, 2013), Sub-Saharan Africa (Grossman, Pierskalla, and Dean, 2017), and larger collections of countries (Enikolopov and Zhuravskaya, 2007; Ponce-Rodriguez et al., 2018). Only four of these 10 consider productive service outcomes (either solely or along with social service outcomes), and only two of these further use a quasi-experimental empirical strategy like we do; the other two rely on case studies, in which attributing causality is arguably more challenging.

Table S1: Systematic review of literature on the effect of decentralization on service delivery

Author (Year)	Context	Polity IV	Real GDP	Method	Key independent variable(s)	Dependent variable(s)	Service type	Effect
Barankay and Lockwood (2007)	Switzerland	10 (1981)	55,466.2 (1981)	Quasi-experimental (FE)	Share of education expenditures from local governments in a canton	Share of 19 year old population obtaining university entry qualification	Social services	Positive
Dowding and Mergoupis (2003)	United Kingdom	10 (1997)	32,476.5 (1997)	Observational (ordered probit)	1. Metropolitan level analysis: # councils in metro area 2. Council level analysis: tax base, revenue support grant per capita	5-ladder categorical variable for the degree of satisfaction with local public services	Both	Mixed
Enikolopov and Zhuravskaya (2007)	75 countries	-2.1 (1974)	3243.3 (1974)	Quasi-experimental (IV)	Share of subnational revenues in total government revenues	Average measure of public goods in 1975–2000	Social service	Mixed
Faguet (2013)	Bolivia	-4 (1979)	1,708.2 (1979)	Case study (before and after)	Decentralization	1. Investment in public services 2. Development outcomes such as infant/ maternal mortality rate, improved water/ sanitation/ roads	Both	Mixed
Faguet and Sanchez (2008)	Bolivia and Colombia	8.5 (1986)	2,682.6 (1986)	Quasi-experimental (IV)	Own resources (revenue raised from local taxes and charges) as a share of total expenditure	Year-on-year increase in student enrollment in public schools	Social services	Positive
Francis and James (2003)	Uganda	-4 (1996)	334.9 (1996)	Case study	Decentralization	1. Capacity of the primary school system 2. Level of resources allocated to productive sectors, especially agriculture	Both	Mixed
Goodman (2018)	United States	8 (1971)	23,670.3 (1971)	Quasi-experimental (DiD)	6 dummy variables for local autonomy: city and county level tax and expenditure limits, debt limit, and home rule	Special district share of local public spending	Social services	Null
Grossman, Pierskalla, and Dean (2017)	Sub-Saharan Africa	-3.7 (1960)	1,091.5 (1960)	Quasi-experimental (FE and IV)	The number of top-tier regional governments per 1 million citizens in a country	Summary index for the quality of service provision, constructed from outcomes such as life expectancy at birth and primary school completion rate	Social services	Positive
Hatfield and Kosec (2013)	United States	8 (1968)	23,055.4 (1968)	Quasi-experimental (IV)	Logged number of county governments	Expenditures per capita	Total spending	Positive
Heller, Harilal, and Chaudhuri (2007)	India	9 (2001)	851.6 (2001)	Case study	Decentralization from state government to village council	Fraction of respondents reporting improvements in public services including primary health care, child care and child development, and primary education	Social services	Positive
Lindaman and Thurmaier (2002)	104 countries	1.2 (1989)	11395.3 (1989)	Observational (OLS)	Three measures of fiscal decentralization, such as share of subnational expenditures in total government expenditures	Human development index	Social service	Positive
Linder (2009)	Mozambique	5 (2004)	327.8 (2004)	Case study	Decentralization	Service delivery delay days	Both	Positive
Li, Lu, and Wang (2016)	China	-7 (1994)	1,116 (1994)	Quasi-experimental (DiD)	Dummy – country having adopted the decentralization reform	1. Logged total public investment 2. Logged pro-growth investment	Total spending	Negative
Malesky, Nguyen, and Tran (2014)	Vietnam	-7 (2005)	1,018.1 (2005)	Quasi-experimental (DiD)	Recentralization (dummy – commune having District People's Councils abolished)	1. Dummies – access to various public services 2. Indices of transportation, agriculture, healthcare, education, comms., & business development services	Both	Negative
Ponce-Rodriguez et al. (2018)	135 countries	-1.8 (1975)	6,215 (1975)	Observational (GMM) and quasi-experimental (FE)	1. Dummy – democratic decentralization, party centralization 2. Dummy – democratic decentralization, party decentralization	Education and health outcomes (e.g. primary school enrollment and infant mortality rate)	Social services	Mixed
Sanogo (2019)	Côte d'Ivoire	4 (2000)	1,355.3 (2000)	Quasi-experimental (IV)	Logged ratio of own revenues to total revenues of a département	An adjusted multidimensional poverty index for access to public services	Social services	Mixed
Su, Li, and Tao (2019)	China	-7 (1993)	998.4 (1993)	Quasi-experimental (fuzzy regression discontinuity)	Dummy – county being designated as a Nationally Designated Poverty county in 1994 and thus receiving earmarked transfers with clear spending mandates	1. Local government expenditures per capita 2. Social expenditure, education expenditure, and public sector employment	Total spending	Null
Wang, Zheng, and Zhao (2011)	China	-7 (1998)	1,538.7 (1998)	Quasi-experimental (DiD)	Dummy – county having launched a fiscal decentralization reform	Share of public spending devoted to education in county	Social services	Negative
Wong et al. (2013)	China	-7 (2002)	2061.2 (2002)	Quasi-experimental (FE)	1. Share of county's contribution to village road project 2. Dummy – township govt. manages road construction	1. Road quality score 2. Per kilometer cost of each road	Productive services	Mixed
Zhuravskaya (2000)	Russia	5 (1992)	9047.7 (1991)	Quasi-experimental (FE)	A dummy for shared and own revenues shifting in same direction	1. Infant mortality 2. Unavailability of schools	Social service	Mixed

Notes: Polity IV score and GDP per capita are taken from the closest year that pre-dates the first year of the data set, or else the earliest year that the data are available. For studies involving multiple countries, the Polity IV score and GDP per capita are both calculated by averaging across all countries with available data in the year pre-dating the study. Real GDP per capita is expressed in 2010 USD. DiD refers to a difference-in-differences methodology, and FE refers to use of fixed effects (geographic and/or temporal).

Appendix C Village- and Region-level Statistics

Table S2: Comparison between villages in decentralized and nondecentralized areas

Description		Mean		t-statistic
		Decentra-lized	Non-decentralized	
Interaction between local leaders				
Extension agent spoke personally with village traditional leader within the last month		0.88	0.30	-3.717***
Village chair met with extension agent within the last month		0.94	0.58	-2.609**
Extension agent spoke personally with zonal agriculture staff within the last month		0.29	0.00	-1.964*
Village chair met with village cabinet member within the last month		0.94	0.67	-2.075**
Number of contacts village council member had with village cabinet member in the last 12 months		8.61	0.00	-1.993*
Presence of local groups and associations				
This group/ association exists in the village:	Community social insurance group	0.89	0.17	-5.525***
	Microfinance institution	0.44	0.00	-2.993***
	Youth association	0.88	0.17	-5.325***
	Women's association	0.82	0.50	-1.906*
Share of adults in village that belong to a cooperative		29.72	1.25	-2.875***
Frequency of local meetings				
No. of times in past year that a meeting was called by:	Traditional community association	7.22	0.00	-2.582**
	Village council	7.17	2.33	-2.902***
	Extension agent	6.72	2.00	-1.757*
	District government	4.33	1.75	-1.862*

Notes: Mean-comparison of village-level variables between decentralized and nondecentralized areas. Number of observations (villages) varies between 26 and 30. Statistical significance level of the mean differences is indicated with * p<0.10, **p<0.05, and *** p<0.01.
Source: IFPRI–EEPRI (2008–2009).

Table S3: Per capita local government expenditures (in birr) in decentralized and nondecentralized regions during the study period

Region	Agriculture and rural development	Water supply	Both sectors	Total
Decentralized				
Amhara	20.8	2.9	23.6	193.0
Oromia	36.8	2.3	39.2	171.8
SNNP	20.3	2.0	22.3	154.1
Tigray	22.5	4.3	26.8	242.3
Weighted average	27.6	2.5	30.1	178.1
Not decentralized				
Afar	28.0	6.4	34.5	195.0
Beneshangul-Gumuz	24.2	2.5	26.6	213.4
Gambela	46.1	8.5	54.6	447.3
Weighted average	29.1	5.4	34.5	232.3
Ratio of decentralized to nondecentralized	1.0	0.5	0.9	0.8

Notes: Values for 2008, in birr. Average per capita values for the two groups of regions are population-weighted, using regional population sizes of the 2007 census, linearly extrapolated to 2008.
Source: Authors' calculations, based on data from the Ethiopian Ministry of Finance and Economic Development.

Appendix D Summary Statistics

Table S4: Summary statistics, main sample for analysis (2008–09)

Variable	Mean	S.D.	N
Panel A: Household-level outcomes			
Uses modern inputs (at least one of four)	0.31	0.46	837
Number of modern inputs used	0.41	0.67	837
Uses fertilizer	0.15	0.36	837
Uses insecticide	0.13	0.33	837
Uses herbicide	0.05	0.21	837
Uses improved seed	0.08	0.28	837
Uses improved drinking water source during the wet season	0.07	0.25	838
Uses improved drinking water source during the dry season	0.05	0.21	838
Time to get to water (min.) during the wet season	21.52	28.98	739
Time to get to water (min.) during the dry season	26.99	37.56	743
Panel B: Independent variables in household-level analysis			
Decentralized	0.50	0.50	838
Male head	0.80	0.40	838
Literate head	0.42	0.49	838
Secondary-educated head	0.11	0.31	838
Head's age	42.72	14.81	838
Household size	6.09	2.51	838
Landowner	0.81	0.39	838
Homeowner	0.97	0.18	838
Multi-room house	0.45	0.50	838
Large-livestock owner	0.61	0.49	838
Head's ethnicity's share of population	0.86	0.26	838
Panel C: Individual-level outcomes			
Visited a demonstration plot, home, or research station	0.03	0.18	1436
Learned a new farming practice from district agricultural extension agent	0.03	0.17	1440
Attended meeting to discuss agricultural issues	0.20	0.40	1435
Attended district government-organized meeting to discuss agri. issues	0.15	0.36	1435
Attended village government-organized meeting to discuss agri. issues	0.06	0.25	1435
Meeting held in individual's village to discuss agricultural issues	0.93	0.26	1435
Satisfied with water quality during the wet season	0.51	0.50	827
Satisfied with water quality during the dry season	0.48	0.50	827
Very satisfied with government-organized meetings to discuss agri. issues	0.79	0.41	231
Very satisfied with government-provided agri. inputs	0.53	0.50	277
Panel D: Independent variables in individual-level analysis			
Decentralized	0.53	0.50	1440
Male	0.46	0.50	1440
Literate	0.31	0.46	1440
Secondary education	0.07	0.26	1440
Age	39.24	14.04	1440
Household size	6.26	2.48	1440
Landowner	0.83	0.37	1440
Homeowner	0.97	0.18	1440
Multi-room house	0.47	0.50	1440
Large-livestock owner	0.62	0.49	1440
Respondent's ethnicity's share of population	0.85	0.26	1440

Notes: Sample sizes reflect use of a 75km bandwidth.
Sources: IFPRI–EEPRI (2008–2009).

Appendix E Validation of econometric model

In this section we describe in more detail the three analyses we use to validate our econometric model. First, in Appendix Table S5, we present the regression results depicted visually in Figure 4 and discussed in the sub-section on 'Balance and Validation of Econometric Model.' These broadly show that prior to decentralization, we see smooth changes in the characteristics of individuals and households at regional boundaries separating later decentralized and nondecentralized regions. In addition to generally finding balance as described in that sub-section, the point estimates themselves are also generally modest in size. For example, even if the coefficient on decentralization had been statistically significant (it is not), decentralization would only increase the head's age by about 1.8 years, and household size by 0.37 members. It is also important to highlight that the sample sizes used in our balance tests are significantly larger than those in our main analysis—for most outcomes, over 3,300 observations, compared to at most 1,440 observations in the main analyses. Thus, despite massively increasing our ability to detect statistically significant effects, we find very few.

For the second validation analysis, we examine whether or not there are abrupt changes in key outcomes at region boundaries between nondecentralized and later decentralized regions in the period *preceding* decentralization (1999–2000). We used two nationally-representative household surveys pre-dating decentralization: the 1999–2000 Agricultural Sample Survey (CSA, 2000) and the 2000 Demographic and Health Survey (DHS, 2000). These surveys do not contain information on all 20 of our outcomes. However, they contain several of the same or similar variables. The Agricultural Sample Survey indicates whether the household used three modern agricultural inputs examined in Table 4: fertilizer, pesticide, and improved seed (while our main analysis separates pesticide into insecticide and herbicide, this survey lumps them together). The DHS includes information on whether the household has a piped water source, an improved water source, and the amount of time it takes to reach that main source—outcomes similar to those in Table 6. As both surveys were carried out in all regions of Ethiopia, we can consider a larger number of region borders that separate nondecentralized and later decentralized regions than are in our main dataset—though, for comparability, we omit border segments that include regions not in our main analysis (i.e. Somali or Harari). We can also examine the entire length of borders rather than a small subset as in the main analysis. By increasing our sample size, we significantly increase our power and thus our ability to detect any size effect. Again for comparability, we utilize the bandwidth from our main analyses (i.e. observations within 75km of the border).

Using these outcomes and estimating Eq. (1), Appendix Table S6 presents the impacts of our "placebo" decentralization dummy on pre-decentralization usage of modern agricultural inputs. Columns (1) and (2) have as outcomes an indicator for using modern inputs (either fertilizer, pesticide, or improved seed) and the number of modern inputs used (ranging from 0–3), respectively. Columns, (3)–(5) are dummies for use of each of the three, respectively. We see that farmers on either side of, but in close proximity to, the subsequent policy-change border have statistically insignificant differences in whether they use modern agricultural inputs and in the number of modern inputs used. When we consider the individual inputs themselves, one exception is the dummy for fertilizer use. This significant result should also be interpreted in light of our now much higher power. Appendix Table S7 presents the impacts of our placebo decentralization dummy on pre-decentralization access to piped and

improved water sources and the time required to get to the main water source. Once again, we see that farmers on either side of a border that will later be a policy change boundary are substantially similar. There are no discernible differences in access to either piped water or improved water. We find some indication that subsequently decentralized areas are more proximate to water sources—which would if anything bias us toward identifying improvements in water due to decentralization (something we do not find).

Our third validation analysis uses our main dataset (from 2008–09), but considers a boundary separating two regions that were both decentralized. This "placebo" policy change boundary, separating the Amhara and Tigray regions, is shown in Figure 2d. If one were concerned that there is an important and discrete policy change at *any* region boundary—and that this is driving our results—then we should see differences in service delivery outcomes on either side of this "placebo" policy change boundary. Accordingly, we randomly assign one of these two decentralized regions (Tigray) to be "nondecentralized" (by symmetry, if we had chosen Amhara, significance would be the same and the coefficients on decentralization would simply be multiplied by -1), and observe whether this "placebo decentralization dummy" has a statistically significant impact on access to services in Appendix Table S8. We consider all of the outcomes from our main regression specifications; only one, whether the district holds village meetings on agriculture-related issues, is missing due to no variation in this particular subset of the data, for which the variable has a high mean. The placebo decentralization dummy is statistically significant for only 2 of 13 outcomes related to productive services (compared to being statistically significant for 11 of the 13 in our main analyses): improved seed (significant at the 0.10 level) and being very satisfied with government-organized agricultural meetings (significant at the 0.05 level). This suggests that our main results are due to decentralization itself and not other changes that occur at regional borders.

Table S5: Balance on household characteristics for policy change borders in 2000

		Coeff. on decentralization	S.E. on decentralization	Observations	R^2
(1)	Male head	0.0527	(0.033)	3,373	0.792
(2)	Literate head	0.1513**	(0.057)	3,364	0.373
(3)	Secondary-educated head	0.0257	(0.023)	3,367	0.110
(4)	Head's age	1.7933	(1.462)	3,373	0.900
(5)	Household size	0.3692	(0.278)	3,373	0.812
(6)	Landowner	0.1753*	(0.092)	3,372	0.863
(7)	Homeowner	-0.0495	(0.054)	3,372	0.933
(8)	Multi-room house	0.0764	(0.063)	3,373	0.329
(9)	Large-livestock owner	0.0639	(0.071)	3,372	0.693
(10)	Weight-for-height Z-score (age 0-5)	0.0783	(0.136)	1,757	0.310
(11)	Head's ethnicity's share of population	-0.0351	(0.091)	2,708	0.941

Notes: We estimate Eq. (1) using the sample of all rural households within 75km of the border with a region with opposite decentralization status, matching the analyses of Tables 2–6. We exclude only border segments that contain a region not used in these main analyses (specifically, any borders including Somali or Harari), for comparability. Because our outcomes are household characteristics, we do not control for these in any regressions. Clustered standard errors (at the village level) in parentheses; statistical significance of coefficient estimates at 0.01***, 0.05**, and 0.1* levels.
Source: DHS (2000).

Table S6: Pre-decentralization placebo analysis: Use of modern agricultural inputs in 2000

	Uses modern inputs (1)	Number of modern inputs used (2)	Uses fertilizer (3)	Uses pesticide (4)	Uses improved seed (5)
Decentralized in subsequent year	0.0704	0.1758	0.1120	0.0417**	0.0221
	(0.057)	(0.108)	(0.066)	(0.019)	(0.042)
Mean of outcome	0.242	0.330	0.180	0.049	0.102
N	9,361	9,361	9,361	9,361	9,361
R^2	0.390	0.354	0.378	0.146	0.211

Notes: Control variables include all of those from Eq. (1) that are available in the data source; data on ethnicity, as well as data on two socio-economic status variables (a dummy for house ownership and a dummy for having a multi-room house) were not available; we capture the latter by including a control for agricultural land area (square meters). We employ a bandwidth of 75km, matching the analyses of Tables 2–6. Clustered standard errors (at the village level) in parentheses; statistical significance of coefficient estimates at 0.01***, 0.05**, and 0.1* levels.
Source: CSA (2000).

Table S7: Pre-decentralization placebo analysis: Access to drinking water in 2000

	Piped water source (1)	Improved water source (2)	Time to get to water (min.) (3)
Decentralized in subsequent year	-0.0058	-0.0296	-39.2872**
	(0.027)	(0.107)	(16.682)
Mean of outcome	0.04	0.19	49.22
N	2,694	2,694	2,691
R^2	0.267	0.413	0.628

Notes: Control variables include all of those from Eq. (1). We employ a bandwidth of 75km, matching the analyses of Tables 2–6. Clustered standard errors (at the village level) in parentheses; statistical significance of coefficient estimates at 0.01***, 0.05**, and 0.1* levels. *Source:* DHS (2000).

Table S8: Placebo analysis, showing a lack of significant impacts of "decentralization" at a regional border with no policy change

Dependent Variable		Coeff.	S.E.	Obs.	R^2
Attended meeting to discuss agricultural issues		-0.0904	(0.173)	458	0.609
Attended meeting to discuss agricultural issues organized by:	District government	0.3217	(0.292)	458	0.472
	Village government	-0.2694	(0.236)	458	0.373
Visited a demonstration-plot, home, or research station		-0.1516	(0.151)	457	0.140
Learned new farming practice from district agricultural extension agent		-0.3064	(0.371)	459	0.330
Uses modern inputs		-0.5050	(0.364)	280	0.595
No. of modern inputs used		-1.2478	(0.923)	280	0.575
Uses fertilizer		-0.2025	(0.481)	280	0.626
Uses insecticide		-0.2654	(0.388)	280	0.303
Uses herbicide		-0.3293	(0.206)	280	0.141
Uses improved seed		-0.4507*	(0.214)	280	0.340
Very satisfied with government-organized agricultural meetings		-0.2251**	(0.094)	203	0.938
Very satisfied with government-provided agricultural inputs		0.2529	(0.304)	84	0.972
Use of improved drinking water during the:	Wet season	-0.2920*	(0.151)	280	0.328
	Dry season	-0.3361**	(0.130)	280	0.324
Time to get to water (min.) during the:	Wet season	-26.5136	(21.470)	221	0.633
	Dry season	-22.8419	(23.541)	221	0.668
Dummy – satisfied with water quality during the:	Wet season	0.0772	(0.224)	220	0.850
	Dry season	-0.4547	(0.266)	221	0.844

Notes: All coefficients reflect the coefficient on a dummy for decentralization in a regression of the listed outcome variable on the decentralization dummy and the full set of control variables from Eq. (1). Clustered standard errors (at the village level) in parentheses; statistical significance of coefficient estimates at 0.01^{***}, 0.05^{**}, and 0.1^{*} levels.
Source: IFPRI–EEPRI (2008–2009).

Appendix F Robustness

Appendix F.1 Alternate bandwidths

A potential concern with our analyses is that they rely on data from households that are not always very close to a regional border separating a decentralized and a nondecentralized region. This could serve to make the observations on either side inherently less comparable. While we show balance using this same bandwidth in Appendix Table S5, there could theoretically be other, unobservable factors on which observations on either side of the border are inherently not comparable as we get further away from the border. We thus check the robustness of our results to two alternate bandwidths: 50km from the regional border (this includes 87 percent of our sample) and 25km of the regional border (this includes 79 percent of our sample).

Appendix Table S9 presents all of our previous regression results using the narrower bandwidths. We find that the point estimates are largely unchanged—both in statistical significance and magnitude. Of our 14 productive service delivery outcomes (i.e. those related to agricultural services), all previous findings of a statistically significant impact of decentralization still hold. For our 6 water outcomes, one previously statistically significant finding (for travel time to water) becomes insignificant in both the 50km and 25km bandwidth regressions—if anything further bolstering the evidence that decentralization does not impact social services delivery, and only impacts productive services delivery. Overall, we take these findings as evidence that our main results are not sensitive to the choice of bandwidth we have selected.

Appendix F.2 Alternate specifications

Our findings on the impacts of decentralization are similar to those obtained from estimating a specification suggested by Dell (2010): a semi-parametric RD using a quadratic polynomial in longitude and latitude (see Appendix Table S10). Rather than explicitly allowing covariates influencing service delivery outcomes to change smoothly as one moves along a policy change border and as one moves away from it at a 90 degree angle, this specification instead allows smooth changes in each cardinal direction (i.e. in X–Y space). While the magnitudes of some coefficients change, we again find statistically significant, positive impacts of decentralization on productive services (agricultural services) outcomes, and mixed or null findings for social services (drinking water) outcomes. Decentralization no longer increases learning from extension agents, or reported satisfaction with agricultural meetings and inputs, but it now increases take-up of *all* modern inputs—including insecticide and improved seed. The results also now suggest that decentralization increases the frequency with which meetings focused on agriculture are held in the village, and not only attendance rates. We conclude that our results are robust to different assumptions of how household and policy characteristics change over space.

Appendix F.3 Analysis of district pairs previously in the same province

Next, we check robustness of the results to considering *only* observations along regional borders for which the observations on opposite sides of this recently-drawn border were

all in the *same* top-tier sub-national unit (i.e. province) prior to 1995. Two of our three study locations—namely, the regional boundary between Ibantu and Yaso districts, and the boundary between Bati and Telalak districts—fit this criterion. For these two pairs, one would expect observations on either side of the border to be especially comparable.

Appendix Table S11 shows that our results are indeed largely unchanged when we consider only these two least-problematic district pairs. That is, even when we require that our comparison households spent most of recent history (53 years) under the same top-tier administrative landscape (i.e. the same province), we find that decentralization improves productive service delivery yet has little consistent impact on social services. Of our 14 productive service delivery outcomes (i.e. those related to agricultural services), for none does a previous finding of a statistically significant impact of decentralization no longer hold. Just as in Appendix F.1, for our 6 water outcomes, one previously statistically significant finding (for travel time to water) becomes insignificant—if anything further bolstering the evidence that decentralization does not impact social services delivery, and only impacts productive services delivery. Overall, we take these findings as evidence that our main results are not due to highly divergent history, culture, ethnicity, or other such characteristics on either side of the regional boundaries we analyze.

Table S9: Robustness of results to use of narrower bandwidths

		Within 50 km			Within 25 km		
Dependent Variable		Coeff.	S.E.	N	Coeff.	S.E.	N
Attended meeting to discuss agricultural issues		0.5903***	(0.119)	1,268	0.4706***	(0.116)	1,156
Attended meeting to discuss agricultural issues organized by:	District gov.	0.4858***	(0.106)	1,268	0.3670***	(0.101)	1,156
	Village gov.	0.1890***	(0.033)	1,268	0.1880***	(0.037)	1,156
Meeting held in village to discuss agricultural issues		0.5399	(0.532)	1,268	0.5473	(0.540)	1,156
Visited a demonstration-plot, home, or research station		0.5491***	(0.032)	1,269	0.5426***	(0.041)	1,158
Learned new farming practice from district agricultural extension agent		0.1689**	(0.065)	1,273	0.1430*	(0.076)	1,161
Uses modern inputs		0.8944***	(0.111)	732	0.8816***	(0.134)	663
No. of modern inputs used		1.0788***	(0.212)	732	1.0513***	(0.266)	663
Uses fertilizer		0.8922***	(0.039)	732	0.8981***	(0.040)	663
Uses insecticide		0.0180	(0.123)	732	0.0398	(0.150)	663
Uses herbicide		0.2194***	(0.032)	732	0.2155***	(0.040)	663
Uses improved seed		-0.0508	(0.119)	732	-0.1021	(0.137)	663
Very satisfied with government-organized agricultural meetings		1.1989**	(0.477)	184	1.1347**	(0.519)	172
Very satisfied with government-provided agricultural inputs		1.1396**	(0.459)	284	1.0954**	(0.456)	282
Use of improved drinking water during the:	Wet season	0.3067***	(0.077)	733	0.3404***	(0.088)	664
	Dry season	0.0440	(0.074)	733	0.0725	(0.084)	664
Time to get to water (min.) during the:	Wet season	13.4880	(9.104)	639	12.4464	(8.994)	574
	Dry season	11.2857	(13.930)	643	10.5475	(13.705)	578
Dummy – satisfied with water quality during the:	Wet season	-0.9610***	(0.217)	702	-0.9469***	(0.249)	630
	Dry season	-0.6218***	(0.183)	702	-0.5842**	(0.204)	630

Notes: All coefficients reflect the coefficient on a dummy for decentralization in a regression of the listed outcome variable on the decentralization dummy and the full set of control variables from Eq. (1). Clustered standard errors (at the village level) in parentheses; statistical significance of coefficient estimates at 0.01^{***}, 0.05^{**}, and 0.1^{*} levels.
Source: IFPRI–EEPRI (2008–2009).

Table S10: Robustness of results to a semi-parametric regression discontinuity approach

Dependent Variable		Coeff.	S.E.	Obs.	R^2
Attended meeting to discuss agricultural issues		0.2831**	(0.120)	1,435	0.337
Attended meeting to discuss agricultural issues organized by:	District government	0.0373	(0.126)	1,435	0.266
	Village government	0.2643***	(0.065)	1,435	0.150
Meeting held in village to discuss agricultural issues		0.6796*	(0.373)	1,435	0.962
Visited a demonstration-plot, home, or research station		0.0558	(0.039)	1,436	0.081
Learned new farming practice from district agricultural extension agent		0.1246	(0.074)	1,440	0.086
Uses modern inputs		0.7639***	(0.120)	837	0.789
No. of modern inputs used		1.1172***	(0.198)	837	0.721
Uses fertilizer		0.1900**	(0.070)	837	0.867
Uses insecticide		0.3074***	(0.094)	837	0.667
Uses herbicide		0.1307**	(0.048)	837	0.283
Uses improved seed		0.4891***	(0.155)	837	0.302
Very satisfied with government-organized agricultural meetings		0.0935	(0.781)	231	0.842
Very satisfied with government-provided agricultural inputs provided agricultural inputs		-0.4848	(0.302)	284	0.657
Use of improved drinking water during the:	Wet season	-0.2758***	(0.097)	838	0.158
	Dry season	-0.1828**	(0.086)	838	0.108
Time to get to water (min.) during the:	Wet season	-32.4971**	(12.537)	739	0.529
	Dry season	-29.1480	(19.696)	743	0.574
Dummy – satisfied with water quality during the:	Wet season	0.0784	(0.237)	827	0.577
	Dry season	0.1783	(0.241)	827	0.551

Notes: Coefficients are those on a decentralization dummy in a regression using a quadratic polynomial in longitude and latitude similar to Dell (2010) and our full set of controls from Eq. (1). Clustered standard errors (at the village level) in parentheses; statistical significance of coefficient estimates at 0.01***, 0.05**, and 0.1* levels.
Source: IFPRI–EEPRI (2008–2009).

Table S11: Robustness of results to using only the two border segments for which both districts were in the same province during 1942–1995

Dependent Variable		Coeff.	S.E.	Obs.	R^2
Attended meeting to discuss agricultural issues		0.5333***	(0.127)	964	0.331
Attended meeting to discuss agricultural issues organized by:	District government	0.3986***	(0.114)	964	0.265
	Village government	0.2162***	(0.044)	964	0.162
Meeting held in village to discuss agricultural issues		0.5606	(0.555)	964	0.976
Visited a demonstration-plot, home, or research station		0.5124***	(0.053)	966	0.124
Learned new farming practice from district agricultural extension agent		0.2235***	(0.025)	969	0.057
Uses modern inputs		0.9601***	(0.131)	557	0.840
No. of modern inputs used		1.0998***	(0.340)	557	0.767
Uses fertilizer		0.8937***	(0.038)	557	0.899
Uses insecticide		0.0729	(0.195)	557	0.689
Uses herbicide		0.2099***	(0.055)	557	0.298
Uses improved seed		-0.0768	(0.160)	557	0.385
Very satisfied with government-organized agricultural meetings		1.1043*	(0.602)	140	0.861
Very satisfied with government-provided agricultural inputs provided agricultural inputs		1.1978**	(0.467)	263	0.635
Use of improved drinking water during the:	Wet season	0.2842***	(0.085)	558	0.186
	Dry season	0.0052	(0.071)	558	0.112
Time to get to water (min.) during the:	Wet season	9.1431	(9.055)	476	0.600
	Dry season	8.1653	(13.693)	480	0.680
Dummy – satisfied with water quality during the:	Wet season	-1.0746***	(0.250)	530	0.631
	Dry season	-0.6710***	(0.202)	530	0.601

Notes: Coefficients are those on a decentralization dummy when estimating Eq. (1) with our full set of controls. Clustered standard errors (at the village level) in parentheses; statistical significance of coefficient estimates at 0.01^{***}, 0.05^{**}, and 0.1^{*} levels.
Source: IFPRI–EEPRI (2008–2009).

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