Rain and the Democratic Window of Opportunity

by

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Abstract. According to the economic approach to political transitions, transitory negative economic shocks can open a window of opportunity for democratic improvement. Testing the theory requires a source of transitory shocks to the aggregate economy. We use rainfall shocks in Sub-Saharan African countries and find that negative rainfall shocks are followed by significant improvement in democratic institutions. Instrumental variables estimates indicate that following a transitory negative income shock of 1 percent, democracy scores improve by 0.9 percentage points and the probability of a democratic transition increases by 1.3 percentage points.

Key words: democratization, transitory economic shocks

JEL codes: O0, P0

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1. Introduction

What triggers democratic change? At least since Lipset (1959), it has been argued that democratic change tends to be sparked off by economic recessions (see also Huntington, 1991; Haggard and Kaufmann, 1995). Acemoglu and Robinson's (2001, 2006) theory of political transitions provides an explanation. Transitory, negative economic shocks give rise to a window of opportunity for citizens to contest power, as the cost of fighting ruling autocratic regimes is relatively low. When citizens reject policy changes that are easy to renege upon once the window closes, autocratic regimes must make democratic concessions to avoid costly repression. Hence, democratic improvement is seen as a concession of ruling autocratic regimes when citizens' opportunity cost of contesting power is temporarily low.[1]

Testing the window-of-opportunity effect of transitory economic shocks on political institutions is difficult. The key issue is singling out aggregate economic shocks that are transitory. Another concern is that economic changes may reflect shocks to expectations about future democratization; for example, income levels may rise when countries are more likely to be freed from expropriatory autocratic regimes. Empirical analysis of the window-of-opportunity theory of democratic change therefore requires observing transitory, exogenous shocks to aggregate economic activity. We argue that yearly rainfall shocks in Sub-Saharan African countries satisfy these requirements. This results in a probably unique opportunity to test the theory by examining whether democratic improvement tends to follow negative rainfall shocks.

Our main measure of democratic institutions is the revised combined Polity IV project score (Marshall and Jaggers, 2005). The Polity score is based on the competitiveness of

[1] Lipset and Huntington argue that recessions lead to autocratic regimes losing legitimacy which ends up increasing the probability of democratic change.

political participation, the openness and competitiveness of executive recruitment, and constraints on the executive. The Polity IV project attempts to capture not only outcomes but also procedural rules. The extent to which this goal is achieved is debated, but even critics of the Polity score argue that it is probably the best of the democracy measures used in the literature (e.g. Glaeser et al., 2004).

The data show some striking instances of democratic improvement following negative rainfall shocks in Sub-Saharan Africa. Madagascar transited from autocracy to free democratic elections following a severe drought in 1990. Droughts also preceded free and competitive elections in Mali in 1992 and the multi-party constitution in Mozambique in 1994. Figure 1 shows the evolution of the Polity score for ten Sub-Saharan African countries where democratic improvement was preceded by droughts, defined as rainfall levels below the 20^{th} percentile (a higher Polity score denotes more democratic institutions). Another interesting aspect of the Sub-Saharan African data is that there are twice as many democratic transitions following droughts than following rainfall levels above the 80^{th} percentile.

Our empirical analysis yields a statistically significant link between negative rainfall shocks and subsequent improvements in the Polity score. This continues to be the case when we consider improvements in the Polity sub-scores for the competitiveness of political participation, the openness and competitiveness of executive recruitment, and constraints on the executive. We also find that negative rainfall shocks lead to a statistically significant increase in the probability of a democratic transition, defined following Persson and Tabellini (2003), and to a statistically significant increase in the probability of a step towards democracy, defined following Epstein et al. (2006). The democratic improvements experienced by Sub-Saharan African countries following negative rainfall shocks are

consistent with Acemoglu and Robinson's theory of political transitions as negative rainfall shocks lead to transitory drops in GDP in our data.[2]

When citizens' cost of contesting power is proportional to income, as in Acemoglu and Robinson's theory of political transitions, we can push the empirical analysis further and estimate the democratic window-of-opportunity effect of transitory, negative income shocks by using rainfall shocks as an instrument. Our instrumental variables estimates indicate that a transitory negative income shock of 1 percent is followed by an improvement in the Polity score of 0.9 percentage points. The executive constraints score improves by 1 percentage point; the political competition score by 0.8 percentage points; and the openness and competitiveness of executive recruitment score by 0.9 percentage points. When we consider transitions from autocracy to democracy, we find that a transitory negative income shock of 1 percent increases the probability of a democratic transition by 1.3 percentage points. These estimates reflect the effect of negative transitory income shocks on democratic improvement under the assumption (exclusion restriction) that rainfall shocks affect democratic change only through their effect on income. This condition would not be satisfied if rainfall had a direct effect on the cost of contesting autocratic rule.[3]

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[2] A positive effect of rainfall on the GDP of Sub-Saharan African countries is also reported by Benson and Clay (1998); Miguel et al. (2004); and Barrios and Bertinelli (2008). Benson and Clay report annual time-series evidence for six Sub-Saharan African countries between 1970 and 1992, and Miguel et al. report annual time-series evidence for forty-one Sub-Saharan African countries between 1981 and 1999. Our analysis extends the sample further and also differs in that we control for common time effects (shocks affecting all Sub-Saharan African countries) and check on the robustness of the rainfall-GDP link. Barrios and Bertinelli examine the effect of rainfall on GDP growth averaged over five-year periods.

[3] For example, road flooding could make it more costly for citizens to coordinate against autocratic regimes. In this case, negative rainfall shocks could lead to democratic improvement because of their direct (negative) effect on the cost of contesting power or because of their (indirect, negative) effect through income. Hence, direct negative effects of rainfall on the cost of contesting power imply that our instrumental variables estimates cannot be interpreted as the effect of transitory income shocks. But the window-of-opportunity theory of political transitions can still be tested by examining whether negative rainfall shocks lead to democratic improvement (this is true as long as the total—direct plus indirect—effect of negative rainfall shocks is a reduction of the cost of contesting autocratic regimes).

If rainfall shocks open a window of opportunity for democratic change because of their effect on income, rainfall shocks should have a weak effect on democratic change in countries where the effect of rainfall shocks on income is weak because agricultural sectors are small. This is consistent with our finding of a statistically insignificant effect of rainfall shocks on democratic change and on GDP in countries with agricultural GDP shares below the sample median.[4] The result that rainfall shocks have an insignificant effect on democratic change in the sample where they have an insignificant effect on income also suggests that rainfall does not have (strong) direct effects on democratic change.

Our work fits into the literature on the economic determinants of democratic change. One of the most thoroughly investigated issues is the modernization hypothesis, which posits a positive link between income and democracy (Lipset, 1959). For empirical work see, for example, Przeworski and Limongi (1997); Barro (1999); Przeworski et al. (2000); and Epstein et al. (2006). This literature has found evidence of a positive link between income and democracy, but recent work by Acemoglu et al. (2008, 2009) indicates that this relationship is absent when one focuses on within-country variation using fixed effects specifications (as we do). Our work differs from the modernization literature in that we are interested in democratic change following transitory economic shocks. It is for this reason that we rely on rainfall variation as a source of transitory shocks to the aggregate economy. Haggard and Kaufman (1995), Geddes (1999), Berger and Spoerer (2001), and Acemoglu and Robinson (2006) also document democratic improvements following negative economic shocks. Methodologically, our work is related to Paxson (1992), which appears to be the first paper using rainfall shocks to test theoretical implications of transitory economic shocks.[5]

[4] The average agricultural share in these countries is 18 percent, which is about half the average agricultural share in Sub-Saharan Africa. Rainfall has a significantly positive effect on GDP and a significantly negative effect on democratic improvement in countries with agricultural GDP shares above the median.

[5] Paxson's objective is to test the validity of the permanent income hypothesis (see also Fafchamps et

The remainder of this paper is organized as follows. Section 2 discusses data and measurement, Section 3 presents the estimation framework, and Section 4 our results. Section 5 concludes.

2. Data and Measurement

Our main measure of democratic institutions is the revised combined Polity score (Polity2) of the Polity IV database (Marshall and Jaggers, 2005). This variable combines scores for constraints on the chief executive, the competitiveness of political participation, and the openness and competitiveness of executive recruitment. It ranges from -10 to +10, with higher values indicating more democratic institutions. Polity2 is based on the combined Polity score but modified for time series analysis. In particular, changes in the combined Polity score during transition periods are prorated across the span of the transition. Polity IV defines transition periods as periods where new institutions are planned, legally constituted, and put into effect. Democratic and quasi-democratic polities are particularly likely to be preceded by such transition periods (Marshall and Jaggers, 2005). Moreover, Polity2 assigns a score of zero (which Polity IV refers to as neutral) to periods where polities cannot exercise effective authority over at least half their established territory (Polity IV refers to such periods as interregnum periods).

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al., 1998). Miguel et al. (2004) examine the link between year-to-year rainfall growth, income growth, and civil conflict. Their aim is to re-examine empirical work arguing that civil conflict is caused by low income growth using instrumental variables (for an early contribution to the civil conflict literature see Collier and Hoeffler, 1998). Burke and Leigh (2008) use a similar approach to estimate the effect of income growth on democratic transitions. Miguel et al.'s approach cannot be used to test the democratic window-of-opportunity theory. This is because the approach tests whether civil conflict outbreak is more likely following years where rainfall turned out to be low compared to rainfall in previous years. What matters for the window-of-opportunity theory is whether rainfall is low compared to expected future rainfall, not compared to past rainfall. The Supplementary Appendix (available as a separate document at www.antoniociccone.eu) shows that the effect of year-to-year rainfall growth on democratic improvement in Sub-Saharan Africa is statistically insignificant, significantly positive, or significantly negative, depending on the measure of democracy used.

We perform a separate empirical analysis for the Polity IV sub-scores for constraints on the chief executive, political competition, and the openness and competitiveness of executive recruitment (Polity IV refers to these variables as concept variables). Constraints on the executive is a measure of the extent of institutionalized constraints on the decision making powers of chief executives and ranges from 1 to 7, with greater values indicating tighter constraints. Political competition measures the extent to which alternative preferences for policy and leadership can be pursued in the political arena. This indicator ranges from 1 to 10, with greater values denoting more competition. Finally, the openness and competitiveness of executive recruitment measures the extent to which the politically active population has an opportunity to attain the position of chief executive through a regularized process and the degree to which prevailing modes of advancement give subordinates equal opportunities to become superordinates. It ranges from 1 to 8, with greater values indicating more open and competitive executive recruitment. We follow the revised combined Polity score in prorating changes during a transition period across its span, and we treat interregnum periods as missing values (in contrast to the combined Polity variable, the Polity concept variables do not have a score that Polity IV considers as neutral). To facilitate the comparison of results for Polity2 with those for the Polity concept variables, we present results for a modified version of Polity2 where we drop interregnum periods.

We also examine transitions to democracy. Persson and Tabellini (2003, 2006, 2008) and the Polity IV project consider countries to be democracies if their Polity2 score is strictly positive; other Polity2 scores correspond to non-democracies. To capture transitions to democracy, we define a year t democratic transition indicator variable for country c that is unity if and only if democratic improvements between t-1 and t lead to the country being upgraded to democracy; if the country already is a democracy at t-1, the year t indicator is not defined. Transitions away from democracy are defined analogously. The Polity IV

project and Epstein et al. (2006) further separate democracies into partial democracies, with Polity2 scores 1 to 6, and full democracies, with Polity2 scores 7 to 10. To analyze the effect of rainfall and income shocks on democratic improvement using this classification, we define a year *t* democratization step indicator variable for country *c* that is unity if and only if democratic improvements between *t*-1 and *t* lead to the country being upgraded to partial or full democracy; if the country already is a full democracy at *t*-1, the year *t* indicator is not defined. We also examine the effect of rainfall shocks on coups d'état in democracies. Polity IV defines coups d'état as a forceful seizure of executive authority and office by a dissident/opposition faction within the country's ruling or political elites that results in a substantial change in the executive leadership and the policies of the prior regime (although not necessarily in the nature of regime authority or mode of governance). We define a coup d'état in democracy indicator variable for year *t* and country *c* that is unity if the country is a democracy and there has been a coup, and zero if the country is a democracy and there has not been a coup. Our measures of political change are summarized in Table 1.

The country-year rainfall estimates come from the National Aeronautics and Space Administration (NASA) Global Precipitation Climatology Project (GPCP). NASA GPCP rainfall estimates are based on data from gauge stations, and microwave, infrared, and sounder data from satellites. Specifically, the NASA GPCP combines special sensor microwave imager emission and scattering algorithms, a geostationary orbital environmental satellite precipitation index, an outgoing longwave precipitation index, information from Tiros operational vertical sounders and National Oceanic and Atmospheric Administration polar orbiting satellites, and measurements from gauge stations to obtain monthly rainfall estimates on a 2.5°x2.5° latitude-longitude grid. A detailed explanation of how gauge

measurements are merged with satellite data is provided in Adler et al. (2003).[6] In comparison to rainfall estimates based exclusively on gauge measurements, there are two main advantages of the GPCP estimates. First, the GPCP rainfall estimates are less likely to suffer from classical measurement error due to the sparseness of operating gauge stations in Sub-Saharan African countries (especially after 1990).[7] Moreover, the number of operating gauge stations in a country may be affected by socio-economic conditions, which could lead to non-classical measurement error in rainfall estimates. Such errors are less of a concern for GPCP rainfall estimates than rainfall estimates based exclusively on gauge measurements.[8] GPCP rainfall estimates are available from 1979 onwards.

Our measure of per capita income is real per capita GDP from the Penn World Tables 6.2 (Heston et al., 2006) which is available up to 2004. Table 2 contains summary statistics for key data.

3. Estimation Framework

To estimate the effect of country-specific rainfall shocks on income, we relate log income per capita in country c at time t ($\log y_{c,t}$) to a country-specific fixed effect plus time trend ($\alpha_c + \beta_c t$), time-varying shocks that affect all Sub-Saharan African countries (ϕ_t), and country-specific rainfall levels ($\log Rain_{c,t}$),

[6] The data are available at http://precip.gsfc.nasa.gov. For a validation study of the GPCP satellite-based rainfall data see Nicholson et al. (2003).

[7] Matsuura and Willmott (2007) provide gauge-based rainfall estimates for a large part of the world and a long time period. The spatial gauge density underlying their rainfall estimates for Sub-Saharan African countries appears to be relatively good for the 1960s and 1970s but declines thereafter. For example, while the average number of gauge stations per country is 40 in the 1960s, the average drops to 32 in the 1980s, 18 in the 1990s, and 8 after 2000. As a result, gauge coverage after 1990 appears unsatisfactory according to the criteria of the World Meteorological Organization (1985) and Rudolf et al. (1994).

[8] For example, a regression of the Matsuura and Willmott rainfall estimates on lagged per capita GDP, country-specific fixed effects plus time trends, and common time effects yields a statistically significant, negative effect of lagged income on rainfall for the 1980-2004 period we focus on (lagged per capita GDP also has a significant effect on the number of reporting gauges in the Matsuura and Willmott dataset). By contrast, lagged GDP has no significant effect on GPCP rainfall.

(1) $$\log y_{c,t} = \alpha_c + \beta_c t + \phi_t + \gamma \log Rain_{c,t} + \theta \log Rain_{c,t-1} + v_{c,t},$$

where v is a disturbance term. The parameter γ captures the contemporaneous effect of country-specific rainfall shocks on income, while θ captures the lagged effect.

To examine the effect of rainfall shocks on democratic change we maintain the right-hand-side explanatory variables of (1) but use measures of democratic change on the left-hand side. Our main measure of democratic change is the change in the Polity2 score between t and t+1, $\Delta D_{c,t} = D_{c,t+1} - D_{c,t}$ where $D_{c,t}$ refers to the year t Polity2 score of country c. In this case, the estimating equation becomes

(2) $$\Delta D_{c,t} = a_c + b_c t + f_t + c \log Rain_{c,t} + d \log Rain_{c,t-1} + e_{c,t},$$

where e is a disturbance term. We use the same estimating equation to examine the effect of rainfall shocks on the change in each of the three Polity concept variables and on the indicator variables for transition to democracy and step towards democracy.[9] Moreover, (2) is the basis for our analysis of the effect of rainfall shocks on transitions away from democracy and coups d'état in democracies.

[9] We use linear specifications because probit and (unconditional) logit with fixed effects yield inconsistent slope estimates due to the incidental parameter problem (Greene, 2003). Consistent slope estimates can be obtained using conditional fixed effects logit, which yields qualitatively and statistically the same results as the corresponding linear probability model (the magnitude of estimates cannot be compared without knowing the distribution of fixed effects, see Wooldridge, 2002). The main drawback of conditional fixed effects logit is that estimates do not converge when we include country-specific time trends and common time effects (this is a general problem associated with maximum likelihood estimation of many coefficients in non-linear models, see for instance Greene, 2004). We also use linear specifications for our instrumental variables estimates because alternative approaches require strong specification assumptions (Angrist and Krueger, 2001; Wooldridge, 2002).

Under the assumption that rainfall shocks affect democratic change only through income, we can estimate the effect of transitory income shocks on democratic institutions using an instrumental variables approach. Our analysis of the effect of income shocks on democratic change uses two specifications. The first controls for log income, country-specific fixed effects plus time trends, and common time effects, while the second specification replaces log income by a country-specific recession indicator. This indicator is unity if and only if income in a country falls below its trend for reasons other than shocks affecting all Sub-Saharan African countries. Specifically, we first estimate

$$\log y_{c,t} = \alpha_c + \beta_c t + \phi_t + \eta_{c,t}, \tag{3}$$

where η is a disturbance term, using least squares. Then we define a country-specific recession indicator that is unity if $\log y_{c,t}$ is below the predicted value $\hat{\alpha}_c + \hat{\beta}_c t + \hat{\phi}_t$ and zero otherwise.

4. Empirical Results

Table 3, column (1) shows our estimates of the effect of rainfall shocks on the change in the Polity2 score using equation (2). We report least squares estimates and Huber robust standard errors clustered at the country level (in parentheses). All our results refer to the 1980-2004 period.[10] The estimates indicate that negative rainfall shocks at *t*-1 are followed by statistically significant democratic improvement. In particular, 10 percent lower rainfall levels lead to an improvement of 0.146 points in the Polity2 score, and the effect is statistically significant at the 95 percent confidence level. Given the [-10,10] range of Polity2, a 0.146 point increase corresponds to an improvement of 0.73 percentage points.

[10] The first Polity2 observation used corresponds to 1980 but the first rainfall observation to 1979 (the starting date of the rainfall data), as our specifications include rainfall levels at *t* and *t*-1.

Table 3, column (2) estimates the same specification as column (1) but codes interregnum years as missing observations (which is why the number of observations drops to 902) to make the results more readily comparable with our analysis for Polity sub-scores in columns (3)-(5). This yields an effect of *t*-1 rainfall shocks that is stronger both quantitatively and statistically than in column (1).

Table 3, columns (3)-(5) estimate the effect of rainfall shocks on the change in the Polity sub-scores for constraints on the executive, political competition, and the openness and competitiveness of executive recruitment. The results show that negative *t*-1 rainfall shocks lead to significant democratic improvement in all three dimensions. 10 percent lower rainfall levels result in an increase of 0.046 points in the executive constraints score, and the effect is statistically significant at the 90 percent confidence level. As this score has a [1,7] range, a 0.046 point increase amounts to a tightening of executive constraints by 0.77 percentage points. The political competition and executive recruitment scores increase by 0.058 and 0.049 points respectively, and both effects are statistically significant at the 95 percent confidence level. These changes amount to improvements of 0.64 and 0.69 percentage points respectively, as political competition has a [1,10] range and executive recruitment a [1,8] range.

Table 4 contains our estimates of the effect of rainfall on GDP per capita and the probability of a country-specific recession. Column (1) estimates the effect of contemporaneous rainfall shocks on GDP per capita using equation (1). Our results indicate that 10 percent lower rainfall levels lead to a 0.79 percent drop in income per capita, and that the effect is statistically significant at the 99 percent confidence level. Columns (2) and (3) augment the specification in column (1) by lagged rainfall levels.[11] Column (2) shows that

[11] The Supplementary Appendix contains a series of robustness checks. In particular, we re-estimate the effect of rainfall on income using rainfall levels rather than log-levels; examine the relationship in first differences rather than levels; control for temperature; check for non-linearities; drop the top 1

rainfall at *t*-1 has a statistically insignificant effect on GDP at *t*. Column (3) includes rainfall at *t*-2 as an additional control and finds that the effect is also statistically insignificant. In column (4), we check whether the contemporaneous effect of rainfall shocks depends on countries' Polity2 score, but find the interaction effect to be statistically insignificant.

Table 4, columns (5)-(8) consider the effect of rainfall shocks on the country-specific recession indicator. In column (5) we find that 10 percent lower rainfall levels raise the probability of a recession by 3.9 percentage points, and that the effect is statistically significant at the 99 percent confidence level. Columns (6) and (7) show that the effect of lagged rainfall levels is statistically insignificant, and column (8) that the contemporaneous effect of rainfall shocks does not vary significantly with countries' Polity2 score.

To check whether our (linear) specifications miss important aspects of the data, we re-estimate the effect of rainfall shocks on per capita GDP and the change in Polity2 using non-parametric local polynomial estimators. Figure 2A presents non-parametric local polynomial estimates of the effect of rainfall on GDP.[12] We use an Epanechnikov kernel and select the bandwidth as suggested by cross-validation criteria.[13] It turns out that the relationship is monotonically increasing except for large positive rainfall shocks, where the relationship is estimated to be hump-shaped.[14] The hump is very imprecisely estimated however because

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percent rainfall observations; account for potential spatial correlation of rainfall; and use a variety of different approaches to calculate standard errors. We also use the Matsuura and Willmott (2007) rainfall data and find a statistically significant effect of rainfall shocks on income for (pre-1990) periods where spatial gauge density is relatively good, see footnote 7. The Matsuura and Willmott rainfall estimates do not yield a significant effect of rainfall on income for the 1980-2004 period we focus on however. We think that this is most likely due to the unsatisfactory gauge density in the second half of this period.

[12] Estimation proceeds in two steps. In the first step, we regress log income per capita and log rainfall on country-specific fixed effects plus time trends and common time effects. Then we take the residuals from these two regressions and use the non-parametric local polynomial estimator to examine the relationship between rainfall and per capita income.

[13] See Bowman and Azzalini (1997). Intuitively, cross validation amounts to choosing the bandwidth to minimize the mean-square error.

[14] We also present non-parametric local polynomial estimates using half and twice the bandwidth recommended by cross validation in the Supplementary Appendix.

less than 1 percent of rainfall observations are to the right of its peak.[15] (Re-estimating equations (1) and (2) after dropping the top 1 percent rainfall observations yields results that are slightly stronger statistically, see the Supplementary Appendix.) Figure 2B uses the same approach to obtain non-parametric local polynomial estimates of the effect of rainfall shocks on the change in the Polity2 score. This relationship is monotonically decreasing over the whole range.

Table 5 presents two-stage least squares (2SLS) estimates of the effect of transitory income shocks on the change in the Polity2 score. These estimates assume that the effect of *t*-1 rainfall shocks on democratic change documented in Table 4 is through income.[16] The top panel of Table 5 contains estimates of the effect of log income per capita on democratic change while the bottom panel presents first-stage effects (when applicable). The result in column (1) indicates that a transitory 1 percent negative income shock at *t*-1 leads to an improvement in the Polity2 score of 0.18 points.[17] This effect is statistically significant at the 95 percent confidence level and amounts to an increase of 0.9 percentage points given the [-10,10] range of the score.[18] In column (2) we drop interregnum periods. The effect continues

[15] The Supplementary Appendix tests for non-linearities by including dummy variables for rainfall levels above or below certain percentiles. These dummy variables turn out to have small and statistically insignificant effects while the linear effect remains statistically significant.

[16] In the Supplementary Appendix we examine whether the effect of rainfall shocks on democratic change could be through government expenditures, military expenditures, or consumer prices (rather than GDP per capita). Our analysis does not yield a statistically significant effect of rainfall shocks on these variables. In the case of military expenditures, this could be because limited data force us to work with a quite reduced sub-sample (interestingly, however, we do find a statistically significant effect of rainfall on GDP per capita and democratic change in this sub-sample).

[17] The p-values in square brackets below 2SLS estimates are based on the Anderson-Rubin test of statistical significance. A key property of this test is robustness to weak instruments. 2SLS standard errors, on the other hand, are not robust to weak instruments, and inference based on 2SLS standard errors can be very misleading as a result. See Andrews and Stock (2005) for a review of these issues. The power properties of the Anderson-Rubin test are also good (it is a uniformly most powerful unbiased test under certain conditions). We implement a version of the Anderson-Rubin test that is robust to heteroskedasticity and arbitrary within-country correlation of the residuals.

[18] In the Supplementary Appendix, we show that the effect of year *t* income shocks is statistically insignificant.

to be statistically significant at the 95 percent confidence level and is somewhat larger in absolute value than in column (1).[19]

For comparison we show the results using least squares for the world sample (the largest possible sample for 1980-2004) and Sub-Saharan Africa in columns (3) and (4) respectively. The least squares estimates have the same sign as the 2SLS estimates, but are much smaller in absolute value and statistically insignificant. For example, in the world sample, a negative income shock of 1 percent leads to an improvement in Polity2 scores of less than one-hundredth of a percentage point. For Sub-Saharan Africa, the effect is less than one-twentieth of a percentage point.[20] Our finding that the least squares effect of income shocks is larger than the instrumental variables estimate is most likely explained by the combination of three factors.[21] First, the window-of-opportunity theory of political transitions stresses transitory economic shocks; permanent shocks change the balance of power permanently and will therefore allow citizens to demand and obtain policy concessions in the future even in the absence of democratic reforms. When we instrument income shocks using rainfall shocks, we isolate transitory income shocks. Hence, the stronger negative effect obtained using 2SLS in column (1) compared to using least squares in column (4) is consistent with theory. Second, the income estimates in the Penn World Tables contain a substantial amount of noise, especially for Sub-Saharan African countries (e.g. Heston, 1994; Deaton, 2005). Classical measurement error would affect our least squares estimate in column (4), but not our instrumental variables estimate in (1) as long as noise in income estimates is uncorrelated with noise in rainfall estimates. Classical measurement error could therefore

[19] In the Supplementary Appendix, we show that results are similar when we measure democratic institutions using the Freedom House (2007) political rights indicator.

[20] A formal test yields that there is no statistically significant difference between the results for the world sample and for Sub-Saharan Africa.

[21] A Hausman test rejects the equality of the least squares estimate in column (4) and the 2SLS estimate in column (1) at the 90 percent confidence level.

lead to the least squares estimate in column (4) being attenuated relative to the instrumental variables estimate in (1). A third reason why the least squares estimate is larger than the instrumental variables estimate could be that democratic reforms are partly anticipated, and that this leads to increases in income before reforms are actually in place. This would bias the least squares estimate upward but leave the instrumental variables estimate unaffected.

Table 6 uses the country-specific recession indicator to examine democratic change following recessions. The top panel presents our estimates of the effect of recessions on democratic change, while the bottom panel presents first-stage effects (when applicable). Columns (1) and (2) measure democratic change using the Polity2 score. The 2SLS estimates in column (1) imply that recessions increase the Polity2 score by 18 percentage points, and that the effect is statistically significant at the 95 percent confidence level. The effect is somewhat stronger statistically and quantitatively when we exclude interregnum periods in column (2). Columns (3) and (4) show that least squares estimates of the effect of recessions on Polity2 are much smaller than 2SLS estimates, whether we consider the world sample in (3) or Sub-Saharan Africa in (4). Columns (5)-(7) indicate that recessions also lead to statistically significant improvements in the Polity sub-scores. Our 2SLS estimates imply that the score for executive constraints improves by 19 percentage points, while the scores for political competition and for the openness and competitiveness of executive recruitment both improve by 17 percentage points.

Table 7 augments our baseline estimating equations by including the lagged Polity2 score as an additional control. Columns (1) and (2) use the augmented specifications to re-examine the effect of rainfall shocks on the change in the Polity2 score. Column (1) contains least squares results, while column (2) contains system-GMM estimates (Blundell and Bond, 1998). Both show an effect of *t*-1 rainfall shocks that is very similar to our baseline result in Table 3, column (1). Columns (3) and (4) contain 2SLS estimates of the effect of income

shocks on the change in the Polity2 score, and columns (5)-(8) add further Polity2 lags on the right-hand side of the estimating equation. Results are again very similar to our baseline estimates.[22]

Table 8, column (1) shows the effect of rainfall shocks on the probability of democratization using the Persson and Tabellini (2003, 2006, 2008) and Polity IV project definition of democracy. Our results indicate that negative *t*-1 rainfall shocks lead to an increase in the probability of a transition to democracy between *t* and *t*+1, and that the effect is statistically significant at the 95 percent confidence level. The point estimate implies that 10 percent lower rainfall levels increase the probability of a democratic transition by 1.25 percentage points.[23] Column (2) repeats the analysis using the democratization step indicator based on the Epstein et al. (2006) and Polity IV trichotomous classification of polities. This yields that 10 percent lower rainfall levels raise the probability of a step towards democracy by 1.4 percentage points, and that the effect is statistically significant at the 95 percent confidence level.

Columns (3) and (4) estimate the effect of rainfall shocks on the probability of transitions away from democracy (autocratic transitions) and coups d'état in democracies. The estimates in column (3) indicate that autocratic transitions are more likely following positive *t*-1 rainfall shocks. The effect of rainfall shocks is actually larger in absolute value than for democratic transitions in column (1) but very imprecisely estimated and therefore statistically insignificant. For coups d'état in democracies, the effect of rainfall shocks is small and statistically insignificant.[24]

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[22] In the Supplementary Appendix we show that results are very similar when we put the Polity2 level (instead of the Polity2 change) on the left-hand side of these estimating equations.

[23] In an earlier working paper version (see Brückner and Ciccone, 2008) we showed that negative rainfall shocks also have a significantly positive effect on the probability of a transition to democracy when using the Przeworski et al. (2000) democracy indicator.

[24] The sample of autocratic transitions and coups d'état in democracies is much smaller than the sample of democratic transitions. It is also interesting to note that Acemoglu and Robinson's (2001)

Table 9, columns (1)-(3) summarize our findings on the effect of income shocks on transitions to democracy. The least squares effect of income shocks on democratic transitions is very small and statistically insignificant. The effect also turns out to have the wrong sign from the point of view of the democratic window-of-opportunity theory (it implies that negative income shocks decrease the probability of a democratic transition). But the 2SLS estimate in column (2) indicates that negative income shocks lead to an increase in the probability of a democratic transition and that the effect is statistically significant at the 95 percent confidence level. The point estimate implies that a transitory negative income shock of 1 percent increases the probability of democratization by 1.3 percentage points. Column (3) shows that following recessions, the probability of a democratic transition increases by 23.5 percentage points, and that the effect is statistically significant at the 95 percent confidence level.[25]

The results for the democratization step indicator in Table 9, columns (4)-(6) are similar to the results for democratic transitions. Least squares estimation in column (4) yields a very small and statistically insignificant effect. But 2SLS estimation in columns (5) and (6) yields a statistically significant increase in the probability of a step towards democracy following negative income shocks. For example, according to column (5), a transitory negative income shock of 1 percent increases the probability of a step towards democracy by 1.5 percentage points, and the effect is statistically significant at the 95 percent confidence level. Column (6) indicates that a step towards democracy is 27.9 percentage points more likely following a

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theory of political transitions is consistent with negative economic shocks leading to democratic transitions but not to democratic reversals.

[25] Bratton and van de Walle (1997) discuss democratic transitions in Africa over the 1988-1994 period and argue that transitions are largely explained by domestic political forces rather than by domestic economic conditions. Our results indicate that country-specific economic factors did play a role over the 1980-2004 period (there are too few transitions for the 1988-1994 period for statistical analysis).

recession, and that this effect is also statistically significant at the 95 percent confidence level.

Our interpretation of the effect of rainfall shocks on democratic change is that a negative rainfall shock opens a window of opportunity for democratic improvement because it translates into a transitory negative GDP shock and hence a lower opportunity cost of contesting power. If this interpretation is correct, the effect of rainfall shocks on democratic change should be absent in countries where rainfall shocks do not affect GDP. Moreover, if rainfall shocks affect GDP through agricultural output, the effect of rainfall shocks on GDP should be weak in countries with small agricultural sectors.[26] It is therefore interesting to examine whether there is evidence of weak effects of rainfall shocks on democratic change and on per capita GDP in countries with relatively small agricultural sectors. To do so, we use data from the World Development Indicators (2009) to calculate the average agricultural GDP share over the 1980-2004 period for each country in our sample, and analyze the effect of rainfall shocks on GDP and on democratic change in countries with agricultural GDP shares below the median.[27] The results in the top panel of Table 10 show that the effect of rainfall shocks on GDP per capita is statistically insignificant in these countries, see column (1), and that the effect of rainfall shocks on democratic change is also statistically insignificant, see columns (2)-(5). This result is consistent with rainfall shocks affecting democratic institutions through income. The finding also suggests that rainfall does not have (strong) direct effects on democratic change.[28]

[26] The Supplementary Appendix shows that rainfall has a highly statistically significant, positive effect on agricultural output in our sample (see Dell, Jones, and Olken, 2008, for evidence on the positive effect of rainfall on agricultural value added in a wider sample of countries).

[27] The median agricultural GDP share in our sample is 34 percent, and the average agricultural share in below-median countries is 18 percent.

[28] The bottom panel of Table 10 shows results for countries with agricultural sectors above the median (the average agricultural share in these countries is 44 percent). Rainfall has a significantly positive effect on GDP and a significantly negative effect on democratic improvement in these

5. Conclusions

It has long been argued that democratic improvement is often triggered by economic recessions. The economic approach to political change (Acemoglu and Robinson, 2001, 2006) provides a rationale. Political change is more likely following transitory negative economic shocks because opportunity costs of contesting power are temporarily low. Empirical tests of economic theories of political change are difficult—we rarely have clean measures of the theoretical driving forces—and the window-of-opportunity theory of democratic change is not an exception. Testing the theory requires a source of transitory shocks to the aggregate economy. Our approach relies on country-specific rainfall shocks in Sub-Saharan Africa, where such shocks have a significant but transitory impact on GDP. Our analysis yields that negative rainfall shocks lead to significant democratic improvement and, in particular, a tightening of executive constraints, greater political competition, and more open and competitive executive recruitment. Our instrumental variables results indicate that improvements in democratic institutions triggered by transitory negative income shocks can be substantial. For example, rainfall-driven recessions are followed by an improvement in the score for executive constraints by 19 percentage points and an improvement in the scores for political competition and for the openness and competitiveness of executive recruitment by 17 percentage points.

countries (and the point estimates are larger in absolute value than for countries with agricultural shares below the median).

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Table 1. Measures of Political Change

Variable	Description	Source
ΔPolity2	The *t* to *t*+1 change in the revised combined Polity score. The maximum range of this variable is from -20 to 20. Positive (negative) values indicate an improvement (deterioration) in democracy. We also analyze the effect on Polity scores after excluding interregnum periods.	Polity IV database (Marshall and Jaggers, 2005)
ΔExrec	The *t* to *t*+1 change in the executive recruitment concept (Polity IV) score. The maximum range of this variable is from -7 to 7. Positive (negative) values indicate an improvement (deterioration) in the executive recruitment concept.	Polity IV database (Marshall and Jaggers, 2005)
ΔPolcomp	The *t* to *t*+1 change in the political competition concept (Polity IV) score. The maximum range of this variable is from -9 to 9. Positive (negative) values indicate an improvement (deterioration) in the political competition concept.	Polity IV database (Marshall and Jaggers, 2005)
ΔExconst	The *t* to *t*+1 change in the executive constraint concept (Polity IV) score. The maximum range of this variable is from -5 to 5. Positive (negative) values indicate an improvement (deterioration) in the executive constraint concept.	Polity IV database (Marshall and Jaggers, 2005)
Democratic Transition	Indicator variable that is equal to unity in year *t* if and only if the country is a democracy in *t* but a non-democracy in *t*-1 (the year *t* indicator is not defined if the country is a democracy in *t*-1).	Polity IV database (Marshall and Jaggers, 2005)
Democratization Step	Indicator variable that is equal to unity in year *t* if and only if the country is upgraded to either a partial or full democracy between *t*-1 and *t* (the year *t* indicator is not defined if the country is a full democracy in *t*-1).	Polity IV database (Marshall and Jaggers, 2005)
Autocratic Transition	Indicator variable that is equal to unity in year *t* if and only if the country is a non-democracy in *t* but a democracy in *t*-1 (the year *t* indicator is not defined if the country is a non-democracy in *t*-1).	Polity IV database (Marshall and Jaggers, 2005)
Coup in Democracy	Indicator variable that is unity if and only if in period *t* there was a coup d'état in countries that have strictly positive Polity2 scores (democracies).	Polity IV database (Marshall and Jaggers, 2005)

Table 2. Descriptive Statistics

Variable	Mean	Std. Dev.	Observations
ΔPolity2	0.249	2.097	955
ΔExrec	0.083	0.763	902
ΔPolcomp	0.183	1.007	902
ΔExconst	0.071	0.700	902
Democratic Transition Indicator	0.036	0.186	700
Democratization Step Indicator	0.035	0.183	867
Autocratic Transition Indicator	0.055	0.238	255
Coup in Democracy Indicator	0.106	0.308	255
Real Per Capita GDP	1585.14	1732.38	955
Rainfall (mm per year)	980.39	501.41	955

Note: See Table 1 for detailed definitions of the measures of political change.

Table 3. Rainfall and Polity Change

	ΔPolity2		ΔExconst	ΔPolcomp	ΔExrec
	(1)	(2)	(3)	(4)	(5)
	LS	LS	LS	LS	LS
Log Rainfall, t	0.261 (0.347)	0.031 (0.381)	0.093 (0.111)	-0.153 (0.152)	0.091 (0.171)
Log Rainfall, t-1	-1.461** (0.723)	-1.660** (0.740)	-0.459* (0.256)	-0.578** (0.286)	-0.485** (0.244)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	955	902	902	902	902

Note: The method of estimation is least squares; Huber robust standard errors (in parentheses) are clustered at the country level. The dependent variable in columns (1)-(2) is the *t* to *t*+1 change in the revised combined Polity score (*Polity2*); column (2) excludes observations that correspond to interregnum periods. The dependent variable in columns (3)-(5) is the *t* to *t*+1 change in Polity IV sub-scores that reflect changes in a country's constraints on the executive (*Exconst)*, political competition (*Polcomp*), and executive recruitment (*Exrec*). The range of the dependent variables is as follows: *Polity2* [-10,10], *Exconst* [1,7], *Polcomp* [1,10], and *Exrec* [1,8]. *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 4. Rainfall, Per Capita GDP, and Country Specific Recessions

	Log GDP				Country Specific Recession			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LS	LS	LS	LS	LS	LS	LS	LS
Log Rainfall, t	0.079***	0.075***	0.076***	0.082***	-0.399***	-0.382***	-0.383***	-0.376**
	(0.029)	(0.026)	(0.027)	(0.030)	(0.140)	(0.127)	(0.130)	(0.154)
Log Rainfall, t-1		0.048	0.046			-0.191	-0.189	
		(0.032)	(0.029)			(0.139)	(0.125)	
Log Rainfall, t-2			0.010				-0.018	
			(0.035)				(0.147)	
Log Rainfall, t* Polity2, t				0.001				0.005
				(0.003)				(0.013)
Polity2, t				-0.002				-0.048
				(0.021)				(0.091)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	955	955	955	955	955	955	955	955

Note: The method of estimation is least squares; Huber robust standard errors (in parentheses) are clustered at the country level. The dependent variable in columns (1)-(4) is log real per capita GDP (PWT 6.2). The dependent variable in columns (5)-(8) is an indicator variable (*Country Specific Recession*) that is unity if and only if per capita GDP falls below the country-specific time trend for reasons other than shocks affecting all Sub-Saharan countries (see equation (3) in the main text). *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 5. Income Shocks and Polity Change

	Δ Polity2				ΔExconst	ΔPolcomp	ΔExrec
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	2SLS	2SLS	LS	LS	2SLS	2SLS	2SLS
Log GDP, t-1	-18.021** [0.049]	-21.410** [0.026]	-0.045 [0.901]	-0.836 [0.139]	-5.809* [0.073]	-7.680** [0.037]	-6.137* [0.054]
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	955	902	3191	955	902	902	902
	First Stage for Log GDP Per Capita, t-1						
Log Rainfall, t-1	0.079*** (0.029)	0.077*** (0.029)			0.077*** (0.029)	0.077*** (0.029)	0.077*** (0.029)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	955	902	3191	955	902	902	902

Note: The method of estimation for the first-stage regressions in the bottom panel is least squares; below the least squares estimates we report Huber robust (in parentheses) standard errors that are clustered at the country level. The method of estimation used in the top panel is two-stage least squares in columns (1)-(2) and (5)-(7); below the two-stage least squares estimates we report p-values [in square brackets] based on the Anderson-Rubin test of statistical significance. A key property of this test is that it is robust to weak instruments; 2SLS standard errors are not robust to weak instruments, and inference based on 2SLS can be very misleading as a result. See Andrews and Stock (2005) for a review of these issues. We implement a version of the Anderson-Rubin test that is robust to heteroskedasticity and arbitrary within-country correlation of the residuals. For comparison with the two-stage least squares estimates, the top panel also reports least squares estimates for the world sample (in column (3)) and the Sub-Saharan African sample (in column (4)) with p-values that are robust to heteroskedasticity and arbitrary within-country correlation below the estimates. The dependent variable in the top panel, columns (1)-(4) is the *t* to *t*+1 change in the revised combined Polity score (*Polity2*); column (2) excludes observations that correspond to interregnum periods. The dependent variable in the top panel, columns (5)-(7) is the *t* to *t*+1 change in Polity IV sub-scores of constraints on the executive (*Exconst)*, political competition (*Polcomp*), and executive recruitment (*Exrec*). The range of the dependent variables is as follows: *Polity2* [-10,10], *Exconst* [1,7], *Polcomp* [1,10], and *Exrec* [1,8]. The dependent variable in the bottom panel is the log of real per capita GDP. *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 6. Country Specific Recessions and Polity Change

	Δ Polity2				ΔExconst	ΔPolcomp	ΔExrec
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	2SLS	2SLS	LS	LS	2SLS	2SLS	2SLS
Country Specific Recession, t-1	3.584** [0.049]	4.166** [0.026]	-0.085 [0.149]	0.199* [0.085]	1.130* [0.073]	1.494** [0.037]	1.194* [0.054]
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	955	902	3191	955	902	902	902
	First Stage for Country Specific Recession, t-1						
Log Rainfall, t-1	-0.399*** (0.140)	-0.398*** (0.141)			-0.398*** (0.141)	-0.398*** (0.141)	-0.398*** (0.141)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	955	902	3191	955	902	902	902

Note: The method of estimation for the first-stage regressions in the bottom panel is least squares; below the least squares estimates we report Huber robust (in parentheses) standard errors that are clustered at the country level. The method of estimation used in the top panel is two-stage least squares in columns (1)-(2) and (5)-(7); below the two-stage least squares estimates we report p-values [in square brackets] based on the Anderson-Rubin test of statistical significance. A key property of this test is that it is robust to weak instruments; 2SLS standard errors are not robust to weak instruments, and inference based on 2SLS can be very misleading as a result. See Andrews and Stock (2005) for a review of these issues. We implement a version of the Anderson-Rubin test that is robust to heteroskedasticity and arbitrary within-country correlation of the residuals. For comparison with the two-stage least squares estimates, the top panel also reports least squares estimates for the world sample (in column (3)) and the Sub-Saharan African sample (in column (4)) with p-values that are robust to heteroskedasticity and arbitrary within-country correlation below the estimates. The dependent variable in the top panel, columns (1)-(4) is the *t* to *t*+1 change in the revised combined Polity score (*Polity2*); column (2) excludes observations that correspond to interregnum periods. The dependent variable in the top panel, columns (5)-(7) is the *t* to *t*+1 change in Polity IV sub-scores of constraints on the executive (*Exconst)*, political competition (*Polcomp*), and executive recruitment (*Exrec*). The range of the dependent variables is as follows: *Polity2* [-10,10], *Exconst* [1,7], *Polcomp* [1,10], and *Exrec* [1,8]. The dependent variable in the bottom panel is a *Country Specific Recession* indicator that is unity if and only if per capita GDP falls below the country-specific time trend for reasons other than shocks affecting all Sub-Saharan countries (see equation (3) in the main text). *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 7. Income Shocks, Polity Change, and Democratic Convergence

	Δ Polity2							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LS	SYS-GMM	2SLS	2SLS	LS	SYS-GMM	2SLS	2SLS
Polity2, t	-0.294***	-0.359***	-0.282***	-0.286***	-0.174***	-0.255***	-0.199***	-0.215***
	(0.023)	(0.037)	[0.000]	[0.000]	(0.034)	(0.041)	[0.000]	[0.000]
Polity2, t-1					-0.171***	-0.154***	-0.120**	-0.102*
					(0.025)	(0.031)	[0.020]	[0.065]
Log Rainfall, t	0.213	-0.024			0.169	-0.275		
	(0.317)	(0.387)			(0.296)	(0.392)		
Log Rainfall, t-1	-1.404**	-1.487**			-1.403**	-1.659**		
	(0.690)	(0.738)			(0.661)	(0.737)		
Log GDP, t-1			-17.360**				-17.416**	
			[0.046]				[0.036]	
Country Specific Recession, t-1				3.450**				3.460**
				[0.046]				[0.036]
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	955	955	955	955	955	955	955	955

Note: The method of estimation in columns (1) and (5) is least squares, in columns (2) and (6) system-GMM (Blundell-Bond), and in columns (3), (4), (7), and (8) two-stage least squares; below the least squares estimates we report Huber robust (in parentheses) standard errors that are clustered at the country level; below the two-stage least squares estimates we report p-values [in square brackets] based on the Anderson-Rubin test of statistical significance. A key property of this test is that it is robust to weak instruments; 2SLS standard errors are not robust to weak instruments, and inference based on 2SLS can be very misleading as a result. See Andrews and Stock (2005) for a review of these issues. We implement a version of the Anderson-Rubin test that is robust to heteroskedasticity and arbitrary within-country correlation of the residuals. The dependent variable is the *t* to *t*+1 change in the revised combined Polity score (*Polity2*). The instrumental variable in columns (3)-(4) and (7)-(8) is rainfall. *Country Specific Recession* is an indicator variable that takes on the value of unity if and only if per capita GDP falls below the country-specific time trend for reasons other than shocks affecting all Sub-Saharan countries (see equation (3) in the main text). *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 8. Rainfall and Polity Transitions

	Democratic Transition	Democratization Step	Autocratic Transition	Coup in Democracy
	(1)	(2)	(3)	(4)
	LS	LS	LS	LS
Log Rainfall, t	0.027	0.016	-0.021	-0.005
	(0.034)	(0.027)	(0.048)	(0.089)
Log Rainfall, t-1	-0.125**	-0.140**	0.169	-0.003
	(0.057)	(0.064)	(0.113)	(0.115)
Country Fixed Effect	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes
Observations	700	867	255	255

Note: The method of estimation is least squares; Huber robust standard errors (in parentheses) are clustered at the country level. The dependent variable in column (1) is a *Democratic Transition Indicator* that is equal to unity in year *t* if and only if the country is a democracy in *t* but a non-democracy in *t*-1 (the year *t* indicator is not defined if the country is a democracy in *t*-1). The dependent variable in column (2) is a *Democratization Step Indicator* that is equal to unity in year *t* if and only if the country is upgraded to either a partial or full democracy between *t*-1 and *t* (the year *t* indicator is not defined if the country is a full democracy in *t*-1). The dependent variable in column (3) is an *Autocratic Transition Indicator* that is equal to unity in year *t* if and only if the country is a non-democracy in *t* but a democracy in *t*-1 (the year *t* indicator is not defined if the country is a non-democracy in *t*-1). The dependent variable in column (4) is the incidence of a coup in African countries that were democracies. Coup data is taken from Polity IV, where a coup is defined as a forceful seizure of executive authority and office by a dissident/opposition faction within the country's ruling or political elites that results in a substantial change in the executive leadership and the policies of the prior regime. For further detail on the coding of the dependent variables see the main text, pages 6 and 7. *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 9. Income Shocks and Transitions to Democracy

	Democratic Transition			Democratization Step		
	(1)	(2)	(3)	(4)	(5)	(6)
	LS	2SLS	2SLS	LS	2SLS	2SLS
Log GDP, t-1	0.056 (0.058)	-1.285** [0.027]		-0.053 (0.051)	-1.471** [0.029]	
Country Specific Recession, t-1			0.235** [0.027]			0.279** [0.029]
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	700	700	700	867	867	867
	First Stage for Log GDP Per Capita / Country Specific Recession, t-1					
Log Rainfall, t-1		0.095*** (0.037)	-0.519*** (0.164)		0.094*** (0.032)	-0.494*** (0.151)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	700	700	700	867	867	867

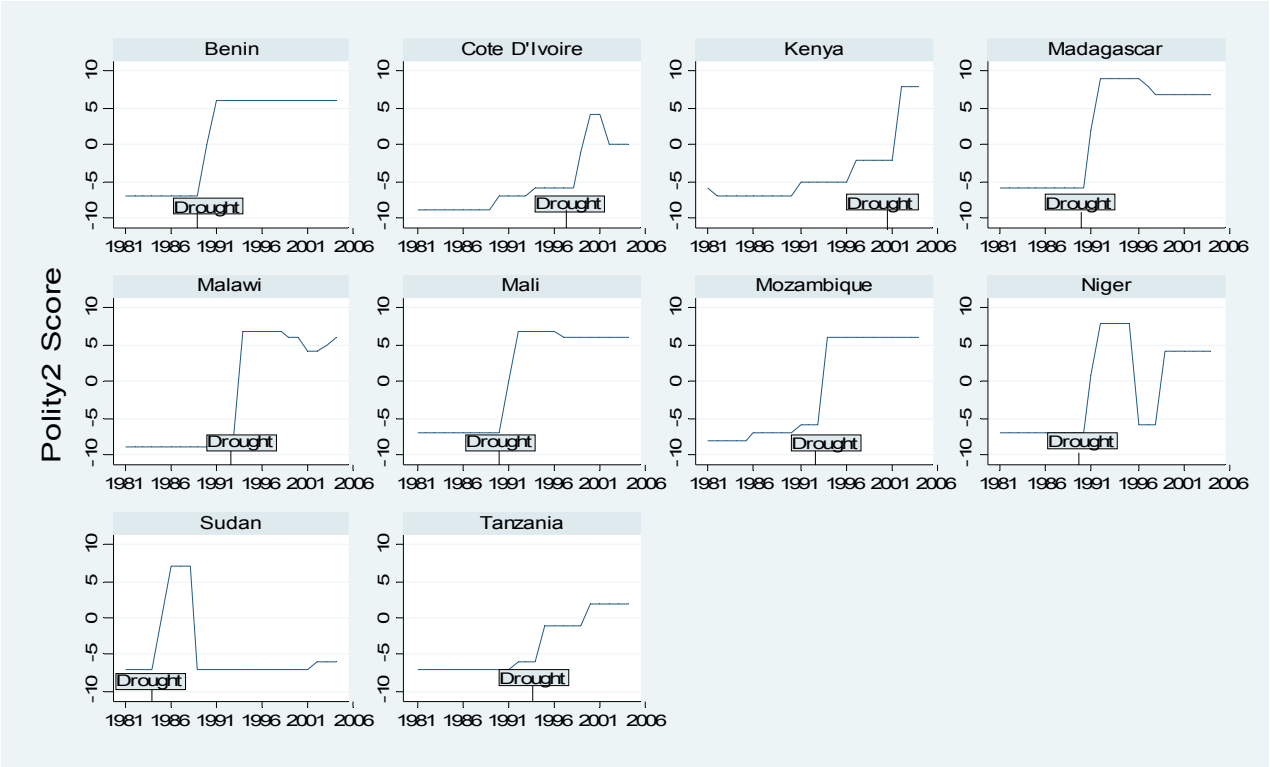
Note: The method of estimation in columns (1) and (4) is least squares and columns (2), (3), (5), and (6) two-stage least squares; below the least squares estimates we report Huber robust (in parentheses) standard errors that are clustered at the country level; below the two-stage least squares estimates we report p-values [in square brackets] based on the Anderson-Rubin test of statistical significance. A key property of this test is that it is robust to weak instruments; 2SLS standard errors are not robust to weak instruments, and inference based on 2SLS can be very misleading as a result. See Andrews and Stock (2005) for a review of these issues. We implement a version of the Anderson-Rubin test that is robust to heteroskedasticity and arbitrary within-country correlation of the residuals. The dependent variable in columns (1)-(3) is a *Democratic Transition Indicator* that is equal to unity in year *t* if and only if the country is a democracy in *t* but a non-democracy in *t*-1 (the year *t* indicator is not defined if the country is a democracy in *t*-1). The dependent variable in columns (4)-(6) is a *Democratization Step Indicator* that is equal to unity in year *t* if and only if the country is upgraded to either a partial or full democracy between *t*-1 and *t* (the year *t* indicator is not defined if the country is a full democracy in *t*-1). For further detail on the coding of the dependent variables see the main text, pages 6 and 7. *Country Specific Recession* is an indicator variable that is unity if and only if per capita GDP falls below the country-specific time trend for reasons other than shocks affecting all Sub-Saharan countries (see equation (3) in the main text). *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 10. Rain, Agriculture, GDP, and Democratic Change

	Log GDP	ΔPolity2		Democratic Transition	Democratic Step
			Panel A: Below the Sample Median		
	(1)	(2)	(3)	(4)	(5)
	LS	LS	LS	LS	LS
Log Rainfall, t	0.031	0.240	0.181	-0.010	0.021
	(0.032)	(0.380)	(0.386)	(0.039)	(0.020)
Log Rainfall, t-1	0.003	-0.885	-1.010	-0.083	-0.042
	(0.036)	(0.734)	(0.730)	(0.084)	(0.067)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	468	468	450	336	396
			Panel B: Above the Sample Median		
	(1)	(2)	(3)	(4)	(5)
	LS	LS	LS	LS	LS
Log Rainfall, t	0.130***	0.519	0.011	0.070	0.021
	(0.045)	(0.685)	(0.840)	(0.070)	(0.049)
Log Rainfall, t-1	0.088	-2.773*	-3.490***	-0.207**	-0.297***
	(0.056)	(1.430)	(1.329)	(0.090)	(0.105)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	487	487	452	364	471

Note: The method of estimation is least squares; Huber robust standard errors (in parentheses) are clustered at the country level. Panel A computes regressions for countries whose 1980-2004 agricultural share in GDP is below sample median; Panel B whose 1980-2004 agricultural share is above sample median. The dependent variable in column (1) is the log of real per capita GDP; in column (2) the dependent variable is the *t* to *t*+1 change in the revised combined Polity score (*Polity2*); column (3) excludes observations that correspond to interregnum periods; in column (4) the dependent variable is a *Democratic Transition Indicator* that is equal to unity in year *t* if and only if the country is a democracy in *t* but a non-democracy in *t*-1 (the year *t* indicator is not defined if the country is a democracy in *t*-1); in column (5) the dependent variable is a *Democratization Step Indicator* that is equal to unity in year *t* if and only if the country is upgraded to either a partial or full democracy between *t*-1 and *t* (the year *t* indicator is not defined if the country is a full democracy in *t*-1). For further detail on the coding of the dependent variables see the main text, pages 6 and 7. The average share of agriculture in GDP is from WDI (2009). *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Figure 1. Time Series Plots of Polity Change and Drought Years



Note: The variable on the y-axis is the *Polity2* score; *Drought* is an indicator variable that is equal to unity if and only if rainfall is below the 20th percentile of the country-specific rainfall distribution.

Figure 2A. Rainfall and Per Capita GDP

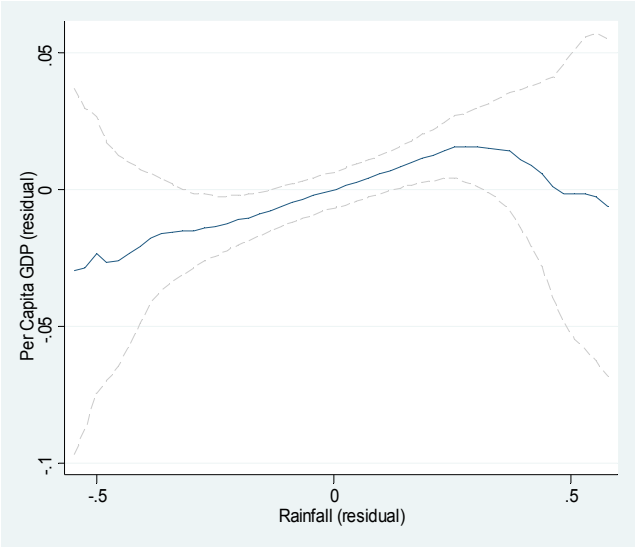
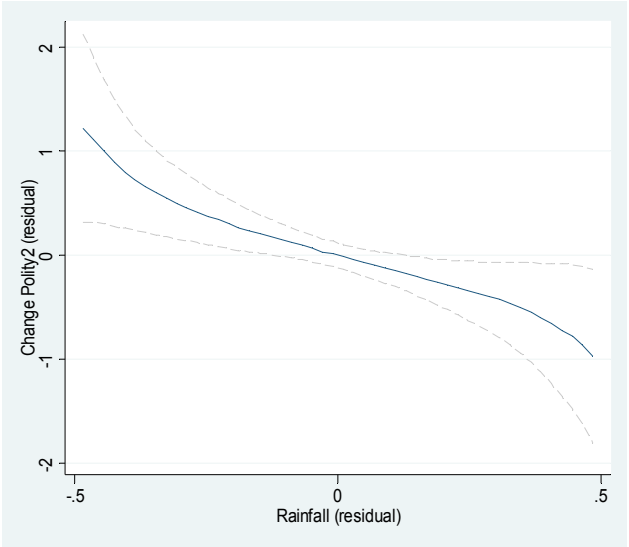


Figure 2B. Rainfall and Polity Change



Note: Non-parametric local polynomial estimates are computed using an Epanechnikov kernel; the bandwidth in Figure 2A (2B) is 0.1 (0.25) as suggested by cross-validation criteria. Dashed lines indicate 95 percent confidence bands.

Supplementary Appendix

to the paper

Rain and the Democratic Window of Opportunity

by Markus Brückner and Antonio Ciccone

October 2009

downloadable from: www.antoniociccone.eu

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Table 1. First Stage Log-Level and First-Difference Estimation

	Log GDP	ΔLog GDP
	(1)	(2)
	LS	LS
Rainfall, t	0.875***	
	(0.328)	
Rainfall, t-1	0.944**	
	(0.399)	
ΔLog Rainfall, t		0.058***
		(0.016)
ΔLog Rainfall, t-1		0.042***
		(0.015)
Country Fixed Effect	Yes	Yes
Country Time Trend	Yes	No
Common Time Effect	Yes	Yes
Observations	955	955

Note: The method of estimation is least squares; Huber robust standard errors in parentheses are clustered at the country level. The dependent variable in column (1) is the log of real per capita GDP; in column (2) the dependent variable is the first difference of the log of real per capita GDP. Rainfall units are in 100mm per year. *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 2. Controlling for Temperature

	Log GDP	ΔPolity2	
	(1)	(2)	(3)
	LS	LS	LS
Log Rainfall, t	0.078***	0.361	0.100
	(0.028)	(0.354)	(0.402)
Log Rainfall, t-1	0.054*	-1.209*	-1.440*
	(0.032)	(0.727)	(0.745)
Temperature, t	0.007	0.367	0.323
	(0.016)	(0.252)	(0.262)
Temperature, t-1	0.009	0.267	0.198
	(0.022)	(0.277)	(0.253)
Country Fixed Effect	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes
Observations	955	955	902

Note: The method of estimation is least squares; Huber robust standard errors in parentheses are clustered at the country level. The dependent variable in column (1) is the log of real per capita GDP; in column (2) the dependent variable is the *t* to *t*+1 change in the revised combined Polity score (*Polity2*); column (3) excludes observations that correspond to interregnum periods. Rainfall data are from GPCP (Adler et al. 2003); temperature data from Matsuura and Willmott (2007). The Matsuura and Willmott data contain temperature estimates on a 0.5x0.5 degree latitude/longitude grid. We obtain country-level temperature as the average of the estimates corresponding to grid points within countries' borders. *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 3. Non-Linearities

Log GDP

Panel A: 80th, 90th, 95th Percentile

	Country Specific Rainfall Dummies			Global Rainfall Dummies		
	(1)	(2)	(3)	(4)	(5)	(6)
	LS	LS	LS	LS	LS	LS
Log Rainfall, t	0.087***	0.079**	0.091***	0.093**	0.075**	0.063**
	(0.029)	(0.034)	(0.029)	(0.037)	(0.031)	(0.030)
Above 95th	-0.016			-0.017		
Percentile Dummy	(0.018)			(0.018)		
Above 90th		0.001			0.003	
Percentile Dummy		(0.015)			(0.012)	
Above 80th			-0.007			0.008
Percentile Dummy			(0.011)			(0.012)

Panel B: 5th, 10th, 20th Percentile

	Country Specific Rainfall Dummies			Global Rainfall Dummies		
	(1)	(2)	(3)	(4)	(5)	(6)
	LS	LS	LS	LS	LS	LS
Log Rainfall, t	0.075***	0.073***	0.082**	0.084**	0.086**	0.067*
	(0.028)	(0.030)	(0.038)	(0.032)	(0.037)	(0.038)
Below 5th	-0.009			0.006		
Percentile Dummy	(0.023)			(0.017)		
Below 10th		-0.007			0.005	
Percentile Dummy		(0.013)			(0.012)	
Below 20th			0.002			-0.006
Percentile Dummy			(0.012)			(0.009)
Observations	955	955	955	955	955	955

Note: The dependent variable is the log of real per capita GDP. Huber robust standard errors are clustered at the country level. The dummy variables in Panel A are indicator functions that are equal to unity if and only if rainfall is above the 95th/90th/80th percentile of the rainfall distribution; in Panel B dummy variables are indicator functions that are equal to unity if and only if rainfall is below the 5th/10th/20th percentile of the rainfall distribution. Columns (1)-(3) refer to the percentiles of the country-specific rainfall distribution of yearly rainfall levels, while columns (4)-(6) refer to the percentiles of the distribution of yearly rainfall levels across all Sub-Saharan African countries. All regressions control for country fixed effects, country-specific time trends, and year fixed effects. *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 4. Excluding Top 1 Percent of Rainfall

	Log GDP	ΔPolity2	
	(1)	(2)	(3)
	LS	LS	LS
Log Rainfall, t	0.086***	0.245	0.007
	(0.029)	(0.345)	(0.375)
Log Rainfall, t-1	0.041	-1.174**	-1.345**
	(0.033)	(0.560)	(0.562)
Country Fixed Effect	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes
Observations	945	945	893

Note: The method of estimation is least squares; Huber robust standard errors in parentheses are clustered at the country level. The regressions are for the sample excluding the top 1 percent of rainfall observations. The dependent variable in column (1) is the log of real per capita GDP; in column (2) the dependent variable is the *t* to *t*+1 change in the revised combined Polity score (*Polity2*); column (3) excludes observations that correspond to interregnum periods. *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 5. Spatial Correlation

	Log GDP	ΔPolity2	
	(1)	(2)	(3)
	LS	LS	LS
Log Rainfall, t	0.077**	0.539	0.395
	(0.033)	(0.429)	(0.473)
Log Rainfall, t-1	0.036	-1.701**	-1.974**
	(0.033)	(0.766)	(0.760)
Log Rainfall of	0.011	-0.680	-0.914
Neighbors, t	(0.031)	(0.725)	(0.789)
Log Rainfall of	0.037	0.633	0.822
Neighbors, t-1	(0.037)	(0.771)	(0.828)
Country Fixed Effect	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes
Observations	955	955	902

Note: The method of estimation is least squares; Huber robust standard errors in parentheses are clustered at the country level. The dependent variable in column (1) is the log of real per capita GDP; in column (2) the dependent variable is the *t* to *t*+1 change in the revised combined Polity score (*Polity2*); column (3) excludes observations that correspond to interregnum periods. *Rainfall of Neighbors* is the average amount of rainfall in bordering countries. *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 6. Alternative Estimation of Standard Errors

	Panel A: Log GDP								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	HAC BW(2)	HAC BW(4)	HAC BW(24)	FGLS AR(1)	Country Cluster	Bootstrap	Year Cluster	CGM (2007)	DK (1998)
Log Rainfall, t	0.075*** (0.023)	0.075*** (0.023)	0.075*** (0.026)	0.068*** (0.016)	0.075*** (0.026)	0.075*** (0.026)	0.075*** (0.023)	0.075*** (0.028)	0.075*** (0.019)
Log Rainfall, t-1	0.048** (0.023)	0.048** (0.023)	0.048* (0.029)	0.048*** (0.016)	0.048 (0.032)	0.048 (0.030)	0.048** (0.019)	0.048 (0.032)	0.048*** (0.013)
Observations	955	955	955	955	955	955	955	955	955
	Panel B: ΔPolity2								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	HAC BW(2)	HAC BW(4)	HAC BW(24)	FGLS AR(1)	Country Cluster	Bootstrap	Year Cluster	CGM (2007)	DK (1998)
Log Rainfall, t	0.261 (0.384)	0.261 (0.380)	0.261 (0.363)	0.265 (0.421)	0.261 (0.347)	0.261 (0.355)	0.261 (0.342)	0.261 (0.327)	0.261 (0.394)
Log Rainfall, t-1	-1.461** (0.588)	-1.461** (0.603)	-1.461** (0.708)	-1.391*** (0.430)	-1.461** (0.723)	-1.461** (0.739)	-1.461*** (0.459)	-1.461** (0.675)	-1.461*** (0.314)
Observations	955	955	955	955	955	955	955	955	955
	Panel C: Adjusted ΔPolity2								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	HAC BW(2)	HAC BW(4)	HAC BW(24)	FGLS AR(1)	Country Cluster	Bootstrap	Year Cluster	CGM (2007)	DK (1998)
Log Rainfall, t	0.031 (0.406)	0.031 (0.405)	0.031 (0.394)	0.008 (0.400)	0.031 (0.381)	0.031 (0.389)	0.031 (0.383)	0.031 (0.396)	0.031 (0.466)
Log Rainfall, t-1	-1.660*** (0.615)	-1.660** (0.631)	-1.660** (0.734)	-1.744*** (0.452)	-1.660** (0.740)	-1.660** (0.751)	-1.660*** (0.509)	-1.660** (0.718)	-1.660*** (0.369)
Observations	902	902	902	902	902	902	902	902	902

Note: The dependent variable in Panel A is the log of real per capita GDP; in Panel B the *t* to *t*+1 change in the revised combined Polity score; Panel C excludes observations that correspond to interregnum periods. Standard errors are listed in parentheses. All regressions control for country fixed effects, country-specific time trends, and year fixed effects. Columns (1)-(3) compute heteroskedasticity and autocorrelation consistent standard errors based on the Newey-West estimator with a bandwidth of 2 (column (1)), 4 (column (2)), and 24 (column (3)); column (4) computes FGLS standard errors assuming country-specific AR(1) serial correlation; column (5) computes Huber robust standard errors that are clustered at the country level; column (6) computes standard errors using the block-bootstrap; column (7) computes Huber robust standard errors that are clustered at the year level; column (8) computes Huber robust standard errors that are clustered at the country and year level using the Cameron, Gelbach, and Miller (*Robust Inference with Multi-Way Clustering*, 2006, NBER Technical Paper No. T0327) multi-cluster estimator; column (9) computes standard errors that are robust to arbitrary spatial correlation using the Driscoll and Kraay (*Consistent Estimation of Covariance Matrix Estimation with Spatially Dependent Panel Data*, 1998, Review of Economics and Statistics) estimator. *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 7. Matsuura and Willmott Rainfall Data

Time Period:	1980-2004	1960-1980	1960-1990	Independence-1980	Independence-1990
			Panel A: First Stage Per Capita GDP		
	(1)	(2)	(3)	(4)	(5)
	LS	LS	LS	LS	LS
Log Rainfall, t	-0.007	0.085***	0.059**	0.084***	0.073**
	(-0.021)	(0.021)	(0.028)	(0.019)	(0.029)
Log Rainfall, t-1	-0.022	0.092***	0.049	0.083***	0.051
	(-0.030)	(0.030)	(0.037)	(0.034)	(0.039)
Observations	955	683	1083	624	1024
			Panel B: Reduced Form ΔPolity2		
	(1)	(2)	(3)	(4)	(5)
	LS	LS	LS	LS	LS
Log Rainfall, t	0.166	-0.990*	-0.736**	-0.852	-0.683**
	(0.277)	(0.542)	(0.344)	(0.548)	(0.324)
Log Rainfall, t-1	-1.325*	-0.121	-0.379	-0.203	-0.443
	(0.735)	(0.548)	(0.353)	(0.523)	(0.360)
Observations	955	689	1089	720	1120
			Panel C: Reduced Form Adjusted ΔPolity2		
	(1)	(2)	(3)	(4)	(5)
	LS	LS	LS	LS	LS
Log Rainfall, t	0.126	-1.044**	-0.749**	-0.904*	-0.688**
	(0.292)	(0.525)	(0.345)	(0.536)	(0.326)
Log Rainfall, t-1	-1.207	-0.138	-0.340	-0.221	-0.399
	(0.786)	(0.523)	(0.360)	(0.518)	(0.363)
Observations	902	682	1075	713	1106

Note: The method of estimation is least squares; Huber robust standard errors (in parentheses) are clustered at the country level. Rainfall data are from Matsuura and Willmott (2007). The Matsuura and Willmott data contain rainfall estimates on a 0.5x0.5 degree latitude/longitude grid. We obtain country-level rainfall as the average of the estimates corresponding to grid points within countries' borders. All regressions control for country fixed effects, country-specific time trends, and year fixed effects. The dependent variable in Panel A is the log of real per capita GDP; in Panel B the *t* to *t*+1 change in the revised combined Polity score; Panel C excludes observations that correspond to interregnum periods. *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 8. The Effect of Rainfall on Government (Military) Expenditures and Consumer Prices

	ΔGovernment Expenditure		ΔMilitary Expenditure		ΔConsumer Prices	
	(1)	(2)	(3)	(4)	(5)	(6)
	LS	SYS-GMM	LS	SYS-GMM	LS	SYS-GMM
Log Rainfall, t	-0.006	0.011	-0.016	-0.089	-0.069	-0.079
	(0.035)	(0.048)	(0.084)	(0.079)	(0.073)	(0.073)
Log Rainfall, t-1	0.029	0.019	0.106	0.016	0.059	0.023
	(0.029)	(0.045)	(0.135)	(0.105)	(0.061)	(0.055)
Log Government Expenditure, t-1		-0.449***				
		(0.028)				
Log Military Expenditure, t-1				-0.682***		
				(0.149)		
Log Consumer Price, t-1						-0.334***
						(0.037)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	936	936	431	431	936	936

Note: The method of estimation in columns (1), (3), and (5) is least squares; columns (2), (4) and (6) SYS-GMM (Blundell-Bond). Huber robust standard errors (in parentheses) are clustered at the country level. The dependent variable in columns (1) and (2) is the log change in government expenditure; in columns (3) and (4) the dependent variable is the log change in military expenditure; in columns (5) and (6) the log change in consumer prices. Government expenditure data and consumer price data are from PWT 6.2; data on military expenditure are from WDI (2009). *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 9. Freedom House Political Rights Indicator

	ΔPolitical Rights						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	LS	2SLS	2SLS	LS	SYS-GMM	2SLS	2SLS
Log Rainfall, t	0.042			0.044	0.113		
	(0.135)			(0.129)	(0.143)		
Log Rainfall, t-1	-0.190			-0.135	-0.094		
	(0.142)			(0.151)	(0.147)		
Log Rainfall, t-2	-0.300**			-0.334**	-0.283*		
	(0.143)			(0.151)	(0.147)		
Log GDP, t-2		-4.446**				-4.827***	
		[0.024]				[0.007]	
Country Specific Recession, t-2			0.863**				0.943***
			[0.024]				[0.007]
Political Rights, t				-0.355***	-0.342***	-0.333***	-0.356***
				(0.030)	(0.043)	[0.000]	[0.000]
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	956	956	956	956	956	956	956

Note: The method of estimation in columns (1) and (4) is least squares, column (5) system-GMM (Blundell-Bond), and columns (2), (3), (6), and (7) two-stage least squares; below least squares estimates we report Huber robust standard errors (in parentheses) clustered at the country level; below the two-stage least squares estimates we report p-values [in square brackets] based on the Anderson-Rubin test of statistical significance. A key property of this test is that it is robust to weak instruments; 2SLS standard errors are not robust to weak instruments, and inference based on 2SLS can be very misleading as a result. See Andrews and Stock (2005) for a review of these issues. We implement a version of the Anderson-Rubin test that is robust to heteroskedasticity and arbitrary within-country correlation of the residuals. The FH political rights index has a [1,7] range with higher values indicating lower political rights. In the case of the Polity score, higher values denote greater political rights. To make results more easily comparable, we therefore use the negative of the *t* to *t*+1 change in the FH political rights index so that positive changes denote more political rights and negative changes less political rights. Given the [-10,+10] range of the Polity score, the FH estimates in the table should be multiplied by 3 before comparing them to the Polity estimates (this yields FH estimates that are about 60 percent of the corresponding Polity estimates). *Country Specific Recession* is an indicator variable that is unity if and only if per capita GDP falls below the country-specific time trend for reasons other than shocks affecting all Sub-Saharan countries (see equation (3) in the main text). *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 10. Second Stage with Income Shocks in *t* and *t*-1

	Δ POLITY2		ΔEXCONST	ΔPOLCOMP	ΔEXREC
			Panel A: Per Capita GDP, t and t-1		
	(1)	(2)	(3)	(4)	(5)
	2SLS	2SLS	2SLS	2SLS	2SLS
Log GDP, t	5.389	2.493	2.122	-1.907	2.113
	(7.878)	(8.355)	(2.569)	(3.049)	(3.264)
Log GDP, t-1	-22.482*	-23.499*	-7.587	-6.083	-7.907*
	(11.746)	(13.160)	(4.860)	(4.824)	(4.545)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	955	902	902	902	902
			Panel B: Country Specific Recession, t and t-1		
	(1)	(2)	(3)	(4)	(5)
	2SLS	2SLS	2SLS	2SLS	2SLS
Country Specific Recession, t	-2.897	-2.102	-0.880	-0.153	-0.903
	(2.210)	(2.160)	(0.764)	(0.737)	(0.869)
Country Specific Recession, t-1	5.331**	5.423**	1.657	1.586	1.734*
	(2.453)	(2.478)	(0.849)	(0.995)	(0.892)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	955	902	902	902	902

Note: The method of estimation is two-stage least squares; Huber robust standard errors (shown in parentheses) are clustered at the country level. The 2SLS regressions use rainfall as an instrument for income. The dependent variable in column (1) is the *t* to *t*+1 change in the revised combined Polity score (*Polity2*); column (2) excludes observations that correspond to interregnum periods. The dependent variable in columns (3)-(5) is the *t* to *t*+1 change in Polity IV sub-scores of constraints on the executive (*EXCONST)*, political competition (*POLCOMP*), and executive recruitment (*EXREC*). The range of the dependent variables is as follows: *Polity2* [-10,10], *EXCONST* [1,7], *POLCOMP* [1,10], and *EXREC* [1,8]. *Country Specific Recession* is an indicator variable that is unity if and only if per capita GDP falls below the country specific time trend for reasons other than shocks affecting all Sub-Saharan countries (see equation (3) in the main text). *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 11. Second Stage with Income Shocks in *t*

	Δ Polity2		ΔExconst	ΔPolcomp	ΔExrec
			Panel A: Per Capita GDP, t		
	(1)	(2)	(3)	(4)	(5)
	2SLS	2SLS	2SLS	2SLS	2SLS
Log GDP, t	1.499 [0.781]	-1.994 [0.716]	0.673 [0.645]	-3.068 [0.155]	0.604 [0.808]
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	955	902	902	902	902
			Panel B: Country Specific Recession, t		
	(1)	(2)	(3)	(4)	(5)
	2SLS	2SLS	2SLS	2SLS	2SLS
Country Specific Recession, t	-0.285 [0.781]	0.370 [0.716]	-0.125 [0.645]	0.570 [0.155]	-0.112 [0.808]
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	955	902	902	902	902

Note: The method of estimation is two-stage least squares; the instrumental variable is rainfall. Below the two-stage least squares estimates we report p-values [in square brackets] based on the Anderson-Rubin test of statistical significance. A key property of this test is that it is robust to weak instruments; 2SLS standard errors are not robust to weak instruments, and inference based on 2SLS can be very misleading as a result. See Andrews and Stock (2005) for a review of these issues. We implement a version of the Anderson-Rubin test that is robust to heteroskedasticity and arbitrary within-country correlation of the residuals. The dependent variable in column (1) is the *t* to *t*+1 change in the revised combined Polity score (*Polity2*); column (2) excludes observations that correspond to interregnum periods. The dependent variable in columns (3)-(5) is the *t* to *t*+1 change in Polity IV sub-scores of constraints on the executive (*Exconst)*, political competition (*Polcomp*), and executive recruitment (*Exrec*). The range of the dependent variables is as follows: *Polity2* [-10,10], *Exconst* [1,7], *Polcomp* [1,10], and *Exrec* [1,8]. *Country Specific Recession* is an indicator variable that is unity if and only if per capita GDP falls below the country-specific time trend for reasons other than shocks affecting all Sub-Saharan countries (see equation (3) in the main text). *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 12. Dynamic Panel Estimates

	Panel A: Per Capita GDP				
	(1)	(2)	(3)	(4)	(5)
	LS	LS	LS	SYS-GMM	SYS-GMM
Log Rainfall, t	0.075***	0.061***	0.062***	0.065***	0.061***
	(0.026)	(0.017)	(0.017)	(0.019)	(0.019)
Log Rainfall, t-1	0.048	0.004	0.003	0.013	0.007
	(0.032)	(0.021)	(0.021)	(0.020)	(0.020)
Log GDP, t-1		0.635***	0.655***	0.550***	0.583***
		(0.033)	(0.046)	(0.013)	(0.051)
Log GDP, t-2			-0.029		-0.029
			(0.040)		(0.042)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	955	955	955	955	955
	Panel B: ΔPolity2				
	(1)	(2)	(3)	(4)	(5)
	LS	LS	LS	SYS-GMM	SYS-GMM
Log Rainfall, t	0.261	0.213	0.169	-0.024	-0.275
	(0.347)	(0.317)	(0.296)	(0.387)	(0.392)
Log Rainfall, t-1	-1.461**	-1.401**	-1.403**	-1.486**	-1.659**
	(0.723)	(0.690)	(0.661)	(0.738)	(0.737)
Polity2, t		-0.294***	-0.174***	-0.359***	-0.255***
		(0.023)	(0.034)	(0.037)	(0.041)
Polity2, t-1			-0.171***		-0.154***
			(0.025)		(0.031)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	955	955	955	955	955

Note: The method of estimation in columns (1)-(3) is least squares, in columns (4) and (5) system-GMM (Blundell-Bond). Huber robust standard errors (in parentheses) are clustered at the country level. The dependent variable in Panel A is the log of real per capita GDP; in Panel B the *t* to *t*+1 change in the revised combined Polity score. *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 13. Polity Level Estimates

	Polity2							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LS	SYS-GMM	LS	SYS-GMM	LS	SYS-GMM	LS	SYS-GMM
Polity2, t	0.706***	0.641***	0.826***	0.746***	0.728***	0.637***	0.860***	0.769***
	(0.023)	(0.037)	(0.034)	(0.041)	(0.022)	(0.031)	(0.030)	(0.033)
Polity2, t-1			-0.171***	-0.154***			-0.185***	-0.170***
			(0.025)	(0.031)			(0.026)	(0.030)
Log Rainfall, t	0.213	-0.024	0.169	-0.275	0.053	0.236	-0.016	-0.034
	(0.317)	(0.387)	(0.296)	(0.392)	(0.346)	(0.371)	(0.326)	(0.365)
Log Rainfall, t-1	-1.401**	-1.486**	-1.403**	-1.649**	-1.665**	-1.524**	-1.612**	-1.667**
	(0.690)	(0.738)	(0.661)	(0.737)	(0.701)	(0.746)	(0.671)	(0.724)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	955	955	955	955	902	902	902	902

Note: The dependent variable is the revised combined Polity score in *t*+1; columns (5)-(8) exclude observations that correspond to interregnum periods. The method of estimation in columns (1), (3), (5), and (7) is least squares; columns (2), (4), (6), and (8) SYS-GMM (Blundell-Bond). Huber robust standards errors (in parentheses) are clustered at the country level. *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

Table 14. Year-to-Year Rainfall Growth and Democratic Change

	ΔPolity2		ΔExconst	ΔPolcomp	ΔExrec	Democratic Transition	Democratic Step
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	LS	LS	LS	LS	LS	LS	LS
Rainfall Growth, t	0.586**	0.470	0.195	0.032	0.230	0.059	0.067**
	(0.293)	(0.330)	(0.125)	(0.137)	(0.149)	(0.036)	(0.030)
Rainfall Growth, t-1	-0.628	-0.836*	-0.180	-0.404**	-0.125	-0.040	-0.026
	(0.466)	(0.459)	(0.134)	(0.197)	(0.202)	(0.035)	(0.031)
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	955	902	902	902	902	700	867

Note: The method of estimation is least squares, standard errors (in parentheses) are clustered at the country level. The dependent variable in column (1) is the *t* to *t+1* change in the revised combined Polity score (*Polity2*); column (2) excludes observations that correspond to interregnum periods. The dependent variable in columns (3)-(5) is the *t* to *t+1* change in Polity IV sub-scores that reflect changes in a country's constraints on the executive (*Exconst)*, political competition (*Polcomp*), and executive recruitment (*Exrec*). The range of the dependent variables is as follows: *Polity2* [-10,10], *Exconst* [1,7], *Polcomp* [1,10], and *Exrec* [1,8]. The dependent variable in column (6) is a *Democratic Transition Indicator* that is equal to unity in year *t* if and only if the country is a democracy in *t* but a non-democracy in *t*-1 (the year *t* indicator is not defined if the country is a democracy in *t*-1); in column (7) the dependent variable is a *Democratization Step Indicator* that is equal to unity in year *t* if and only if the country is upgraded to either a partial or full democracy between *t*-1 and *t* (the year *t* indicator is not defined if the country is a full democracy in *t*-1). Rainfall growth in *t* is calculated as logRain in *t* minus logRain in *t*-1 and therefore denotes the growth rate of rainfall between *t* and *t*-1 in log points. Rainfall growth in *t*-1 is calculated as logRain in *t*-1 minus logRain in *t*-2 and therefore denotes the growth rate of rainfall between *t*-1 and *t*-2 in log points. *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

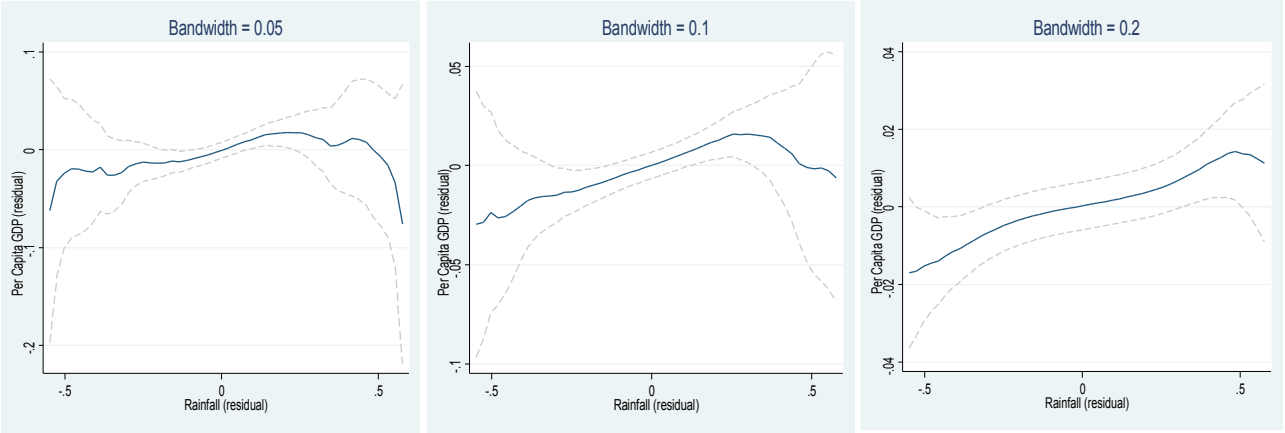
Table 15. Rainfall and Value Added in the Agricultural Sector

	Log Agricultural GDP			
	(1)	(2)	(3)	(4)
	LS	LS	LS	LS
Log Rainfall, t	0.205***	0.195***	0.198***	0.188***
	(0.052)	(0.049)	(0.050)	(0.051)
Log Rainfall, t-1		0.128***	0.122***	0.124***
		(0.045)	(0.042)	(0.042)
Log Rainfall, t-2			0.071	
			(0.064)	
Log Rainfall, t* Polity2, t				-0.002
				(0.003)
Polity2, t				-0.001
				(0.003)
Log Rainfall, t-1* Polity2, t-1				0.010
				(0.021)
Polity2, t-1				0.002
				(0.019)
Country Fixed Effect	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes
Common Time Effect	Yes	Yes	Yes	Yes
Observations	814	814	814	814

Note: The method of estimation is least squares; Huber robust standard errors (in parentheses) are clustered at the country level. The dependent variable is the log of agricultural GDP, calculated as the log of the share of agricultural value added in GDP (from WDI, 2009) plus the log of real GDP (from PWT 6.2). *Significantly different from zero at 90 percent confidence, ** 95 percent confidence, *** 99 percent confidence.

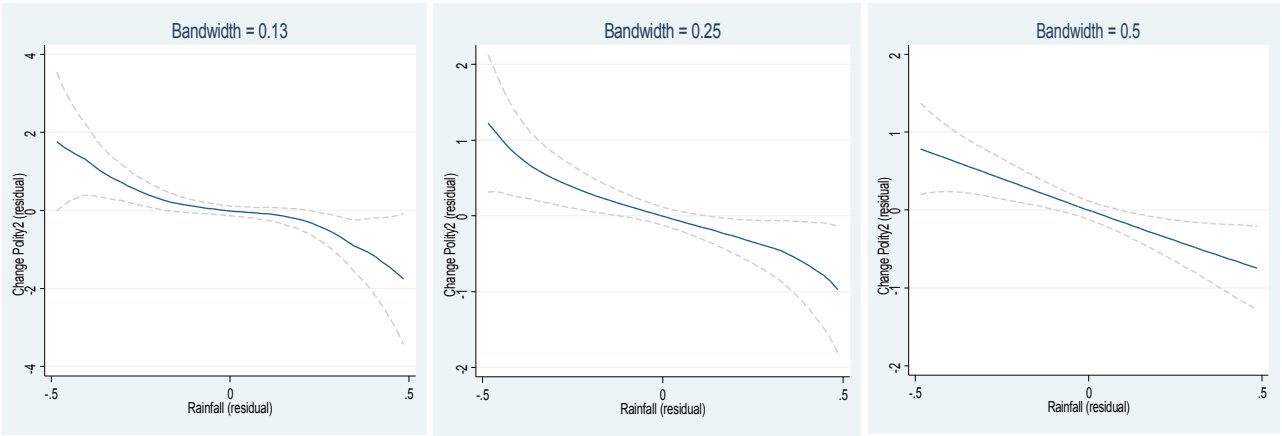
Figure 1. Non-Parametric Local Polynomial Estimates with Alternative Bandwidths

Figure 1A. Rainfall and Per Capita GDP



Note: Non-parametric local polynomial estimates are computed using an Epanechnikov kernel. Dashed lines indicate 95 percent confidence bands. The graph in the middle uses the bandwidth suggested by cross-validation criteria.

Figure 1B. Rainfall and Polity Change



Note: Non-parametric local polynomial estimates are computed using an Epanechnikov kernel. Dashed lines indicate 95 percent confidence bands. The graph in the middle uses the bandwidth suggested by cross-validation criteria.