Democratic Tipping Points

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Abstract

We examine whether transitory random events can tip the scales against nondemocratic regimes and lead to persistent democratization. The events we examine are rainfall shocks in the world's most agricultural countries. We find that these shocks have solely contemporaneous effects on agricultural output. But the effects of rainfall shocks on democratization are persistent and do not taper off over time. As the agricultural economics literature, we find that agricultural output rises with rainfall up to a relatively high level; beyond this level, additional rainfall lowers agricultural output. That is, the effect of rainfall on agricultural output is inverted-U-shaped. The effect of rainfall on the probability of democratization turns out to be U-shaped, as it would be if the effect of rainfall on democratization is through agricultural output.

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1 Introduction

Political institutions may be shaped enduringly by seemingly random events at critical junctures (e.g. Lipset and Rokkan, 1967; Mahoney, 2000, 2001; Capoccia and Kelemen, 2007; Acemoglu and Robinson, 2012). This elementary idea appears to fit important historical narratives. We propose an empirical examination that combines transitory economic shocks in the world's most agricultural countries with their history of democratic (non-)transitions.

Empirically, it will be hard to say whether political institutions are at a critical juncture in a specific country at a certain point in time. As a result, it is difficult to examine whether random events at specific critical junctures have persistent effects on political institutions. However, suppose one observes a group of countries subject to similar transitory shocks over a long enough time period. If political institutions were at critical junctures in some of these countries during some of the time, these transitory shocks should lead to persistent changes in political institutions. This is the basic idea of our empirical examination. The group of countries is the world's most agricultural countries, the transitory shocks are rainfall shocks, and the changes in political institutions are transitions from nondemocratic regimes to democracy.

The theory of political transitions we build our empirical examination on is that of Acemoglu and Robinson (2001, 2006). The main conclusion from our point of view is that transitory economic shocks may trigger persistent democratization. The theory has countries initially being ruled by nondemocratic regimes. The disenfranchised poor majority can contest the authoritarian rule. As the opportunity cost of doing so is lower following transitory negative economic shocks, such shocks may put the disenfranchised in a temporary position to demand democratization. As a result, transitory negative economic shocks can lead to democratization. Democratization may be followed by nondemocratic reversal or may be permanent, depending on the constellation of several factors—income inequality and the cost of coups for example. We refer to the constellations of preconditions where a transitory negative economic shock would lead to persistent democratization as democratic tipping points.

The persistence of democratization plays an important role in Acemoglu and Robinson's theory of political transitions. The disenfranchised poor could demand policy concessions rather than contest authoritarian rule. When they demand democratization, it is because democra-

tization is more difficult to reverse. Put differently, the demand for democratization is based on the expectation that democratization will tend to persist beyond the transitory events that backed up democratization demands.

The world's most agricultural countries are a logical place to examine whether transitory economic shocks can lead to persistent democratization. Before 1960, most of them were ruled by nondemocratic regimes, but today many are democratic. Evidently, democratization was a possibility in some of these countries during some of the time. Moreover, the economic weight of agriculture and the lack of irrigation make rainfall shocks an exogenous source of repeated economic shocks in these countries.

We start our empirical examination with the effect of rainfall shocks on agricultural output since 1961 (the start date of the agricultural output dataset). We find a comparatively strong effect in countries with agricultural GDP shares in the top quintile of the distribution. The median year-on-year drop in rainfall starting at the median level of rainfall—which we refer to as the median year-on-year negative rainfall shock—caused an average drop in agricultural output of around 1% in these countries.[1] We also find the effect of rainfall on agricultural output to be transitory: there is a contemporaneous effect only; the effect of lagged rainfall is small and statistically insignificant.

We then go on to show that transitory rainfall shocks have had persistent effects on democratic institutions in the world's most agricultural countries since 1946 (different democratization datasets we use have different start and end dates). When lower rainfall leads to below-average agricultural output, countries ruled by nondemocratic regimes are more likely to democratize and more likely to be democratic ten years later. There is no evidence that this effect tapers off over time. This holds for three different dichotomous political regime classifications: the classification of Acemoglu, Naidu, Restrepo, and Robinson (2019); of Geddes, Wright, and Frantz (2014); and of Przeworski, Alvarez, Cheibub, and Limongi (2000) as updated by Cheibub, Gandhi, and Vreeland (2010) and Bjørnskov and Rode (2020). The median year-on-year negative rainfall shock makes countries ruled by nondemocratic regimes 1–2 per-

[1]The median year-on-year drop in rainfall starting at the median level of rainfall assumes a level of rainfall equal to the median in year $t-1$ and a subsequent decrease in rainfall between year $t-1$ and year t equal to the median year-on-year drop in rainfall. The median year-on-year drop in rainfall is obtained by calculating the year-on-year change in rainfall for all years and all countries in the sample and taking the median of all negative values.

centage points more likely to be democratic in the short run. Ten years later, these countries are 2–3 percentage points more likely to be democratic. Hence, transitory random events can tip the scales against nondemocratic regimes and lead to persistent democratization.[2]

The finding that democratic improvements in countries ruled by nondemocratic regimes are more likely when lower rainfall leads to below-average agricultural output and that this effect is persistent also holds using the multivalued Polity Project polity score (Marshall et al., 2014) and Freedom House index of political rights (Freedom House, 2014).

We estimate the effect of rainfall on agricultural output following the agricultural economics literature, see Schlenker and Lobell (2010) and Lobell, Schlenker, and Costa-Roberts (2011) for example. The literature finds an inverted-U-shaped effect of rainfall: agricultural output rises with rainfall up to a relatively high level; beyond this level, additional rainfall lowers agricultural output. We confirm this inverted-U-shaped effect of rainfall in our data.

The inverted-U-shaped effect of rainfall on agricultural output yields an opportunity to examine whether the effect of rainfall on democratization we find is through agricultural output. In the theory of Acemoglu and Robinson (2001, 2006) we build on, transitorily lower output raises the probability of democratization, and transitorily higher output lowers the probability of democratization. The inverted-U-shaped effect of rainfall on agricultural output implies that when the level of rainfall is to the left of the peak of the inverted U, higher rainfall raises output. According to Acemoglu and Robinson's theory, higher rainfall should therefore lower the probability of democratization. But when the level of rainfall is to the right of the peak, higher rainfall lowers output and should, in theory, raise the probability of democratization. As a result—if the effect of rainfall on democratization is through agricultural output—the inverted-U-shaped effect of rainfall on agricultural output should translate into a U-shaped effect of rainfall on democratization. That is, the shape of the effect of rainfall on the probability of democratization should be the flipped image of the shape of the effect of rainfall on agricultural output. We find this to be the case. Moreover, the lowest point of the U-shaped effect of rainfall on the probability of democratization turns out to be at a similar level of rainfall as the highest

[2]For comparison, on average, the share of t to $t+1$ democratization events that persist ten years later in this sample of countries is between 50% (Przeworski et al. democratizations) and 70% (Geddes et al. democratizations). Including countries with agricultural GDP shares outside the top quintile yields somewhat greater persistence of democratization events.

point of the inverted-U-shaped effect of rainfall on agricultural output. Hence, rainfall shocks tend to produce the largest change in the probability of democratization when the estimated effect of rainfall on agricultural output is the largest.

Our work fits into the literature on the economic determinants of democratic change. Some of the more recent contributions are Przeworski and Limongi (1997), Barro (1999), Przeworski, Alvarez, Cheibub, and Limongi (2000), Acemoglu, Johnson, Robinson, and Yared (2008), Brückner and Ciccone (2011), Aidt and Franck (2015), and Caselli and Tesei (2016). Our contribution is to investigate the existence of democratic tipping points: persistent changes in democratic institutions caused by transitory shocks.

Within the literature on the economic determinants of democratic change, we are closest to Acemoglu, Johnson, Robinson, and Yared (2008) and Brückner and Ciccone (2011). With Acemoglu et al., we have in common that we also examine economic determinants of democratic change over shorter and longer periods. The main difference is that we focus on democratization following transitory economic shocks, while Acemoglu et al. analyze democratization in response to more persistent changes in income. Acemoglu et al.'s objective is to examine the empirical support for the so-called modernization theory, according to which higher income per capita leads to countries becoming more democratic. Our goal is to examine the empirical support for democratic tipping points.[3]

Brückner and Ciccone (2011) examine the effect of rainfall shocks on short-run democratic change in Sub-Saharan Africa over the 25-year period from 1980 to 2004. They find that negative rainfall shocks lead to short-run democratic improvements in the group of 21 countries with agricultural GDP shares above the Sub-Saharan-African median but not in the group of 20 countries with agricultural GDP shares below the median. With Brückner and Ciccone, we have in common that we also examine the effect of rainfall shocks on democratic change. The main difference is that they solely examine the impact of rainfall shocks on the short-run, year-on-year change in democratic institutions. That is, Brückner and Ciccone do not analyze the persistence of democratization following rainfall shocks or the effect of rainfall shocks on changes in democratic institutions over longer periods. These issues are at the core

[3]Dell (2012) also examines longer-run effects of transitory rainfall shocks. She shows that local variation in drought severity just before the Mexican Revolution affected long-run local development in Mexico through the intensity of local insurgent activity during the revolution and the amount of land redistribution following it.

of our empirical examination of democratic tipping points.[4] A methodological difference with Brückner and Ciccone is that we build on the evidence in agricultural economics that the effect of rainfall on agricultural output is inverted-U-shaped, which—if the effect of rainfall on democratization is through agricultural output—should translate into a U-shaped effect of rainfall on democratization. Brückner and Ciccone assume a monotonic effect of rainfall on democratization in their empirical analysis. There are also substantial differences in the data. We look at the most agricultural countries in the world for the largest possible period since World War II, which results in a larger and longer sample. Moreover, our empirical analysis incorporates the new political regime classifications of Acemoglu, Naidu, Restrepo, and Robinson (2019) and of Geddes, Wright, and Frantz (2014), as well as Bjørnskov and Rode's (2020) revision of the original Przeworski, Alvarez, Cheibub, and Limongi (2000) regime classification. This allows us to examine the existence of democratic tipping points for a broad set of measures of democratization.

Lipset (1959) appears to have been first to observe that democratic change often follows economic recessions. Evidence for the link between recessions and democratization is provided by Haggard and Kaufman (1995) and Acemoglu and Robinson (2001, 2006). Acemoglu and Robinson also develop a theoretical framework for understanding the effect of economic recessions on democratization. In particular, they address the key question of how an economic recession can lead to persistent democratization even if the recession itself is transitory.

The remainder of this paper is structured as follows. Sections 2 and 3 present the data and the empirical specifications. Section 4 discusses the empirical results. Section 5 concludes.

2 Data

The agricultural output data we use is the real crops production index from the United Nation's Food and Agricultural Organization (FAOSTAT, 2016). The index is available since 1961. Start

[4]Brückner and Ciccone estimate some specifications where year-on-year democratic change is linked to rainfall shocks as well as lagged democracy indices, see their Table VII. But they do not (and cannot) relate the effect of lagged democracy indices in these specifications to persistent democratization caused by (transitory) rainfall shocks. This is because the effect of lagged democracy indices they estimate reflects all sorts of reasons why democratic change may be persistent. For example, persistent socio-economic shocks in the country or persistent shocks to the international political environment.

and end dates for individual countries are listed in Appendix Table 1. We use this index to examine the effect of rainfall on agricultural output in countries grouped by their average share of agriculture in GDP. Agricultural GDP shares come from the World Development Indicators (2016) and are available since 1970.

The rainfall data comes from the United States Government's National Oceanic and Atmospheric Administration and the temperature data from the United States Government's Center for Environmental Prediction. This data is available globally on a grid of approximately 50×50 km at the equator since 1946. Country-year rainfall and temperature are measured as average annual rainfall and average temperature within a country's territory.

We use three different datasets that classify regimes into democracies and nondemocracies, and two multivalued measures of the quality of democratic institutions. Start and end dates vary across datasets and countries and are listed in Appendix Table 1. The three dichotomous regime classifications we use are Acemoglu, Naidu, Restrepo, and Robinson (2019); Geddes, Wright, and Frantz (2014)[5]; and Przeworski, Alvarez, Cheibub, and Limongi (2000) as updated by Cheibub, Gandhi, and Vreeland (2010) and Bjørnskov and Rode (2020). The Acemoglu et al. classification is especially attractive as it is available for the broadest sample of countries and combines information from several different sources.[6] The two multivalued indices measuring the quality of democratic institutions we use are the Polity Project combined polity score and the Freedom House index of political rights (Marshall, Gurr, and Jaggers, 2014; Freedom House, 2014). We drop so-called interregnum years when according to the Polity Project there is no government controlling most of the territory. Former colonies are only included since independence and we require countries to have been independent for at least 25 years (about half our sample period).

It is useful to keep in mind that the five measures of democratic improvement we use differ in definitions and technical implementation, as explained in detail in the papers cited in the previous paragraph. For example, Geddes et al. (2014) code a competitive election for the

[5]Using their regime classification we code a country as democratic if it is a democracy or if it is ruled by a provisional government overseeing its transition to democracy. We drop the years where according to Geddes, Wright, and Frantz the country is not independent, it is occupied by a foreign nation, or there is no government controlling most of the territory.

[6]Acemoglu et al. (2019) combine information from Freedom House and Polity IV, supplemented by dichotomous measures from Cheibub, Gandhi, and Vreeland (2010) and Boix, Miller, and Rosato (2013).

executive as democratization only if a person other than the previous authoritarian incumbent or someone allied with the incumbent wins the election. They also use a different timing rule when coding the start date of democratic rule (more about this further below). As a result of these differences, the five measures of democratic improvement we use sometimes indicate a different timing and speed of democratic improvement. However, all measures coincide in that the vast majority of the world's most agricultural countries were governed by nondemocratic regimes at the beginning of the time period we study.

3 Empirical Framework

The estimating equation for the effect of rainfall on real agricultural output follows the agricultural economics literature, see Schlenker and Lobell (2010), Lobell, Schlenker, and Costa-Roberts (2011), and Maertens (2016) for example. The literature finds the within-country effect of rainfall on agricultural output to be quadratic and inverted-U-shaped. We therefore model the effect of rainfall on agricultural output in country c and year t as

$$\begin{aligned} &RealAgriculturalOutputIndex_{c,t} = Controls_{c,t} \\ &+ \left(a_0 R_{c,t} + b_0 R_{c,t}^2\right) + \left(a_1 R_{c,t-1} + b_1 R_{c,t-1}^2\right) + \left(a_2 R_{c,t-2} + b_2 R_{c,t-2}^2\right) + \epsilon_t \end{aligned} \tag{1}$$

where the three terms $aR + bR^2$ capture the (quadratic) within-country effect of rainfall at different lags and $Controls_{c,t}$ always include (i) country fixed effects; (ii) year fixed effects; (iii) country-specific linear time trends; and (iv) linear-quadratic terms for temperature that match the lag structure of the rainfall variable. The quadratic specification for the effect of rainfall allows for an inverted-U-shaped effect of rainfall on agricultural output (a positive linear effect of rainfall but a negative quadratic effect). In this case, additional rainfall would increase agricultural output for rainfall levels to the left of the peak of the inverted U, but additional rainfall would decrease agricultural output for rainfall levels to the right of the inverted U—there could be too much rain as far as agricultural productivity is concerned. The method of estimation is least squares with HAC standard errors that are robust to both arbitrary

heteroskedasticity and serial correlation.[7]

The estimating equation for the effect of rainfall on democratization outcomes in country c between years $t-1$ and T mirrors the estimating equation for agricultural output (1)

$$\begin{aligned} Democratization^{T}_{c,t-1} &= Controls_{c,t} \\ &+ \left(a_0 R_{c,t} + b_0 R^2_{c,t}\right) + \left(a_1 R_{c,t-1} + b_1 R^2_{c,t-1}\right) + \left(a_2 R_{c,t-2} + b_2 R^2_{c,t-2}\right) + \epsilon_t \end{aligned} \tag{2}$$

where the three terms $aR + bR^2$ capture the (quadratic) within-country effect of rainfall at different lags and $Controls_{c,t}$ always include (i) country fixed effects; (ii) year fixed effects; (iii) country-specific linear time trends; and (iv) linear-quadratic terms for temperature that match the lag structure of the rainfall variable.[8] The method of estimation is identical to that used for estimating equation (1).

Democratization between years $t-1$ and T in (2) is measured in two main ways. The first measure is a democratization indicator based on dichotomous political regime classifications. The democratization indicator takes the value of 1 if the country is a nondemocracy in year $t-1$ but a democracy in year T. If the country is a nondemocracy in year $t-1$ and a nondemocracy in year T, the democratization indicator takes the value of 0. The second measure of democratization is based on multivalued indices measuring the quality of democratic institutions. In this case, democratic improvement between $t-1$ and T is measured as the change in the index between years $t-1$ and T if this change is towards more democratic institutions.

If the effect of rainfall on democratization in (2) is through agricultural output, the model for the effect of rainfall on agricultural output in (1) has two interesting testable implications. First, if—as found in the agricultural economics literature—the effect of rainfall on agricultural output in (1) is inverted-U-shaped, the effect of rainfall on democratization in (2) should be U-shaped. Second, the highest point of the inverted-U-shaped effect of rainfall on agricultural output should be at the same level of rainfall as the lowest point of the U-shaped effect of

[7] We also estimate the equation using (log-)GDP per capita from the Penn World Tables on the left-hand side but never find any significant effects. A likely explanation is the quite extreme noise in the PWT GDP for low-income countries, see Johnson et al. (2013).

[8] Our empirical specifications also include a linear and quadratic term for rainfall lagged by three years but these terms are generally statistically insignificant and not reported.

rainfall on democratization.

4 Empirical Results

We first examine the effect of rainfall on agricultural output in countries grouped by agricultural GDP shares. Then we examine the effect of rainfall on different measures of democratic improvement in the world's most agricultural countries.

4.1 Rainfall and Agricultural Output Since 1961

Table 1 summarizes our results on the effect of rainfall on agricultural output using estimating equation (1). The different columns contain results for different groups of countries. These groups are based on the average GDP share of agriculture over the 1970–2013 period (the agricultural GDP share is only available since 1970).

Column (1) shows the results for the 32 countries with an average GDP share of agriculture in the top quintile of the distribution. The effect of rainfall in year t on agricultural output in year t is statistically significant and inverted-U-shaped, and the lagged effects are statistically insignificant.[9] To get a sense for the strength of the contemporaneous effect, it is useful to calculate the percentage decrease in agricultural output caused by the median year-on-year drop in rainfall starting at the median level of rainfall—which we refer to as the median year-on-year negative rainfall shock. This decrease is around 1%. As the average share of agriculture in GDP in countries in the top quintile of the distribution is 40%, the implied effect on GDP of the median year-on-year negative rainfall shock is around -0.4%.[10] The lagged effects of rainfall are statistically insignificant and small. The conclusion of column (1) is that rainfall has a significant and transitory effect on agricultural output in the world's most agricultural countries.

Column (2) considers countries whose average share of agriculture in GDP is outside of the top quintile of the distribution (the complement of the group of countries in column (1)). Now

[9] Agricultural output peaks at a level of rainfall at the 85th percentile of the rainfall distribution in this group of countries.

[10] We do not find any significant effects when we reestimate the equation with (log-)GDP per capita from the PWT on the left-hand side of the regression (see footnote 7).

the contemporaneous and the lagged effects of rainfall on agricultural output are statistically insignificant. The implied contemporaneous effect of the median year-on-year negative rainfall shock on agricultural output is basically zero.

Columns (3) and (4) consider countries with shares of agriculture in GDP in the top quarter and the top tercile of the distribution respectively. For countries in the top quarter of the distribution in column (3), the effect of rainfall in year t on agricultural output in year t is statistically significant and inverted-U-shaped. The implied contemporaneous effect of the median year-on-year negative rainfall shock on agricultural output is around -0.3%, less than one-third of the effect that we estimated in countries with agricultural GDP shares in the top quintile of the distribution. Making use of the average GDP share of agriculture in the top quarter of the distribution yields an implied effect of the median year-on-year negative rainfall shock on GDP of -0.1%, around one-quarter of the implied GDP effect we estimated in countries with agricultural GDP shares in the top quintile of the distribution. For countries in the top tercile of the distribution in column (4), the effect of rainfall on agricultural output is statistically insignificant and the implied effect of a median negative rainfall shock on agricultural output is basically zero.

More widespread use of irrigation is one explanation for the drop off in the effect of rainfall on agricultural output as one moves outside the group of countries with agricultural GDP shares in the top quintile. There is very little irrigation in countries in the top quintile of the distribution of agricultural GDP shares. According to the World Development Indicators (2016), the median share of irrigated agricultural land in these countries over the 2001–2010 period was around 0.7% (very little data is available for earlier years). Outside of the group of countries in the top quintile of the distribution of agricultural GDP shares, the share of irrigated agricultural land is much higher. For example, the median share of irrigated agricultural land in countries with agricultural GDP shares in the top tercile but not the top quintile of the distribution was around 9%. Another factor likely to play a role is that rainfall is measured over a country's entire territory. In less agricultural countries, more of the measured rainfall is not over agricultural land and hence will not have an effect on agricultural output.

Column (4) considers all countries. The effect of rainfall on agricultural output is statistically insignificant and the implied effect of a median year-on-year negative rainfall shock on

agricultural output is basically zero.

4.2 Rainfall and Persistent Democratic Change in the World's Most Agricultural Countries

Tables 2 to 5 summarize the short-run and longer-run effects of transitory rainfall shocks on democratic change in countries with agricultural GDP shares in the top quintile of the distribution. We start with three different indicators of democratization based on dichotomous political regime classifications: (i) Acemoglu, Naidu, Restrepo, and Robinson (2019); (ii) Przeworski, Alvarez, Cheibub, and Limongi (2000) as updated by Cheibub, Gandhi, and Vreeland (2010) and Bjørnskov and Rode (2020); and (iii) Geddes, Wright, and Frantz (2014). We also measure democratic improvement using the multivalued Polity Project polity score and the Freedom House index of political rights. The number of countries and observations per country depend on the measure of democratization or democratic improvement as datasets differ in terms of countries and time periods covered, see Appendix Table 1.

4.2.1 Measuring Democratization Following Acemoglu et al.

Table 2 summarizes our results when the measure of democratization in estimating equation (2) is based on the political regime classification of Acemoglu, Naidu, Restrepo, and Robinson (2019), which we refer to as Acemoglu et al. in short. The democratization indicator between years $t-1$ and T is only defined if the country is a nondemocracy in year $t-1$. The indicator takes the value 1 if the country is a democracy in year T and the value 0 if the country is a nondemocracy in T. The table contains results for the effect of rainfall on the probability that a nondemocracy in year $t-1$ is a democracy in year t (one year later); in year $t+2$ (three years later); in year $t+4$ (five years later); and in year $t+9$ (ten years later).

The main empirical finding is that the effect of rainfall in year t on the Acemoglu et al. democratization indicator is statistically significant and U-shaped for democratization between year $t-1$ and year t (one year later); year $t+2$ (three years later); year $t+4$ (five years later); and year $t+9$ (ten years later). Hence, transitory rainfall shocks lead to persistent democratization.[11]

[11] We also find a statistically significant and U-shaped effect of rainfall on democratization between year $t-1$ and year $t+14$ (15 years later).

Figure 1 illustrates the strength of the effect of rainfall shocks in year t on the probability that a nondemocracy at $t-1$ is a democracy one, three, five, and ten years later using the political regime classification of Acemoglu et al. The figure assumes a median year-on-year negative rainfall shock in year t. This shock is defined as the median year-on-year drop in rainfall starting at the median level of rainfall. The figure contains the point estimates (the dots) and the corresponding 90% confidence intervals. It can be seen that the median year-t negative rainfall shock increases the probability that a nondemocracy at $t-1$ is a democracy one year later by around 1.5 percentage points. The 90% confidence interval ranges from 0.1 percentage points to 2.9 percentage points. Three years later, the median year-t negative rainfall shock increases the probability that the country is a democracy by 2.5 percentage points. The 90% confidence interval goes from 0.7 percentage points to 4.3 percentage points. Five years later, the probability that the country is a democracy increases by around 3.5 percentage points, with a 90% confidence interval from 1.9 percentage points to 5.5 percentage points. And ten years later, the increase in the probability that the country is a democracy is above 3 percentage points, with a 90% confidence interval from 1.2 percentage points to 4.9 percentage points. Hence, the (transitory) median year-on-year negative rainfall shock increases the probability of democratization in the shorter run (one and three years) by 1.5–2.5 percentage points and in the longer run (five and ten years) by 2.5–3 percentage points. The somewhat stronger effect in the longer run could indicate a buildup of democratic momentum or issues related to the measurement of democratization. In any case, because of the relatively large confidence intervals, we cannot reject the hypothesis that shorter and longer run effects are identical.

Figure 2 compares the shape of the contemporaneous effect of rainfall on agricultural output with the shape of the effect of rainfall on Acemoglu et al. democratizations between years $t-1$ and t. The solid black curve is the effect of rainfall in year t on agricultural output in year t (measured on the left scale). This effect is calculated using the estimates in column (1) of Table 1. The solid blue curve is the effect of rainfall in year t on the probability of an Acemoglu et al. democratization between years $t-1$ and t (measured on the right scale). This effect is calculated using the estimates in column (1) of Table 2. (The relevance of the green and red curves in the figure will become clear further below.) It can be seen that the effect of rainfall on agricultural output is inverted-U-shaped. The peak of the effect is at a level of rainfall equal

to the 85th percentile of the rainfall distribution. The effect of rainfall on the probability of an Acemoglu et al. democratization is U-shaped. This is consistent with the effect of rainfall on democratization working through its (inverted-U-shaped) effect on agricultural output. The rainfall level where the inverted-U-shaped effect of rainfall on agricultural output reaches its maximum is similar to the rainfall level where the U-shaped effect of rainfall on democratization reaches its minimum (a formal hypothesis test cannot reject that the two levels of rainfall are the same at any standard confidence level). This is also consistent with the effect of rainfall on democratization working through agricultural output.

4.2.2 Measuring Democratization Following Przeworski et al.

The left panel of Table 3 summarizes our results when the measure of democratization in estimating equation (2) is based on the political regime classification of Przeworski, Alvarez, Cheibub, and Limongi (2000) as updated by Cheibub, Gandhi, and Vreeland (2010) and Bjørnskov and Rode (2020), which we refer to as Przeworski et al. in short. The main empirical finding is that the effect of rainfall in year t on the Przeworski et al. democratization indicator is also statistically significant and U-shaped for democratization between year $t-1$ and year t (one year later); year $t+2$ (three years later); year $t+4$ (five years later); and year $t+9$ (ten years later).[12]

The strength of the effect of rainfall shocks on the probability of democratization is illustrated in Figure 3 for the median year-on-year negative rainfall shock in year t. The median negative rainfall shock continues to be defined as the median year-on-year drop in rainfall starting at the median level of rainfall. The figure contains the point estimates (the dots) and the corresponding 90% confidence intervals. It can be seen that the median year-t negative rainfall shock increases the probability that a nondemocracy at $t-1$ is a democracy one year later by around 1.5 percentage points. The 90% confidence interval ranges from 0.5 percentage points to 2.5 percentage points. Three years later, the median year-t negative rainfall shock increases the probability that the country is a democracy by 2.3 percentage points. The 90% confidence interval goes from 0.5 percentage points to 4.1 percentage points. Five years later, the increase

[12]We also find a statistically significant and U-shaped effect of rainfall on democratization between year $t-1$ and year $t+14$ (15 years later).

in the probability of democratization is above 3 percentage points. And ten years later, the increase in the probability that the country is a democracy is around 2.5 percentage points, with a 90% confidence interval from 0.8 percentage points to 4.2 percentage points.

The dotted red curve in Figure 2 illustrates the effect of year-t rainfall on the probability of a Przeworski et al. democratization between years $t-1$ and t (measured on the left scale). This effect is calculated using the estimates in columns (1) of Table 3. The figure allows to compare the effect of rainfall on Przeworski et al. democratizations with the effect of rainfall on agricultural output (solid black curve) as well as the effect of rainfall on Acemoglu et al. democratizations (solid blue curve). The effect of rainfall on the probability of Przeworski et al. democratizations can be seen to be U-shaped and similar to the effect of rainfall on the probability of Acemoglu et al. democratizations. Hence, the effect of rainfall on Przeworski et al. democratizations is consistent with rainfall affecting democratization through its (inverted-U-shaped) effect on agricultural output.

4.2.3 Measuring Democratization Following Geddes et al.

The right panel in Table 3 summarizes the results when the democratization indicator in estimating equation (2) is based on the political regime classifications of Geddes, Wright, and Frantz (2014). The results again indicate a statistically significant, U-shaped effect of rainfall on the probability of democratization over different time periods. The timing of the rainfall effect is somewhat different than for Przeworski et al. democratizations in the left panel. In particular, it is rainfall in year $t-1$ that is statistically significant over all time periods. Differences in timing are not particularly surprising as different political regime classifications use different definitions and measurement criteria. A specific difference between the Geddes et al. and the Przeworski et al. regime classifications that probably matters most for the difference in the timing of the rainfall effect in Table 3 is that Geddes et al. do not follow "the convention" (their own words) in coding the start date of democratic regimes. If a democratic regime becomes established in year t, the convention is to code December 31 of that year as the start date. This is the coding rule used by Przeworski et al. for example. Geddes et al. use January 1 of the subsequent year instead. To see how the rule regarding democratic regime start dates can affect the empirical results imagine that a negative year-t rainfall shock causes democrati-

zation in year t. With the December 31 rule for regime start dates, this democratization event is recorded in year t and researchers would observe that negative year-t rainfall shocks lead to democratization in year t. With the January 1 rule for start dates, the democratization event is recorded in year t+1 and researchers would observe that negative year-t rainfall shocks lead to democratization in year $t+1$ (or put differently, that year-t democratizations are related to negative rainfall shocks in year $t-1$).

Because of the unconventional rule for the start dates of democratic regimes used by Geddes, Wright, and Frantz, we illustrate the strength of the effect of the median year-on-year negative rainfall shock on the probability of democratization in Figure 4 in two different ways. Our first approach uses the results in column (5) of Table 3 and therefore relies on the original Geddes et al. dataset. The corresponding point estimates are the red dots in Figure 4. It can be seen that the median year-t negative rainfall shock increases the probability that a nondemocracy at $t-1$ is a democracy one year later by around 0.8 percentage points. The 90% confidence interval ranges from -0.2 percentage points to 1.8 percentage points. The probability that a nondemocratic country is a democracy five or ten years later is around 2.5 percentage points. The 90% confidence interval goes from around 0.6 percentage points to around 4.3 percentage points. Our second approach recodes the start dates of democratic regimes in the Geddes et al. dataset according to the convention, reestimates the specification in column (5) of Table 3 using this recoded data, and then uses these new estimates to illustrate the strength of the effect of the median negative rainfall shock in year t on the probability of democratization between year $t-1$ and year t. The corresponding point estimates are the blue squares. In this case, the median year-t negative rainfall shock increases the probability that a nondemocracy at $t-1$ is a democracy one year later by around 1.5 percentage points. The 90% confidence interval ranges from 0.2 percentage points to 2.8 percentage points. The probability that a nondemocratic country is a democracy five or ten years later is around 2 percentage points. The 90% confidence interval goes from 0.1 percentage points to 4 percentage points.

The dashed green curve in Figure 2 illustrates the effect of year-t rainfall on the probability of a Geddes et al. democratization between years $t-1$ and t (measured on the left scale). Because of the unconventional rule for start dates of regimes used by Geddes at al., the figure shows the probability of a Geddes et al. democratization as a function of rainfall in year

$t-1$. This effect is calculated using the estimates in column (5) of Table 3. This allows for a better comparison of the effect of rainfall on Geddes et al. democratizations with the effect of rainfall on Acemoglu et al. and Przeworski et al. democratizations. The effect of rainfall on the probability of Geddes et al. democratizations is U-shaped and similar to the effect of rainfall on the probability of Acemoglu et al. and Przeworski et al. democratizations. Hence, the effect of rainfall on Geddes et al. democratizations is also consistent with rainfall affecting democratization through its (inverted-U-shaped) effect on agricultural output.

4.2.4 Measuring Democratic Improvement Following the Polity Project

The left panel in Table 4 summarizes the results when the left-hand side of estimating equation (2) is democratic improvement as measured by the change in the Polity Project combined polity score towards more democratic institutions. This score ranges from -10 to 10, with higher values indicating more democratic institutions. The Polity Project convention is that countries with a score smaller or equal to -1 are nondemocracies and countries with a score greater or equal to 1 are democracies (a zero score denotes a so-called interregnum where according to the Polity Project there is no government controlling most of the territory). As we are interested in improvements in democratic institutions in nondemocracies, we use the positive change between years $t-1$ and T in the combined polity score in nondemocracies at $t-1$ as the measure of democratic improvement. Negative changes, which correspond to democratic setbacks, are dropped from the analysis (results including negative changes are similar, see Appendix Table 2). By focusing on democratic improvements in nondemocracies, we are staying as close as possible to the analysis of democratization in Tables 2 and 3.

The left panel of Table 4 shows the results for the effect of rainfall on democratic improvement as measured by the Polity Project between year $t-1$ and year t (one year later); year $t+2$ (three years later); year $t+4$ (five years later); and year $t+9$ (ten years later). The effect of year-t rainfall is statistically significant and U-shaped over all time periods.[13]

The strength of the effect of rainfall shocks on democratic improvement is illustrated in Figure 5 for the median year-on-year negative rainfall shock. The figure shows the point estimates

[13]We also find a statistically significant and U-shaped effect of rainfall on democratic improvement between year $t-1$ and year $t+14$ (15 years later).

(the dots) and 90% confidence intervals. The effect of the median year-t negative rainfall shock on the improvement in the polity score between year $t-1$ and t is around 0.12 polity points. The 90% confidence interval ranges from 0.01 to 0.23 points. The improvement in the polity score over a three-year period is around 0.31 points. The 90% confidence interval goes from 0.11 to 0.51 points. Over five-year and ten-year periods, the improvement in the polity score is 0.35–0.4 points. The 90% confidence interval goes from around 0.1 to around 0.6 points.

Figure 6 compares the effect of year-t rainfall on agricultural output (solid curve, measured on the left scale) calculated using column 1 of Table 1, with the effect of year-t rainfall on democratic improvement between years $t-1$ and t according to the Polity Project polity score (dotted curve, measured on the right scale) calculated using column (1) of Table 4. The effect of rainfall on democratic improvement can be seen to be U-shaped. This is consistent with the effect of rainfall on democratic improvement working through its (inverted-U-shaped) effect on agricultural output. Moreover, the rainfall level where the inverted-U-shaped effect of rainfall on agricultural output reaches its maximum is similar to the rainfall level where the U-shaped effect of rainfall on democratic improvement reaches its minimum (a formal hypothesis test cannot reject that the two levels of rainfall are the same at any standard confidence interval).

The right panel in Table 4 contains the results for the effect of rainfall on a democratization indicator based on the dichotomized combined polity score. We continue to follow the convention in classifying countries with a polity score smaller or equal -1 as nondemocracies and countries with a polity score greater or equal to 1 as democracies. The results indicate a statistically significant, U-shaped effect of rainfall on the probability of democratization over different time periods. The timing of the rainfall effect on the dichotomized polity score is different than the timing of the rainfall effect on the improvement in the polity score in the left panel of Table 4.

The strength of the effect of rainfall shocks on the probability of a polity democratization is illustrated in Figure 7 for the median year-on-year negative rainfall shock in year t. The median year-t negative rainfall shock increases the probability that a nondemocracy in year $t-1$ is a democracy in year t by around 0.8 percentage points. The 90% confidence interval ranges from -0.5 percentage points to 2.1 percentage points. Three years later, the median year-t negative rainfall shock increases the probability that an nondemocratic country is a democracy

by around 3 percentage points. The 90% confidence interval goes from around 1 percentage point to around 5 percentage points. Ten years later, the increase in the probability that the country is a democracy is around 2.4 percentage points. The 90% confidence interval ranges from 0.4 percentage points to 4.4 percentage points.

4.2.5 Measuring Political Rights Following Freedom House

Table 5 summarizes the results when the left-hand side of equation (2) is democratic improvement as measured by the Freedom House index of political rights. This index ranges from 1 to 7, with higher values indicating less political rights. Put differently, an improvement in political rights corresponds to a drop in the political rights index. To make results more comparable with those using the Polity Project combined polity score, where higher values indicate more democratic institutions, we use the negative of the Freedom House political rights index as the basis of our empirical work. This leaves the range of the index unchanged but ensures that positive changes over time correspond to improvements in political rights. As in the case of the combined polity score, we focus on improvements in political rights and drop years where political rights deteriorate (results including negative changes are similar, see Appendix Table 2).[14]

Table 5 shows the results for the effect of rainfall on improvements in political rights between year $t-1$ and year t (one year later); year $t+2$ (three years later); year $t+4$ (five years later); and year $t+9$ (ten years later). The effect of rainfall in year t on improvements in political rights is statistically significant and U-shaped over all time periods. The strength of the effect of the median year-on-year negative rainfall shocks on improvements in political rights is illustrated in Figure 8. The figure shows the point estimates (the dots) and 90% confidence intervals. The effect of the median year-t negative rainfall shock is an improvement in political rights of around 0.03 points over one year. The 90% confidence interval ranges from -0.02 to 0.08 points. Over a three-year period, the increase in political rights is around 0.08 points and the 90% confidence interval goes from 0.02 to 0.14 points. Over five-year and ten-year periods, the improvement in political rights rises to around 0.15 points. The 90% confidence interval ranges

[14]We are not looking at results in nondemocracies only as the Freedom House political rights index is not used to classify countries into democracies and nondemocracies.

from 0.06 to 0.24 points.

5 Conclusion

The idea that seemingly random events in the past may have shaped the political institutions we see today is influential in economics, political science and sociology. We examine it by combining transitory economic shocks in the world's most agricultural countries with their history of democratic (non-)transitions. We focus on the world's most agricultural countries for two main reasons. First, we find a comparatively strong effect of rainfall shocks on agricultural output. This, and the importance of agriculture for the economy of these countries, make rainfall shocks an exogenous source of repeated economic shocks. Second, almost all of the world's most agricultural countries were ruled by nondemocratic regimes at the beginning of the time period we consider, and nondemocratic regimes are a necessary condition for democratic tipping points. Today, about half of these countries are democratic. Hence, evidently, democratization was a possibility in at least some of these countries during some of the time.

We find that the effect of rainfall shocks on agricultural output in the world's most agricultural countries is entirely contemporaneous, but that rainfall shocks have persistent effects on democratic institutions. When lower rainfall leads to below-average agricultural output, countries ruled by nondemocratic regimes are more likely to democratize and more likely to be democratic ten years later. There is no evidence that this effect tapers off over time. To get a sense for the magnitude, the median year-on-year negative rainfall shock starting at the median rainfall level makes countries ruled by nondemocratic regimes 1–2 percentage points more likely to democratize in the short run and 2–3 percentage points more likely to be democratic after ten years. Multivalued indices of democratic institutions and political rights confirm a persistent effect of transitory rainfall shocks on democratic improvements. Hence, our empirical findings support the idea that transitory random events can lead to persistent democratization.

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TABLE 1. Rainfall and Agricultural Output Since 1961: Effect by Share of Agriculture in Gross Domestic Product

	Top Quintile Agricultural Countries	All Countries Except Top Quintile Agricultural Countries	Top Quarter Agricultural Countries	Top Tercile Agricultural Countries	All Countries
	(1)	(2)	(3)	(4)	(5)
Rainfall t	2.221***	0.021	1.033*	-0.123	0.302
	(0.636)	(0.392)	(0.534)	(0.429)	(0.367)
Quadratic Rainfall t	-0.059***	-0.004	-0.031***	-0.001	-0.010
	(0.014)	(0.009)	(0.012)	(0.010)	(0.009)
Rainfall t-1	0.134	-0.045	-0.389	-0.577	0.026
	(0.638)	(0.397)	(0.516)	(0.362)	(0.367)
Quadratic Rainfall t-1	-0.010	-0.004	0.003	0.009	-0.007
	(0.015)	(0.010)	(0.012)	(0.008)	(0.009)
Rainfall t-2	0.264	-0.426	-0.294	-0.363	-0.208
	(0.626)	(0.404)	(0.496)	(0.365)	(0.374)
Quadratic Rainfall t-2	-0.002	0.006	0.008	0.008	0.001
	(0.014)	(0.010)	(0.012)	(0.008)	(0.009)
Linear & Quadratic Temperature in Different Years	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y	Y
Country-Specific Linear Time Trends	Y	Y	Y	Y	Y
Countries	32	129	41	53	161
Observations	1,515	5,936	1,934	2,444	7,451
R Squared	0.065	0.009	0.041	0.013	0.013

Note: The left-hand side variable is an index of real agricultural output. Countries are assigned to subsamples by the average share of agriculture in GDP over the sample period. The table reports heteroskedastic and autocorrelation-consistent (HAC) standard errors that are robust to both arbitrary heteroskedasticity and serial correlation. * denotes significance at the 10% level; ** significance at the 5% level; and *** significance at the 1% level.

TABLE 2. Rainfall and Democratization in the World's Most Agricultural Countries: From Short to Longer Term

	Acemoglu et al. Democratization			
	Acemoglu et al. Democratization between t-1 and			
	t (1-Year)	t+2 (3-Year)	t+4 (5-Year)	t+9 (10-Year)
	(1)	(2)	(3)	(4)
Rainfall t	-0.032**	-0.044**	-0.064***	-0.054**
	(0.016)	(0.020)	(0.022)	(0.023)
Quadratic Rainfall t	0.0008**	0.0009**	0.0013**	0.0011*
	(0.0004)	(0.0005)	(0.0005)	(0.0006)
Rainfall t-1	0.015	-0.006	-0.031*	-0.048**
	(0.012)	(0.021)	(0.019)	(0.023)
Quadratic Rainfall t-1	-0.000	-0.000	0.001	0.001*
	(0.000)	(0.001)	(0.000)	(0.001)
Rainfall t-2	-0.017	-0.060***	-0.042**	-0.049**
	(0.014)	(0.018)	(0.018)	(0.024)
Quadratic Rainfall t-2	0.000	0.001***	0.001*	0.001**
	(0.000)	(0.000)	(0.000)	(0.001)
Linear & Quadratic Temperature in Different Years	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Country-Specific Linear Time Trends	Y	Y	Y	Y
Countries	31	31	31	30
Observations	1,132	1,100	1,069	975
R Squared	0.025	0.053	0.056	0.033

Note: The left-hand-side variables in all columns are democratization indicators based on the classification of democratic and nondemocratic regimes of Acemoglu, Naidu, Restrepo, and Robinson (2019). The left-hand-side democratization indicator in column (1) takes the value of 1 if a country that is a nondemocracy at t-1 is a democracy at t (one year later) and the value of 0 otherwise. The left-hand-side democratization indicator in column (2) takes the value of 1 if a country that is a nondemocracy at t-1 is a democracy at t+2 (three years later) and the value of 0 otherwise. The left-hand-side democratization indicator in column (3) is an indicator variable that takes the value of 1 if a country that is a nondemocracy at t-1 is a democracy at t+4 (five years later) and the value of 0 otherwise. The left-hand-side democratization indicator in column (4) takes the value of 1 if a country that is a nondemocracy at t-1 is a democracy at t+9 (10 years later) and the value of 0 otherwise. The included countries are all countries in Table 1 column (1)—countries with an average share of agriculture in GDP over the sample period in the top quintile of the distribution—with democratization data. The empirical specification also includes a linear and quadratic term for rainfall lagged by three years but these terms are generally statistically insignificant and not reported for brevity. The table reports heteroskedastic and autocorrelation-consistent (HAC) standard errors that are robust to both arbitrary heteroskedasticity and serial correlation. * denotes significance at the 10% level; ** significance at the 5% level; and *** significance at the 1% level.

TABLE 3. Rainfall and Democratization in the World's Most Agricultural Countries: From Short to Longer Term

	Przeworski et al. Democratization				Geddes et al. Democratization			
	Przeworski et al. Democratization between t-1 and				Geddes et al. Democratization between t-1 and			
	t (1-Year)	t+2 (3-Year)	t+4 (5-Year)	t+9 (10-Year)	t (1-Year)	t+2 (3-Year)	t+4 (5-Year)	t+9 (10-Year)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rainfall t	-0.032**	-0.043**	-0.058***	-0.044**	-0.013	-0.012	-0.036*	-0.043**
	(0.014)	(0.020)	(0.021)	(0.021)	(0.011)	(0.017)	(0.019)	(0.022)
Quadratic Rainfall t	0.0008*	0.0010*	0.0012**	0.0010*	0.0003	0.0001	0.0005	0.0009*
	(0.0005)	(0.0005)	(0.0005)	(0.0006)	(0.0003)	(0.0004)	(0.0004)	(0.0005)
Rainfall t-1	0.010	-0.020	-0.025	-0.046**	-0.034**	-0.033*	-0.044**	-0.039**
	(0.012)	(0.018)	(0.017)	(0.020)	(0.015)	(0.019)	(0.019)	(0.018)
Quadratic Rainfall t-1	-0.000	0.000	0.000	0.001*	0.001*	0.001*	0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)
Rainfall t-2	-0.022*	-0.034**	-0.019	-0.030	0.014	-0.017	-0.027*	-0.035*
	(0.013)	(0.017)	(0.016)	(0.020)	(0.012)	(0.016)	(0.016)	(0.019)
Quadratic Rainfall t-2	0.000	0.001	0.000	0.001	-0.000	0.000	0.000	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Linear & Quadratic Temperature in Different Years	Y	Y	Y	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Country-Specific Linear Time Trends	Y	Y	Y	Y	Y	Y	Y	Y
Countries	26	26	26	26	26	26	26	26
Observations	1,054	1,016	981	895	1,049	1,012	978	899
R Squared	0.033	0.033	0.033	0.021	0.023	0.030	0.052	0.038

Note: The left-hand-side variable in columns (1) and (5) is a democratization indicator that takes the value of 1 if a country that is a nondemocracy at t-1 is a democracy at t (one year later) and the value of 0 otherwise. The left-hand-side variable in columns (2) and (6) is an indicator variable that takes the value of 1 if a country that is a nondemocracy at t-1 is a democracy at t+2 (three years later) and the value of 0 otherwise. The left-hand-side variable in columns (3) and (7) is an indicator variable that takes the value of 1 if a country that is a nondemocracy at t-1 is a democracy at t+4 (five years later) and the value of 0 otherwise. The left-hand-side variable in columns (4) and (8) is an indicator variable that takes the value of 1 if a country that is a nondemocracy at t-1 is a democracy at t+9 (ten years later) and the value of 0 otherwise. The classification of democratic and nondemocratic regimes in columns (1)-(4) is based on Bjornskov and Rode (2020), who extend the dataset of Cheibub, Gandhi, and Vreeland (2010) and Przeworski, Alvarez, Cheibub, and Limongi (2000). The classification of democratic and nondemocratic regimes in columns (5)-(8) is based on Geddes, Wright, and Frantz (2014). The included countries are all countries in Table 1 column (1)—countries with an average share of agriculture in GDP over the sample period in the top quintile of the distribution—with democratization data. The empirical specification also includes a linear and quadratic term for rainfall lagged by three years but these terms are generally statistically insignificant and not reported for brevity. The table reports heteroskedastic and autocorrelation-consistent (HAC) standard errors that are robust to both arbitrary heteroskedasticity and serial correlation. * denotes significance at the 10% level; ** significance at the 5% level; and *** significance at the 1% level.

TABLE 4. Rainfall and Polity Project Democratic Change in the World's Most Agricultural Countries: From Short to Longer Term

	Polity Project Democratic Improvement				**Polity Project Democratization**			
	Polity Improvement between t-1 and				Polity Democratization between t-1 and			
	t (1-Year)	t+2 (3-Year)	t+4 (5-Year)	t+9 (10-Year)	t (1-Year)	t+2 (3-Year)	t+4 (5-Year)	t+9 (10-Year)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rainfall t	-0.236*	-0.661***	-0.669***	-0.636**	-0.014	-0.052***	-0.053***	-0.036
	(0.126)	(0.220)	(0.245)	(0.262)	(0.015)	(0.020)	(0.020)	(0.023)
Quadratic Rainfall t	0.005*	0.016***	0.013**	0.013**	0.000	0.001**	0.001*	0.001
	(0.003)	(0.005)	(0.006)	(0.006)	(0.000)	(0.000)	(0.000)	(0.001)
Rainfall t-1	-0.097	-0.126	-0.207	-0.200	-0.007	-0.022	-0.015	-0.005
	(0.106)	(0.191)	(0.210)	(0.273)	(0.011)	(0.017)	(0.017)	(0.023)
Quadratic Rainfall t-1	0.003	0.002	0.004	0.005	0.000	0.000	0.000	0.000
	(0.003)	(0.004)	(0.005)	(0.007)	(0.000)	(0.000)	(0.000)	(0.001)
Rainfall t-2	-0.347**	-0.484***	-0.285	-0.125	-0.040**	-0.066***	-0.034**	-0.009
	(0.137)	(0.185)	(0.196)	(0.266)	(0.017)	(0.018)	(0.017)	(0.023)
Quadratic Rainfall t-2	0.009***	0.011**	0.007	0.002	0.001**	0.001***	0.001	0.000
	(0.003)	(0.004)	(0.004)	(0.006)	(0.000)	(0.000)	(0.000)	(0.001)
Linear & Quadratic Temperature in Different Years	Y	Y	Y	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Country-Specific Linear Time Trends	Y	Y	Y	Y	Y	Y	Y	Y
Countries	30	30	30	30	30	30	30	30
Observations	1,073	1,003	941	846	1,101	1,070	1,032	946
R Squared	0.037	0.071	0.077	0.051	0.031	0.076	0.082	0.054

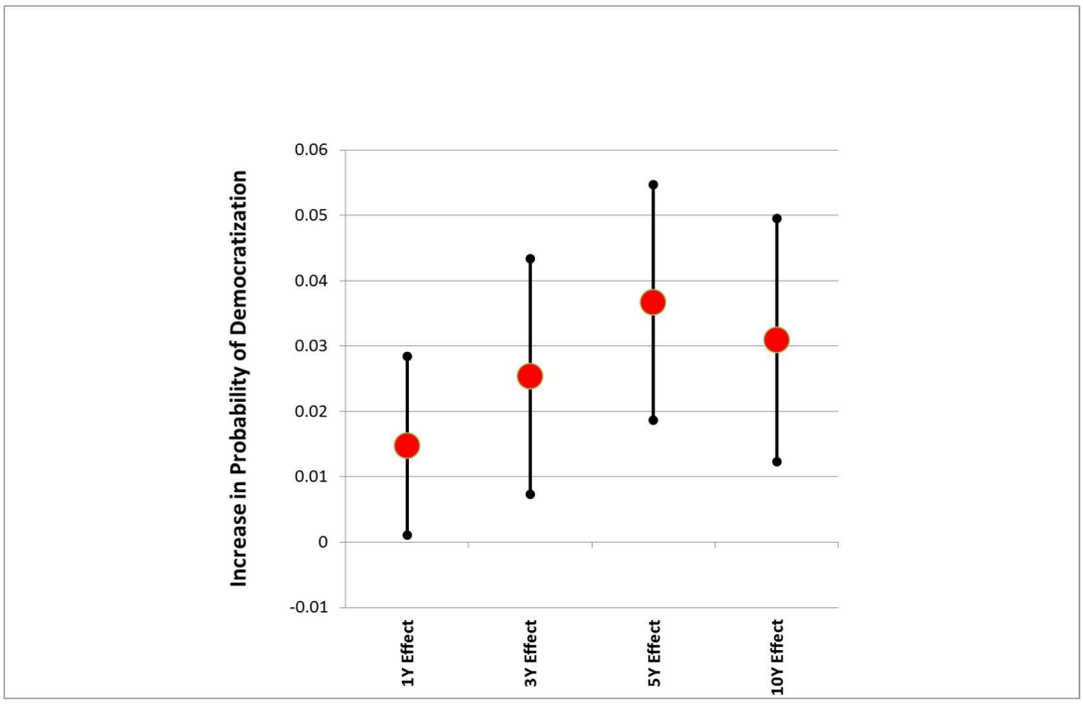
Note: The left-hand-side variables in columns (1) to (4) are the improvements in the Polity Project polity score in nondemocracies over different time periods. The left-hand-side variable in column (1) is the improvement in the polity score between years t-1 and t; the left-hand-side variable in column (2) is the improvement in the polity score between years t-1 and t+2; the left-hand-side variable in column (3) is the improvement in the polity score between years t-1 and t+4; and the left-hand-side variable in column (4) is the improvement in the polity score between years t-1 and t+9. The left-hand-side variables in columns (5) to (8) are indicators for democratization over different time periods. The classification of democratic and nondemocratic regimes is based on the Polity Project combined polity score. The left-hand-side variable in column (5) is a democratization indicator that takes the value of 1 if a country that is a nondemocracy at t-1 is a democracy at t (one year later) and the value of 0 otherwise. The left-hand-side variable in column (6) is a democratization indicator that takes the value of 1 if a country that is a nondemocracy at t-1 is a democracy at t+2 (three years later) and the value of 0 otherwise. The left-hand-side variable in column (7) is a democratization indicator that takes the value of 1 if a country that is a nondemocracy at t-1 is a democracy at t+4 (five years later) and the value of 0 otherwise. The left-hand-side variable in column (8) is a democratization indicator that takes the value of 1 if a country that is a nondemocracy at t-1 is a democracy at t+9 (ten years later) and the value of 0 otherwise. The included countries are all countries in Table 1 column (1)—countries with an average share of agriculture in GDP over the sample period in the top quintile of the distribution—with Polity Project data. The empirical specification also includes a linear and quadratic term for rainfall lagged by three years but these terms are generally statistically insignificant and not reported for brevity. The table reports heteroskedastic and autocorrelation-consistent (HAC) standard errors that are robust to both arbitrary heteroskedasticity and serial correlation. * denotes significance at the 10% level; ** significance at the 5% level; and *** significance at the 1% level.

TABLE 5. Rainfall and Improvements in Freedom House Political Rights in the World's Most Agricultural Countries: From Short to Longer Term

	Political Rights Improvement between t-1 and			
	t (1-Year)	t+2 (3-Year)	t+4 (5-Year)	t+9 (10-Year)
	(1)	(2)	(3)	(4)
Rainfall t	-0.059**	-0.157***	-0.269***	-0.240***
	(0.027)	(0.047)	(0.069)	(0.070)
Quadratic Rainfall t	0.001**	0.003***	0.005***	0.004***
	(0.001)	(0.001)	(0.001)	(0.002)
Rainfall t-1	0.002	-0.114**	-0.129**	-0.207***
	(0.022)	(0.044)	(0.061)	(0.079)
Quadratic Rainfall t-1	0.000	0.002**	0.002*	0.004**
	(0.000)	(0.001)	(0.001)	(0.002)
Rainfall t-2	-0.069**	-0.154***	-0.064	-0.230***
	(0.028)	(0.048)	(0.061)	(0.079)
Quadratic Rainfall t-2	0.001**	0.003**	0.001	0.004**
	(0.001)	(0.001)	(0.001)	(0.002)
Linear & Quadratic Temperature in Different Years	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Country-Specific Linear Time Trends	Y	Y	Y	Y
Countries	31	31	31	31
Observations	1,078	910	808	677
R Squared	0.042	0.079	0.078	0.064

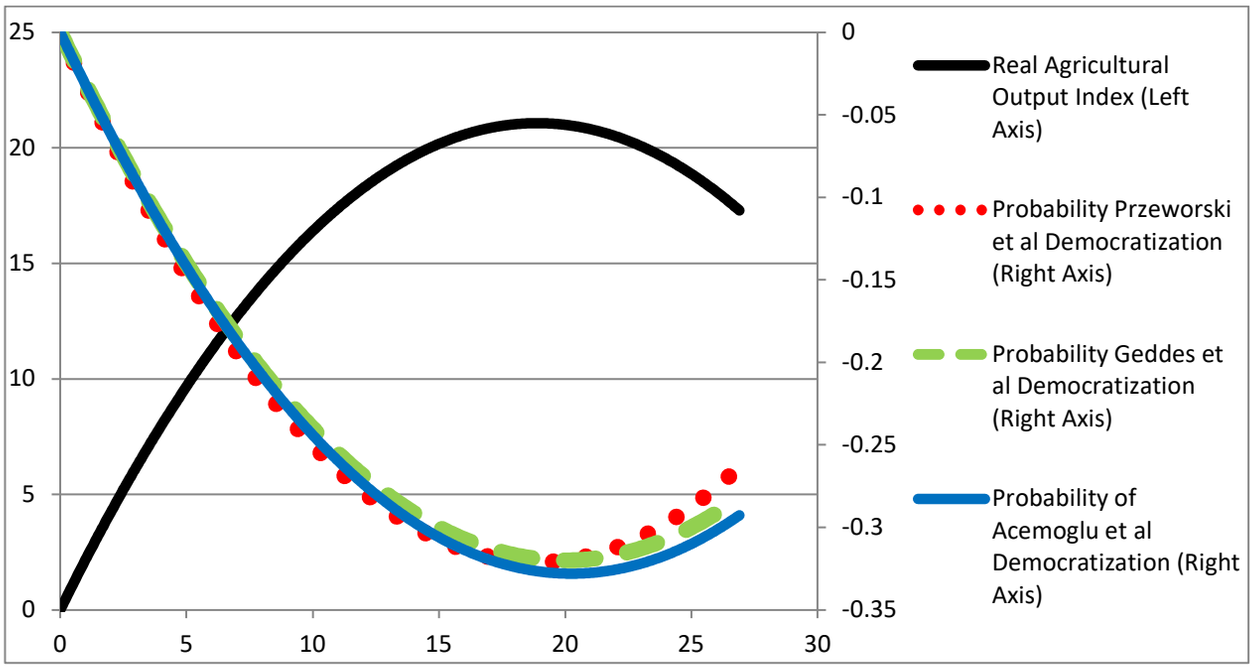
Note: The left-hand-side variables are the improvements in political rights over different time periods measured by the Freedom House political rights index (see page 18 for more details on how we use this index). The left-hand-side variable in column (1) is the improvement in political rights between years t-1 and t; the left-hand-side variable in column (2) is the improvement in political rights between years t-1 and t+2; the left-hand-side variable in column (3) is the improvement in political rights between years t-1 and t+4; and the left-hand-side variable in column (4) is the improvement in political rights between years t-1 and t+9. The included countries are all countries in Table 1 column (1)—countries with an average share of agriculture in GDP over the sample period in the top quintile of the distribution—with Freedom House data. The empirical specification also includes a linear and quadratic term for rainfall lagged by three years but these terms are generally statistically insignificant and not reported for brevity. The table reports heteroskedastic and autocorrelation-consistent (HAC) standard errors that are robust to both arbitrary heteroskedasticity and serial correlation. * denotes significance at the 10% level; ** significance at the 5% level; and *** significance at the 1% level.

FIGURE 1. Effect of Median Negative Rainfall Shock on the Probability of Short- and Longer-Term Acemoglu et al. Democratization



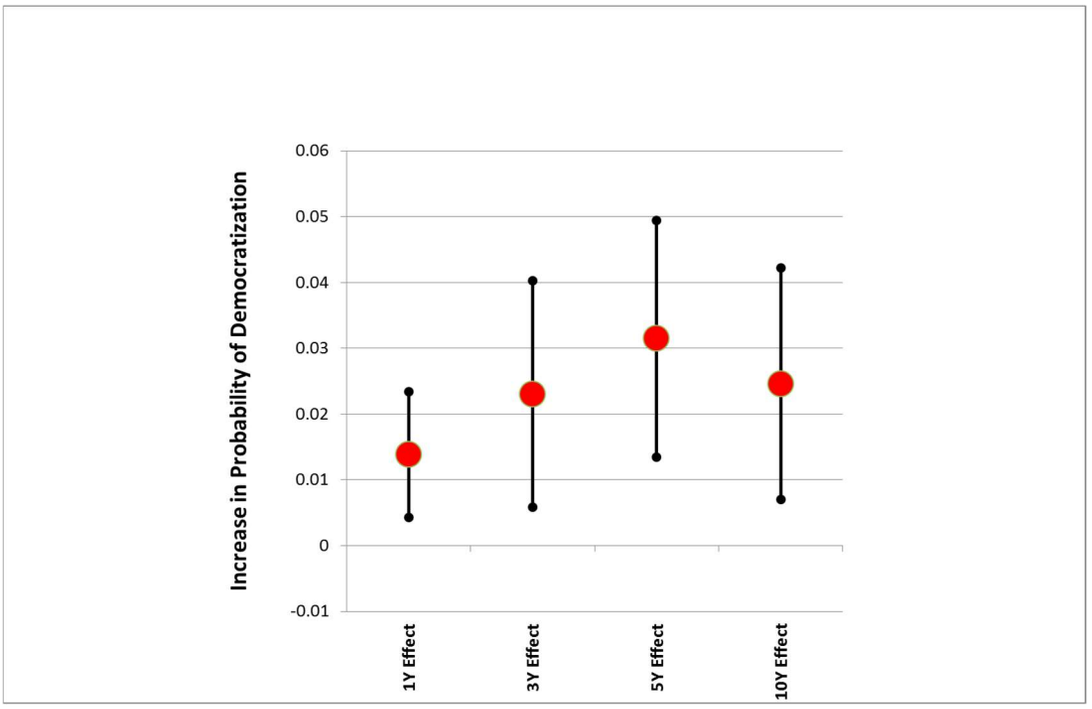
Note**:** Effect of a median negative rainfall shock in year t on the probability of democratization in a country that is a nondemocracy in year t-1. The dots are point estimates for the probability that the country is a democracy by year t (1Y Effect); by year t+2 (3Y Effect); by year t+4 (5Y Effect); and by year t+9 (10Y Effect). The bands give the 90% confidence intervals. The classification of democratic and nondemocratic regimes is based on Acemoglu, Naidu, Restrepo, and Robinson (2019). The median negative rainfall shock refers to a median year-on-year drop in rainfall starting at the median level of rainfall. The confidence bands are based on heteroskedastic- and autocorrelation-consistent (HAC) standard errors that are robust to both arbitrary heteroskedasticity and serial correlation.

FIGURE 2. Effect of Rainfall on Real Agricultural Output and on the Probability of Democratization



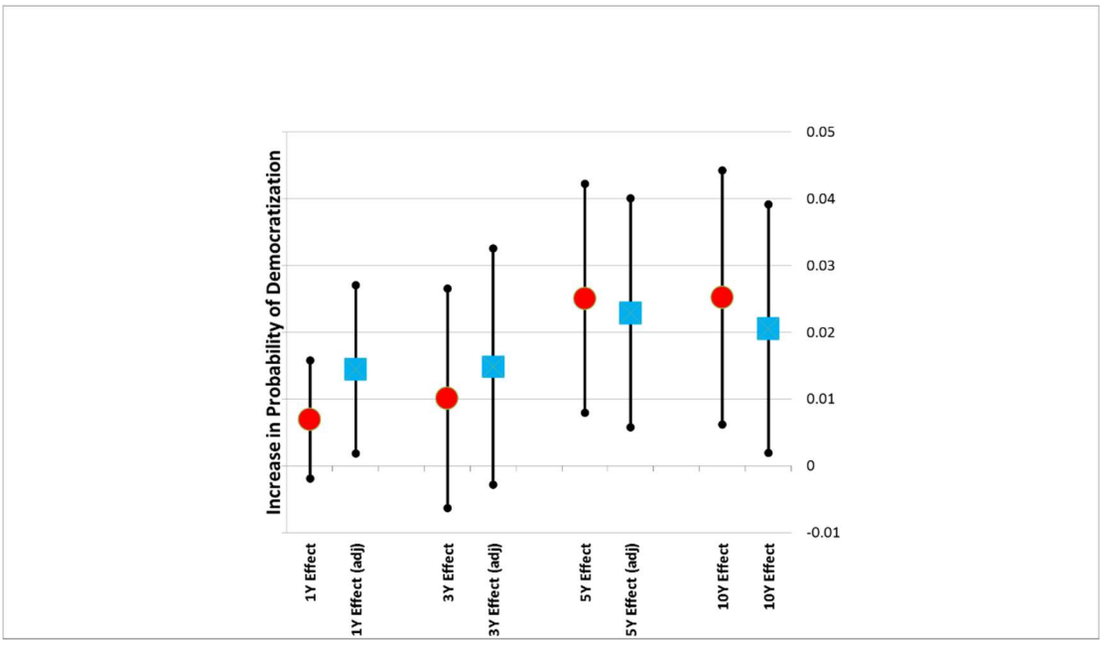
Note: The inverted-U-shaped solid black line is the effect of rainfall in year t on real agricultural output in year t and is measured on the left axis. The U-shaped colored lines are the effect of rainfall on the probability of democratization between years t-1 and t (one year later). The three classifications of democratic and nondemocratic regimes used in the figure are those of Acemoglu, Naidu, Restrepo, and Robinson (2019) (blue solid line); Przeworski, Alvarez, Cheibub, and Limongi, (2000) (red dotted line), as updated by Cheibub, Gandhi, and Vreeland (2010) and Bjornskov and Rode (2020); and Geddes, Wright, and Frantz (2014) (green dashed line). The effect of rainfall on the probability of democratization is calculated using the effect of rainfall in year t in column (1) of Tables 2 and 3 respectively for the Acemoglu et al. and the Przeworski et al. democratization indicator. For the Geddes et al. democratization indicator, the effect of rainfall on the probability of democratization is calculated using the effect of rainfall in year t-1 in column (5) of Table 3. This is because of Geddes et al.'s unconventional start date for democratic regime transitions; see page 14 for details. Real agricultural output is an index with the base period 2004-2006. Rainfall is measured in dm.

FIGURE 3. Effect of Median Negative Rainfall Shock on the Probability of Short- and Longer-Term Przeworski et al. Democratization



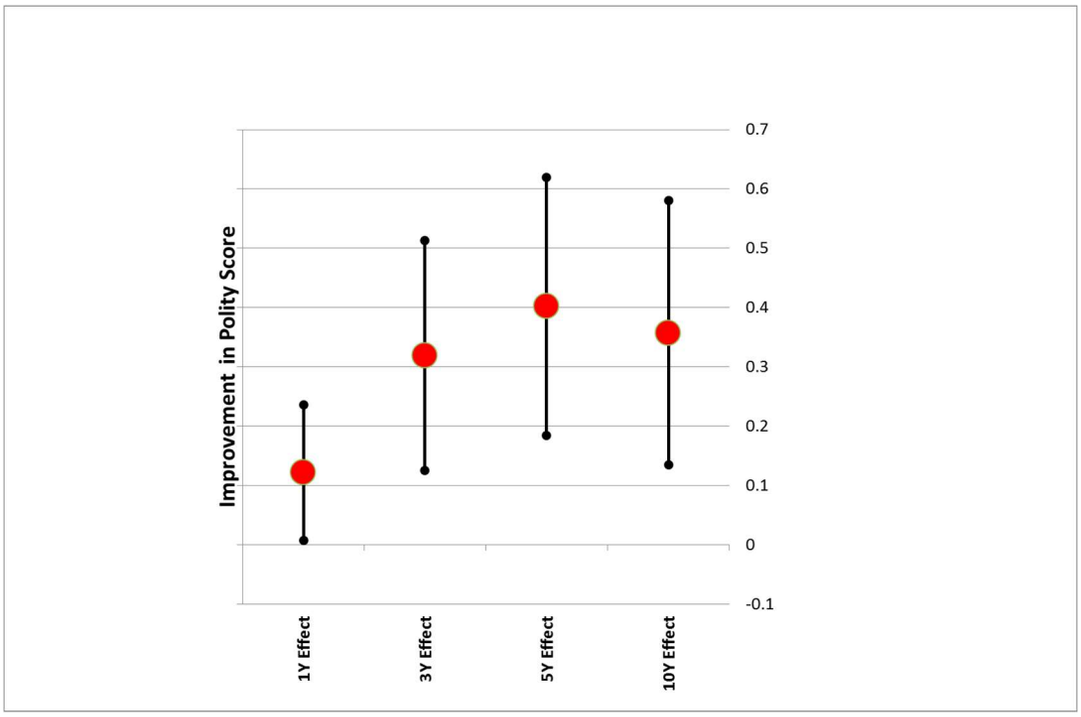
Note: Effect of a median negative rainfall shock in year t on the probability of democratization in a country that is a nondemocracy in year t-1. The dots are the point estimates for the probability that the country is a democracy by year t (1Y Effect); by year t+2 (3Y Effect); by year t+4 (5Y Effect); and by year t+9 (10Y Effect). The bands give the 90% confidence intervals. The classification of democratic and nondemocratic regimes is based on Przeworski, Alvarez, Cheibub, and Limongi (2000) as updated by Cheibub, Gandhi, and Vreeland (2010) and Bjornskov and Rode (2020). The median negative rainfall shock refers to a median year-on-year drop in rainfall starting at the median level of rainfall. The confidence bands are based on heteroskedastic- and autocorrelation-consistent (HAC) standard errors that are robust to both arbitrary heteroskedasticity and serial correlation.

FIGURE 4. Effect of Median Negative Rainfall Shock on the Probability of Short- and Longer-Term Geddes et al. Democratization



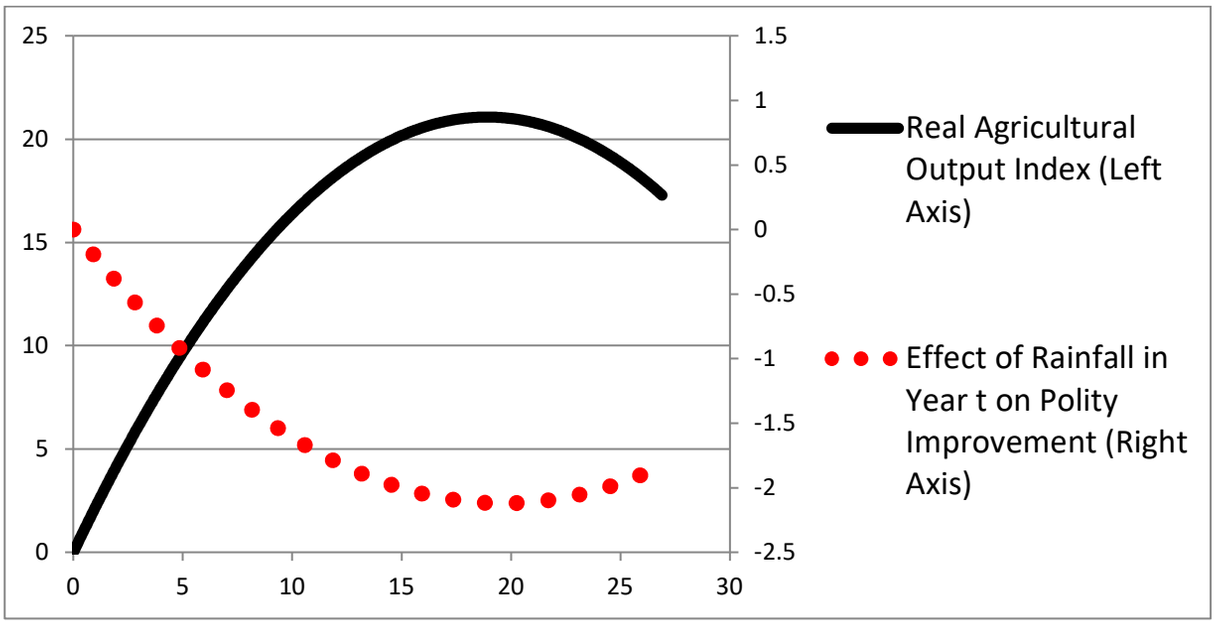
Note**:** Effect of a median negative rainfall shock in year t on the probability of democratization in a country that is a nondemocracy in year t-1. The red dots are the point estimates for the probability that the country is a democracy by year t (1Y Effect); by year t+2 (3Y Effect); by year t+4 (5Y Effect); and by year t+9 (10Y Effect). The bands give the 90% confidence intervals. The classification of democratic and nondemocratic regimes is based on Geddes, Wright, and Frantz (2014). The blue dots and corresponding 90% confidence bands are based on estimations with recoded Geddes, Wright, and Frantz data using the conventional start date for regime transitions, see page 14 for details. The median negative rainfall shock refers to a median year-on-year drop in rainfall starting at the median level of rainfall. The confidence bands are based on heteroskedastic- and autocorrelation-consistent (HAC) standard errors that are robust to both arbitrary heteroskedasticity and serial correlation.

FIGURE 5. Effect of Median Negative Rainfall Shock on the Short- and Longer-Term Improvement in Polity Project Democracy Score



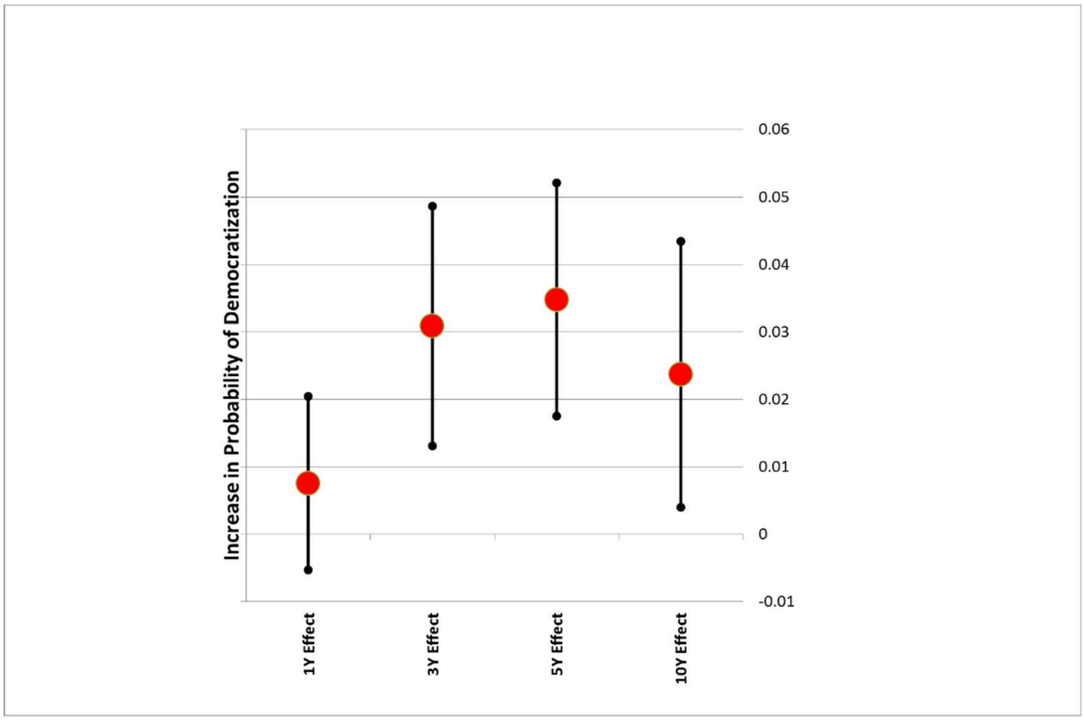
Note: Effect of a median negative rainfall shock in year t on the improvement in the Polity Project polity score in a country that is a nondemocracy in year t-1. The dots are the point estimates for the improvements in the polity score by year t (1Y Effect); by year t+2 (3Y Effect); by year t+4 (5Y Effect); and by year t+9 (10Y Effect). The bands give the 90% confidence intervals. The polity score varies between -10 and +10. Nondemocracies are countries with a score smaller or equal to -1. The median negative rainfall shock refers to a median year-on-year drop in rainfall starting at the median level of rainfall. The confidence bands are based on heteroskedastic- and autocorrelation-consistent (HAC) standard errors that are robust to both arbitrary heteroskedasticity and serial correlation.

FIGURE 6. Effect of Rainfall on Real Agricultural Output and on the Polity Project Democratic Improvement



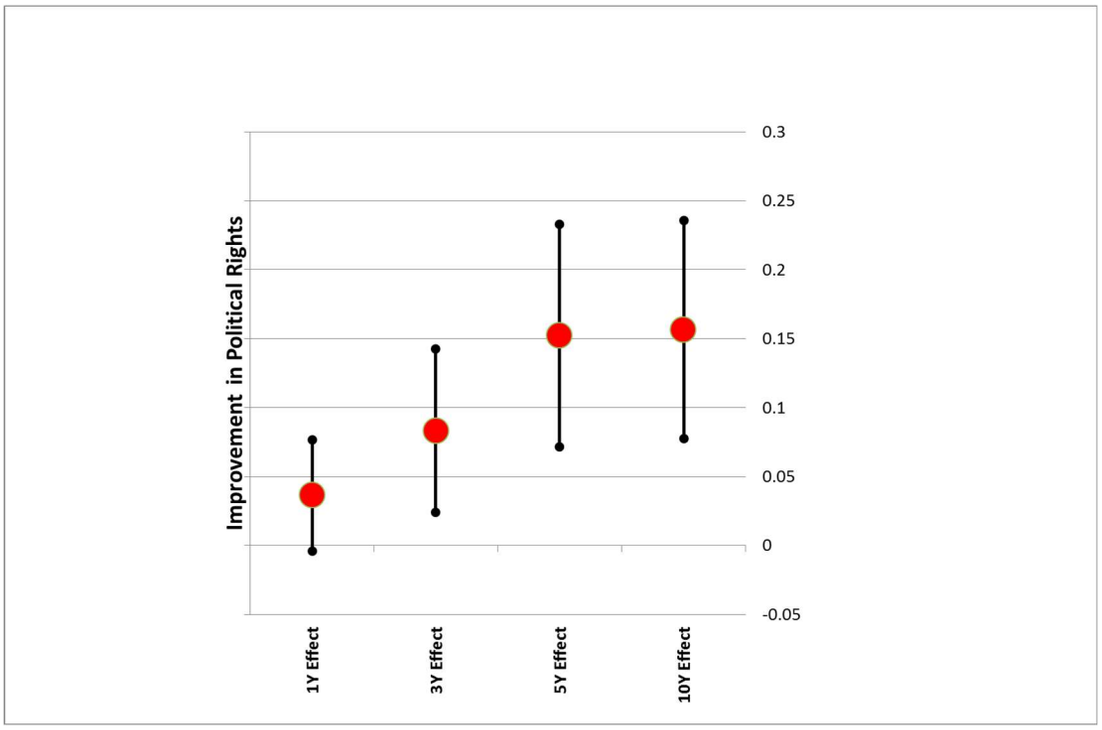
Note: The inverted-U-shaped solid black line is the effect of rainfall on real agricultural output and is measured on the left axis. The U-shaped dotted red line is the effect of rainfall on democratic improvement between year t-1 and t (one year later) calculated using the Polity Project polity score and is measured on the right axis. The effect of rainfall on democratic improvements is calculated using the effect of rainfall in year t in column (1) of Table 4. Real agricultural output is an index with the base period 2004-2006. Rainfall is measured in dm.

FIGURE 7. Effect of Median Negative Rainfall Shock on the Probability of Short- and Longer-Term Polity Project Democratization



Note: Effect of a median negative rainfall shock in year t on the probability of democratization in a country that is a nondemocracy in year t-1. The dots are the point estimates for the probability that the country is a democracy by year t (1Y Effect); by year t+2 (3Y Effect); by year t+4 (5Y Effect); and by year t+9 (10Y Effect). The bands give the 90% confidence intervals. The classification of democratic and nondemocratic regimes is based on the Polity Project polity score. Nondemocracies are countries with a score smaller or equal to -1 and democracies are countries with a score greater or equal to +1. The median negative rainfall shock refers to a median year-on-year drop in rainfall starting at the median level of rainfall. The confidence bands are based on heteroskedastic- and autocorrelation-consistent (HAC) standard errors that are robust to both arbitrary heteroskedasticity and serial correlation.

FIGURE 8. Effect of Median Negative Rainfall Shock on the Short- and Longer-Term Improvement in Freedom House Political Rights



Note: Effect of a median negative rainfall shock in year t on the improvement in the Freedom House political rights index in a country that is a nondemocracy in year t-1. The dots are the point estimates for the improvement in the Freedom House political rights index by year t (1Y Effect); by year t+2 (3Y Effect); by year t+4 (5Y Effect); and by year t+9 (10Y Effect). The Freedom House political rights index varies between 1 and 7 (see page 18 for more details on the measurement of this index). The median negative rainfall shock refers to a median year-on-year drop in rainfall starting at the median level of rainfall. The confidence bands are based on heteroskedastic- and autocorrelation-consistent (HAC) standard errors that are robust to both arbitrary heteroskedasticity and serial correlation.

APPENDIX TABLE 1. Agricultural Output and Democratization Data for the World's Most Agricultural Countries

	Agricultural Output		Acemoglu et al.		Przeworski et al.		Geddes et al.		Polity Project Score		FH Political Rights	
Country	Start Year	End Year	Start Year	End Year	Start Year	End Year	Start Year	End Year	Start Year	End Year	Start Year	End Year
Afghanistan	1961	2013	1960	2010	1946	2010	1950	2010	1946	2000	1972	2013
Albania	1961	2013	1960	2010	1946	2010	1950	2010	1946	2013	1972	2013
Bhutan	1971	2013	1971	2010					1971	2013	1972	2013
Burkina Faso	1961	2013	1961	2010	1961	2010	1961	2010	1961	2013	1972	2013
Burundi	1963	2013	1961	2010	1963	2010	1963	2010	1963	2013	1972	2013
Cambodia	1961	2013	1961	2010	1954	2010	1954	2010	1954	2013	1972	2013
Central African Republic	1961	2013	1961	2010	1961	2010	1961	2010	1961	2013	1972	2012
Chad	1961	2013	1961	2010	1961	2010	1961	2010	1961	2013	1972	2013
Comoros	1976	2013	1961	2010					1976	2013	1976	2013
Equatorial Guinea	1969	2013	1961	2010					1969	2013	1972	2013
Ethiopia	1993	2013	1961	2010	1946	2010	1950	2010	1946	2013	1972	2013
Ghana	1961	2013	1961	2010	1958	2010	1958	2010	1960	2013	1972	2013
Guinea-Bissau	1974	2013	1961	2010	1975	2010	1975	2010	1974	2013	1974	2013
Laos	1961	2013	1961	2010	1954	2010	1954	2010	1954	2013	1973	2013
Liberia	1961	2013	1961	2010	1946	2010	1950	2010	1946	2013	1972	2013
Madagascar	1961	2013	1961	2010	1961	2010	1961	2010	1961	2013	1972	2013
Malawi	1965	2013	1961	2010	1965	2010	1965	2010	1965	2013	1972	2013
Mali	1961	2013	1961	2010	1961	2010	1961	2010	1961	2013	1972	2013
Mauritania	1961	2013	1961	2010	1961	2010	1961	2010	1961	2013	1972	2013
Mozambique	1976	2013	1961	2010	1976	2010	1976	2010	1976	2013	1976	2013
Myanmar (Burma)	1961	2013	1961	2010	1949	2010	1950	2010	1949	2013	1972	2013
Nepal	1961	2013	1961	2010	1946	2010	1950	2010	1946	2013	1972	2013
Niger	1961	2013	1961	2010	1961	2010	1961	2010	1961	2013	1972	2013
Papua New Guinea	1976	2013	1961	2010					1976	2013	1976	2013
Rwanda	1963	2013	1961	2010	1963	2010	1963	2010	1963	2013	1972	2013
Sierra Leone	1962	2013	1961	2010	1962	2010	1962	2010	1962	2013	1972	2013
Solomon Islands	1979	2013	1961	2010					1979	2013	1979	2013
Somalia	1961	2013	1961	2010	1961	1991	1961	1991	1961	2013	1972	2013
Sudan	1961	2010	1961	2010	1957	2010	1957	2010	1957	2010	1972	2010
Togo	1961	2013	1961	2010	1961	2010	1961	2010	1961	2013	1972	2013
Uganda	1963	2013	1961	2010	1963	2010	1963	2010	1963	2013	1972	2013
Vietnam	1977	2013	1961	2010					1977	2013		

Note: The table lists countries included in the main sample used in the analysis and their data coverage for the agricultural output index; the Acemoglu et al. (2019) democratization measure; the Przeworski et al. (2000) democratization measure; the Geddes et al. (2014) democratization measure; the Polity Project polity score; and the Freedom House political rights measure. The sample includes countries with an average agriculture GDP share in the top quintile of the distribution. "Start Year" and "End Year" indicate the first and the last year of observation; omitted years indicate that the data is not available for that particular country during the sample period.

APPENDIX TABLE 2. Rainfall Shocks and Polity Project/Freedom House Democratic Change in the World's Most Agricultural Countries: From Short to Longer Term

	Polity Project Polity Score				Freedom House Political Rights Index			
	Polity Score Change between t-1 and				Political Rights Index Change between t-1 and			
	t (1-Year)	t+2 (3-Year)	t+4 (5-Year)	t+9 (10-Year)	t (1-Year)	t+2 (3-Year)	t+4 (5-Year)	t+9 (10-Year)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rainfall t	-0.199	-0.643***	-0.585**	-0.587**	-0.063**	-0.142**	-0.220***	-0.210**
	(0.125)	(0.219)	(0.236)	(0.258)	(0.030)	(0.057)	(0.078)	(0.089)
Quadratic Rainfall t	0.004	0.014***	0.011*	0.012*	0.001**	0.003***	0.004**	0.004*
	(0.003)	(0.005)	(0.006)	(0.006)	(0.001)	(0.001)	(0.002)	(0.002)
Rainfall t-1	-0.115	-0.193	-0.277	-0.161	0.016	-0.099*	-0.196***	-0.146
	(0.108)	(0.184)	(0.202)	(0.269)	(0.029)	(0.054)	(0.073)	(0.097)
Quadratic Rainfall t-1	0.004	0.004	0.004	0.004	0.000	0.002*	0.003**	0.003
	(0.003)	(0.004)	(0.005)	(0.006)	(0.001)	(0.001)	(0.002)	(0.002)
Rainfall t-2	-0.358***	-0.493**	-0.320	-0.056	-0.096***	-0.186***	-0.136*	-0.167*
	(0.137)	(0.196)	(0.208)	(0.266)	(0.037)	(0.059)	(0.072)	(0.098)
Quadratic Rainfall t-2	0.009**	0.010**	0.006	0.000	0.002**	0.003**	0.002	0.003
	(0.003)	(0.005)	(0.005)	(0.006)	(0.001)	(0.001)	(0.002)	(0.002)
Linear & Quadratic Temperature in Different Years	Y	Y	Y	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Country-Specific Linear Time Trends	Y	Y	Y	Y	Y	Y	Y	Y
Countries	30	30	30	30	31	31	31	31
Observations	1,101	1,070	1,032	946	1,170	1,098	1,032	880
R Squared	0.034	0.061	0.060	0.038	0.030	0.042	0.042	0.022

Note: The left-hand-side variables in columns (1) to (4) are the changes in the Polity Project polity score in nondemocracies over different time periods. The left-hand-side variable in column (1) is the change in the polity score between years t-1 and t; the left-hand-side variable in column (2) is the change in the polity score between years t-1 and t+2; the left-hand-side variable in column (3) is the change in the polity score between years t-1 and t+4; and the left-hand-side variable in column (4) is the change in the polity score between years t-1 and t+9. The left-hand-side variables in columns (5) to (8) are the negative changes in the Freedom House political rights index over different time periods. We use negative changes to ensure that a higher Freedom House index indicates more political rights and thereby make results comparable to those with the change in the polity score (see page 18 for more details). The left-hand-side variable in column (5) is the change in the political rights index between years t-1 and t; the left-hand-side variable in column (6) is the change in the political rights index between years t-1 and t+2; the left-hand-side variable in column (7) is the change in the political rights index between years t-1 and t+4; and the left-hand-side variable in column (8) is the change in the political rights index between years t-1 and t+9. The included countries are all countries in Table 1 column (1)—countries with an average share of agriculture in GDP over the sample period in the top quintile of the distribution—with Polity Project/Freedom House data. The table reports heteroscedastic and autocorrelation-consistent (HAC) standard errors that are robust to both arbitrary heteroscedasticity and serial correlation * denotes significance at the 10% level; ** significance at the 5% level; and *** significance at the 1% level.