

GDP, Rainfall, and Democracy

Abstract: For many years an abundance of studies and policies (especially in the United States) have been aimed at discovering the most efficient manner for nation-building and instilling regime changes that trend towards more democratic structures in various countries around the globe. The economic conditions of said countries are a necessary variable that must be taken into consideration when making such decisions. To find out the causal effect of GDP on democracy for a country, we utilized a 2 Stage Least Squares regression, with rainfall as our instrumental variable. We analyzed data regarding the log GDP per capita (independent variable), average annual rainfall (instrumental variable), and democracy index rating (dependent variable) for 34 different countries in Africa (an agriculturally-dependent economy) during a time period of 18 years (1981-1998). We found that countries with higher GDP per capita do not significantly trend towards a more democratic regime.

The causal question we wish to explore is: do countries with a higher GDP decrease the likelihood of having an authoritarian government? Our motivation to explore this is that depending on the magnitude and direction of the causal effect, it could have implications for American foreign policy, which has been notoriously known for trying to build nations and instill regime changes that trend towards more of a democracy. If a country does not have the economic conditions necessary for such a regime change, a lot of policy interventions could be prevented, saving time, money, and resources.

We looked at recent literature to help frame our expectations, but the literature we reviewed provided ambiguous results in terms of the direction, magnitude, and overall relationship between GDP and democracy. Acemoglu et. al (2019) and Asiedu et al. (2011) explored the causal effect of democracy on GDP and Foreign Direct Investment, respectively. Acemoglu et. al (2019) found that countries which complete a transition to or already have a complete democratic system experience an average GDP per capita growth of 20 percent. Asiedu et al. (2011) found that democracy promotes foreign investment in countries that meet a certain criteria regarding abundance of natural resources. These two papers suggest that democracy can have a causal effect on economic growth and action.

However, other literature suggests the nature of the relationship is reversed: Acemoglu et. al (2008), Brückner et. al (2012), and Kersting et. al (2014) suggest that different economic variables may or may not have a causal effect on democracy in some way. Acemoglu et. al (2008) found that per capita income has no effect on democracy rating, Brückner et. al (2012) found that an oil-price driven 1 percentage point increase in per capita GDP growth increases the Polity democracy score by 0.2 percentage points (more democratic), and Kersting et. al (2014) found that foreign aid incentivizes countries to trend towards a more democratic regime, signaling an incentive effect (however for countries that don't expect any aid, they trend the opposite way). Taking the findings of all this literature, we find that the nature and magnitude of the causal relationship between economic growth and democracy is uncertain: this can be attributed to the substantial omitted variable bias due to the large scale complexity of factors such as the economic growth/conditions and government regime of a country. There are many moving parts that may make it difficult to discern causality with certainty: however, we decided to explore this relationship utilizing a different approach, to see if we can get any closer to answering our research question.

In order to explore this relationship we utilized a 2 stage least squares regression, with log of GDP per capita as the independent variable, democracy rating (from an index) as the dependent variable, and average annual rainfall as the instrumental variable. We looked at panel data of 34 African countries during the time period of 1981-1998. This was motivated by Miguel et. al (2004), which utilized rainfall as an instrument to explore the relationship between economic shocks and civil conflict. To see the specifics of our data and its sources refer to the Data and Background section. To navigate the complex and vast amount of possible omitted variable biases, we used an instrumental variable to help mitigate the magnitude of these biases. We decided to utilize rainfall as the instrument, as we believe that it could be a driving force for GDP in an agriculturally dependent economy (such as Africa). Furthermore, countries have no influence on rainfall, eliminating selection bias. We expect that countries with greater average annual rainfall will have greater GDP per capita and will decrease the likelihood of having an authoritarian government (higher democracy rating). We assumed a number of conditions to be met for a causal interpretation of our regression (see empirical strategy for specifics). The

specifics of our regressions can be found in the empirical strategy as well, but we ended up regressing GDP on democracy rating, instrumented by rainfall, and controlling for population, ethnic fractionalization, and religious fractionalization. This regression reflected several changes to the original regressions denoted in our pre-analysis plan (see appendix).

Our results found that log of GDP per capita does not have a statistically significant effect on democracy index. This is not consistent with what we predicted, however our model has many limitations which could have impacted the results we got: the dropping of the interaction term, the lack of control for country age, the questionable instrumental variable, and the overall lack of data for some observations. Specifics of this can be found in the results/discussion section, as well as robustness checks, and alternate regressions that could reveal more about the nature of our relevant variables. Overall, since we cannot discern the causal effect of GDP per capita on democracy, we are unable to address some of the ambiguity that is seen in recent literature. However, possible next steps that could lead to interesting results include: analyzing different regions of the world, looking at more recent time periods, and adding controls for factors such as civil/international war, natural disasters and cultural shocks.

We initially were interested in why despite our efforts to establish democracies in other countries, these efforts appear to be futile. We thought we could first explore this by seeing the impact of foreign aid on democracy. Kersting et. al. (2014) explored the relationship between foreign aid and the democracy rating of the recipient countries. They used a cross-sectional analysis to determine the long term effect of foreign aid and found a “positive and statistically significant though modest effect.” They used panel data to examine the short run impact of aid on democracy and found a small positive effect from democratic donors and no effect or negative effects from non-democratic donors. They rationalized the positive long-term results by saying that aid as a “general input for democratization by laying the necessary foundation.” They discussed the incentive effects of aid and how the use of instrumental variables would not allow them to examine this effect due to its endogenous nature. They circumvented this problem by identifying recipient countries that do not expect aid to be conditional on democratic reform due to their geopolitical importance to donor countries. They found significant reductions in the democracy levels of these countries. Asiedu and Lien concluded that aid conditional on democratic reform has a significant incentive effect.

This inspired us to then start searching for relevant literature surrounding what else impacts democracy. Brückner et. al (2012) examined the effect of international oil price fluctuations on democratic institutions over the 1960-2007 period and the effect of income shocks on democracy. This suggested to us that perhaps natural resources should be factored into our analysis of democracy. They used oil price shocks as an instrument for changes in income when examining the effect on democracy. The rationale was that positive oil price shocks led to a persistent increase in income in countries with greater net oil exports over GDP and only affected democracy through this channel. What they found was that oil price-driven 1 percentage point increase in per capita GDP growth increases the Polity democracy score by around 0.2 percentage points. In other words, they were examining the effect of *changes* in GDP on *changes* in democracy scores. In addition to instrumentation, they controlled for country and year fixed effects.

From there we looked further into the relationship that natural resources play on democracy. Asiedu et. al. (2011) examined the effect of natural resources on the relationship between democracy and foreign direct investment (FDI). The paper measured 112 developing countries from 1982–2007. They used three different measures for democracy scale: Polity IV (Polity) Democracy Scale and transformed it as a measure from 0 to 1, Freedom House (Free) Democracy Rating, and International Country Risk Guide (ICRG) Democracy Rating. To measure the exporting of natural resources, they generated three variables: the share of fuel in total merchandise exports, the share of minerals in total merchandise exports, and the share of fuel *and* minerals in total merchandise exports (the sum of the last two variables). Using both a “Difference” and a “System” General Method of Moments (GMM) Estimator, they determined that “democracy promotes FDI if and only if the value of the share of minerals and oil in total exports is less than some critical value”. The coefficients for each of the different measures of democracy rating and estimation techniques are as follows (each represents the causal impact of Democracy on FDI: [1.616 (Free) , 1.189 (Polity), and 3.4 (ICRG)] for difference estimator and [1.02 (Free), 1.14 (Polity), and 3.012 (ICRG)] for system estimator. There were 90 countries that meet this criteria in which an increase in democratization increases FDI and 22 countries that do not meet this criteria such that an increase in democratization decreases FDI.

We imagined a link between GDP and natural resources suggesting that perhaps GDP could also play a role in democracy. We then found a study by Acemoglu et. al (2019) that

regressed democracy against GDP per capita¹. While their study focused on the opposite causal direction from the one we predicted, we thought it provided interesting evidence on the relationship between our two main variables of interest. The authors wanted to answer the research question: does the spread of democratic regimes seen around the world in recent times cause a positive impact on economic growth? They looked at panel data from 175 countries during the time frame of 1960-2010. The independent variable is democracy index rating which is a binary variable that determines whether a country is democratic if it is classified as “free” or “partially free” for any given observation year by three different democratic rating sources. The dependent variable is log GDP per capita measured in US dollars. The authors utilized three different strategies: a dynamic (linear) panel model (which includes time and country fixed effects), a semiparametric treatment effects framework, and the third uses an instrumental variable (regional waves in transitions to and away from democracy). Controls include investment, trade, enrollment in secondary schools, infant mortality rate, unrest rate, and tax revenue share of GDP. Results show that democratizations increase GDP per capita by 20 percent in the long run (25 years following permanent democratization) regardless of method utilized.

However, we also discovered another paper, Acemoglu et. al (2008) which sought to challenge existing literature that shows a strong cross-country correlation between income (which is essentially a measure of GDP) and democracy. Existing cross-country studies faced the potential issue of reverse causation and omitted variable bias. One source of omitted variable bias is country-specific factors that affect both income and democracy. Acemoglu et. al tackled these issues by controlling for factors such as country fixed effects and using instrumental variables. By introducing fixed effects, they were able to examine within-country variation or, in other words, whether a country is more likely to become more democratic as it becomes wealthier. Acemoglu et al. (2008) analyzed democracy with two different measures: The change in Freedom House Measure of Democracy and The change in Polity Measure of Democracy. They found no relationship between per capita income and democracy. They additionally used two instrumental variables: past savings rates and income of trading partners, but still found no relationship between per capita income and democracy. Acemoglu’s study reflected our initial understanding of the causal direction between our two variables of interest and thus we attempted to further explore this relationship.

These studies helped frame our expectations for our own results. While keeping the issue of reverse causation in mind, we were unsure if we would find no causal effect of per capita on democracy or a very small effect, as the literature suggests.

Data and Background

In our study, we observed 34 African countries from 1981 to 1998. We chose to replicate the same countries and time period as Miguel et al. (2004)², due to the substantial number of civil conflicts happening in Africa during this time period. 29 of 43 countries suffered from civil conflict during this time period, and several changes in government structure were also seen.

¹ Acemoglu, Daron, Suresh Naidu, Pascual Restrepo, and James A. Robinson. “Democracy Does Cause Growth.” *Journal of Political Economy* 127, no. 1 (2019): 47–100. <https://doi.org/10.1086/700936>.

² Edward Miguel, Shanker Satyanath, and Ernest Sergenti, “Economic Shocks and Civil Conflict: An Instrumental Variables Approach,” *Journal of Political Economy* 112, no. 4 (2004): pp. 725-753, <https://doi.org/10.1086/421174>.

We used Miguel's data in our replication to get figures for the following key variables: the democracy index, rainfall, country, year, population, ethnolinguistic fractionalization, and religious fractionalization. The democracy index captures democracy on a 21-point scale ranging from -10 (hereditary monarchy) to +10 (consolidated democracy). The Polity scores can also be converted into regime categories in a suggested three part categorization of "autocracies" (-10 to -6), "anocracies" (-5 to +5 and three special values: -66, -77 and -88), and "democracies" (+6 to +10). The rainfall data depicts the average annual rainfall in millimeters for distinct countries stretching back to 1979. This data was collected from NASA's Global Precipitation Climatology Project (GPCP) database which estimates the monthly rainfall using weather station data and satellite data. The population variable captures the population of any country for a given observation (year). The ethnolinguistic (retrieved from the Atlas Narodov Mira) and religious fractionalization (retrieved from the CIA factbook) variables are two distinct indices that denote, on a scale from 0 to 1, the probability that two randomly drawn individuals from a population belong to the same ethnic and religious group respectively.

To get the figures for GDP per capita for the distinct countries, we utilized data from the database found on the World Bank³. It depicts the average annual GDP per capita (in US dollars) for a variety of different countries during the time period of 1960-2020. To get the age of the country, we utilized a dataset from Kaggle⁴ which listed the independence day of numerous countries.

The following are the summary statistics of relevant variables:

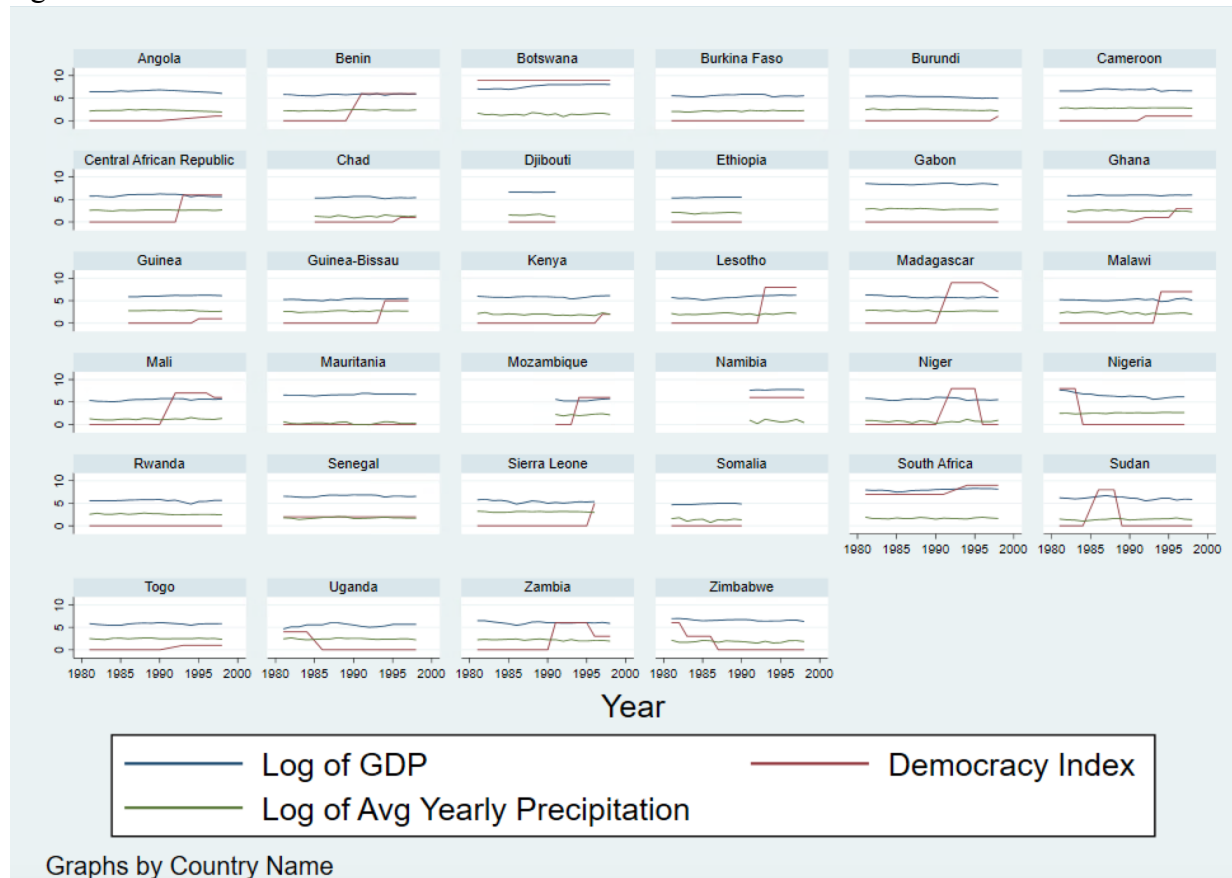
Figure 1: Summary Statistics of all variables

Summary Statistics				
	mean	sd	min	max
Log of GDP	6.10	0.85	4.65	8.63
Avg Yearly Precipitation (meters)	9.60	5.24	0.96	25.88
Democracy Index	1.69	2.95	0.00	9.00
Population in 1000s	12298.07	17769.51	370.00	117897.07
Age of Country	28.27	12.26	1.00	88.00
Ethnic Fractionalization	0.63	0.25	0.04	0.90
Religious Fractionalization	0.48	0.19	0.00	0.78

³ "GDP per Capita (Current US\$)." Data. The World Bank, 2022.
https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?name_desc=false.

⁴ Tatman, Rachael. "Independence Days." Kaggle. Kaggle, July 24, 2017.
<https://www.kaggle.com/datasets/rtatman/independence-days>.

Figure 2: Yearly averages for log of GDP per capita (in US dollars), democracy index rating, and log of annual rainfall



Empirical Strategy

To answer our question of whether higher GDP decreases a country's likelihood of having an authoritarian government or not, we decided to regress a country's GDP per capita for a given year on their democracy index for that year. Prior to our regression analysis, we chose to transform GDP per capita to log (GDP per capita) because we believe that a percent change would be a more intuitive independent variable.

However, in order to make sure we can establish causality with this regression several conditions needed to be satisfied. Since we used panel data, both the Common Trends Assumption and the No Anticipation Assumption must hold. We assumed that if GDP were to remain the same, we would expect countries to have the same trend in democracy rating. Additionally, we assumed that a country did not change their government structure in anticipation of a GDP fluctuation. However, we are aware of a possible violation to this condition. As seen in the literature above, other studies have been conducted that look into the causal effect of democracy on GDP. This implies the opposite causal direction from our question and analysis. If the causal direction is in fact that democracy causes fluctuations in GDP, or is bi-directional, then there is a risk that a government structure may change in anticipation of a change in GDP. For example, to increase GDP, a government may adopt more democratic

policies. This violates the no-anticipation assumption, and would lend to our causal effect being insignificant. This is something we can't really control for and will have a large impact on our results. However, for our study we assume this condition is satisfied while remaining aware that the results of our study may in fact be clouded by this reverse causality. Lastly, since we are using panel data, we have to account for inherent differences between years and between countries that will impact our estimate. To address these inherent differences, we introduce country and year controls. The country control variable refers to the country-specific fixed effects which are the unobserved determinants of democracy rating that are fixed over time for a particular country. The year control variable refers to the year-specific fixed effects which are the unobserved determinants of democracy rating that are common to all the studied countries but vary over time.

With the above conditions satisfied, we are still left with potential bias because we are only looking at observational data and not data from an experiment where GDP is randomly assigned to these countries. Therefore, we decided to find an instrumental variable that would create a natural experiment. We determined that precipitation is likely a good instrumental variable because in an agriculturally dependent economy it can be the driving factor for GDP, but it can't be controlled by a country, and thus selection bias is likely eliminated. Our instrumental variable of average annual precipitation per year has to fulfill the relevance and exclusion restriction conditions. The relevance condition denotes that rainfall has to be correlated with GDP per capita: this means when running the first-stage regression, the coefficient has to be non-zero and statistically significant. To fulfill the exclusion restriction, theoretically, rainfall can only affect the democratic rating of a country through the channel of GDP per capita. We assume this to be true, however, a possible violation could be that rainfall can affect GDP per capita through association with a channel of geographical qualities that also influences the political structures of that region. For instance, mountainous regions near large bodies of water tend to get heavier rainfall, but civilizations may spread themselves out more because of this as well, leading to more decentralized governments in these areas. This would overestimate the causal impact of GDP per capita on democracy rating. On the other hand, countries located in more tropical regions that experience more rainfall, also tend to live closer together. Living closer together, could lend more to an authoritarian government structure and thus violate the exclusion assumption. This would lend to an underestimate of the causal impact of GDP. The magnitude of these violations can vary from significant to negligible depending on the specifications of the region being analyzed. We are assuming that these effects are mitigated by the country fixed effects portion of our regression, yet we understand that some omitted bias may still be present even after controlling for this.

Our final assumption that must be met for causal interpretation of our regression is the Mean Independence Assumption. This implies that after we control for our relevant variables, the log of GDP is uncorrelated with our error term. We determined that population, age of the country, ethnic fractionalization, and religious fractionalization could all be potential variables that violate this condition and thus attempted to control for them. Even after controlling for these variables, we suspected another possible violation of this condition: natural resources. For instance, if a country is abundant in natural resources that contribute to its GDP, they may be less likely to need an organized government to support its people. This would underestimate the causal effect of GDP per capita on democracy rating. We were unable to find data that captured this variable in the manner we desired and therefore it remained omitted. The magnitude of this omitted bias can vary depending on the country, but we assume that by including country fixed

effects some of this bias is mitigated. Thus we assume the Mean Independence Assumption is satisfied.

Our first stage regression to check for relevance in our instrumental variable is as follows:

$$\begin{aligned} \log(\text{GDP per Capita}_{it}) = & \pi_0 + \pi_1 \text{Rainfall}_{it} + \sum_{k=1}^{K-1} \eta_k 1\{i = k\} + \sum_{j=1}^{T-1} \delta_j 1\{j = t\} \\ & + \pi_2 \text{CountryPopulation}_{it} + \pi_4 \text{EthnolinguisticFractionalization}_{it} \\ & + \pi_5 \text{ReligiousFractionalization}_{it} + \eta_{it} \end{aligned}$$

Our predicted treatment regression is as follows (note: we did not actually run this regression, but it is included in the second stage regression we ran in STATA) :

$$\begin{aligned} \log(\hat{\text{GDP per Capita}}_{it}) = & \hat{\pi}_0 + \hat{\pi}_1 \text{Rainfall}_{it} + \sum_{k=1}^{K-1} \eta_k 1\{i = k\} + \sum_{j=1}^{T-1} \delta_j 1\{j = t\} \\ & + \hat{\pi}_2 \text{CountryPopulation}_{it} + \hat{\pi}_4 \text{EthnolinguisticFractionalization}_{it} \\ & + \hat{\pi}_5 \text{ReligiousFractionalization}_{it} \end{aligned}$$

Lastly, our second stage regression to directly answer our causal question is as follows:

$$\begin{aligned} \text{Democracy Rating Index}_{it} = & \alpha + \beta \log(\hat{\text{GDP per Capita}}_{it}) + \sum_{k=1}^{K-1} \eta_k 1\{i = k\} + \sum_{j=1}^{T-1} \delta_j 1\{j = t\} \\ & + \gamma_1 \text{CountryPopulation}_{it} + \gamma_3 \text{EthnolinguisticFractionalization}_{it} \\ & + \gamma_4 \text{ReligiousFractionalization}_{it} + \epsilon_{it} \end{aligned}$$

In all the above regressions subscript i refers to an individual country, subscript t refers to an individual year, α is the baseline democracy index for our chosen reference year (1981) and country (Guinea-Bissau, country code 404), β is the casual estimate of GDP, γ_n are the correlation coefficients of our control variables, η_k is the country fixed effects for a given country, δ_j is the year fixed effects for a given year, and ϵ_{it} is the remaining error unaccounted for by GDP or our control variables.

A number of changes were made to the regressions we had in our pre-analysis plan. We had to drop the interaction term between country and time fixed effects, as STATA omitted variables due to collinearity. This could omit specific interactions between the time and country fixed effects that would change our results significantly. Issues with collinearity arose with the country age control variable, which is directly correlated to the time (year) fixed effects. STATA would drop the time fixed effects as a result, so we dropped the country age control variable.

Results and Discussion

When we run the first stage regression across all 34 countries, we receive statistically significant results. For every 1 meter in Average Yearly Precipitation in a country, on average, GDP increases by 0.02%. These findings show that a significant increase in Average Annual Rainfall leads to a relatively small GDP Growth percentage.

After instrumenting our Log of GDP with precipitation, we discovered that there is a statistically insignificant relationship between Log of GDP and the Democracy Index. Based on our results, we cannot make any conclusions regarding the effect of GDP on the democracy score of a country. If our results were significant, our coefficient of 2.74 would imply that a 1% increase in GDP will increase our Democracy Index rating by 2.74. This is 0.93 standard deviations from the mean of our democracy index distribution. This is a massive increase for only a 1% increase in GDP, but the results are not statistically significant enough to make any meaningful claims about GDP and democracy.

Based on the process of adding controls one by one, we noticed that including Country Fixed Effects and Year Fixed Effects significantly changed our coefficient estimate for Log of GDP from -9.95 to -5.53 to -0.2 respectively. Including religious fractionalization, ethnic fractionalization and population as controls for our regression had no effect on our log of GDP estimate. We therefore assumed we controlled for any observable OVB. However, we remain aware that there are likely other variables that we did not have the data for that impacted GDP and Democracy.

We noticed that in our second stage regression, one of our countries that was present in our first stage regression was omitted from our second stage regression due to a lack of data in its democracy index. In response to these results, we decided to run the first stage regression again without the omitted country. Running this regression produced less significant results such that the log of Average Yearly Precipitation has a statistically insignificant effect on the log of GDP. This violates the relevancy assumption of our instrument.

Thus, we tried removing the rainfall variable to see if our regression would be statistically significant without instrumentation. At first, the uninstrumented log of GDP had a statistically significant relationship with the democracy index of our 34 countries. However, as we added relevant controls such as country fixed effects, year fixed effects, etc. our coefficient became gradually less significant. So, even with an uninstrumented log of GDP compared to the democracy index, our regression is still statistically insignificant.

Compared to our Pre-Analysis Plan, our first stage regression and second stage regression results remained the same. Our regression model was different, however. In our Pre-Analysis plan, our regression equation included an interaction term between our country fixed effect and our year fixed effect variables. However, because the interaction term is directly correlated with the year and country, STATA always dropped this variable due to collinearity. This meant that the variable had no effect on the results of our regression. Our Pre-Analysis Plan also had a country-age variable in which we took the country's year and subtracted it from the observation year. Stata automatically omitted several of our year fixed effects due to their collinearity with the age variable. This meant that when we dropped the age variable in our later regression, the previously omitted year fixed effects were added back in, but no regression results changed. Therefore, despite omitting some of our control variables, the results of our pre-analysis plan regression are the same as our final results.

Our robustness check (as seen in our appendix) presents several alternative regression models which all demonstrate the same conclusion that GDP does not significantly impact democracy rating. Additionally, it shows that in dropping certain observations and logging certain variables, our relevance condition for our instrumental variable also stops being satisfied. This leads us to conclude that even though our instrumental variable is likely not a very good one, our results remain insignificant.

First stage (statistically significant- missing democracy rating scores for some observations)

	Log of GDP
Avg Yearly Precipitation (meters)	0.02** (0.01)
Population in 1000s	-0.00*** (0.00)
Ethnic Fractionalization	0.00 (.)
Religious Fractionalization	0.00 (.)
Constant	6.25*** (0.10)
Country Fixed Effects	Yes
Year Fixed Effects	Yes
Adj. R-squared	0.23
N	567

Second Stage:

	Democracy Index					
	(1)	(2)	(3)	(4)	(5)	(6)
Log of GDP	-9.95 (18.47)	-5.53 (10.07)	-0.20 (13.20)	2.74 (5.58)	2.74 (5.58)	2.74 (5.58)
Population in 1000s				-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)
Ethnic Fractionalization					0.00 (.)	0.00 (.)
Religious Fractionalization						0.00 (.)
Constant	62.34 (112.78)	35.42 (61.40)	2.48 (81.24)	-14.49 (36.02)	-14.49 (36.02)	-14.49 (36.02)
Country Fixed Effects	No	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	No	No	Yes	Yes	Yes	Yes
N	525.00	525.00	525.00	525.00	525.00	525.00

Conclusion

Overall we found that countries with a higher GDP per capita do not significantly trend towards a more democratic regime. Our regression did not elicit statistically significant results. Our instrumental variable fulfilled the relevance condition only when we didn't omit observations where only democracy index data was missing. This led us to present results from both our instrumented GDP and uninstrumented GDP. Our model has many limitations: we had to drop the interaction term between year and country fixed effects, the country age control variable, our instrumental variable may not be as good as originally thought, and we had omitted data for some of the observations. Any one of these could have an effect on our results, and we cannot discern causality as a result (also because our results are statistically insignificant). Some possible next steps that could build on our research would be to analyze different regions of the world, more recent time periods, and adding controls for factors such as civil/international war, natural disasters and cultural shocks. By looking at regions that aren't as agriculturally dependent as Africa, we may find significant differences in the relationships between rainfall, GDP, and democracy. More recent times have seen an influx of technological advancements that facilitate mass production: it would be curious to explore the implications of this on the transferring of government regimes. By nature, exploring GDP and democracy is subject to a lot of omitted variable bias: war, natural disasters, cultural shocks, and other occurrences that deeply impact both GDP and government were not controlled for in our regression. This may be difficult in practice, but could yield significant results as it has been argued that occurrences such as these could be an opening to capture power and deplete a nation's resources for many years. Lastly, a better instrumental variable used on our current data could also yield different results that may provide more insight on GDP's actual impact. Overall, our results were not consistent with our hypothesis and we are unable to address the ambiguity present in the overall discourse of recent literature.

Appendix

- I. Appendix:
- A. PAP regressions
 - 1. First and second stage results
 - B. Other alternatives

Pre-analysis Plan:

First stage:

Log of GDP	
Avg Precipitation in m per year (NASA)	0.02** (0.01)
Constant	6.08*** (0.18)
Adj. R-squared	0.23
N	567

Second Stage:

	(1)	(2)	Democracy Index		(5)	(6)	(7)
			(3)	(4)			
Log of GDP	-7.31 (13.89)	-4.16 (8.65)	0.94 (10.92)	0.94 (10.92)	2.74 (5.58)	2.74 (5.58)	2.74 (5.58)
Age of Country				0.10* (0.05)	0.13** (0.06)	0.13** (0.06)	0.13** (0.06)
Population in 1000s					-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)
Ethnic Fractionalization						0.00 (.)	0.00 (.)
Religious Fractionalization							0.00 (.)
Constant	46.29 (84.83)	27.15 (52.82)	-4.48 (67.23)	-6.49 (68.02)	-17.07 (35.11)	-17.07 (35.11)	-17.07 (35.11)
Country Fixed Effects	No	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	No	No	Yes	Yes	Yes	Yes	Yes
N	552.00	552.00	552.00	552.00	525.00	525.00	525.00

Alternatives:

First Stage - not statistically significant due to dropping of observations with no democracy rating scores

	(1)
	Log of GDP
Log of Avg Yearly Precipitation	0.08 (0.11)
Log of Population	0.02 (0.84)
Ethnic Fractionalization	0.00 (.)
Religious Fractionalization	0.00 (.)
Constant	5.79 (7.26)
Adj. R-squared	0.07
N	525

First Stage Alternative: logged rain, but all observations are present (ones with missing values for dem index that aren't included in second stage regression)

	(1)
	Log of GDP
Log of Avg Yearly Precipitation	0.14* (0.08)
Population in 1000s	-0.00*** (0.00)
Ethnic Fractionalization	0.00 (.)
Religious Fractionalization	0.00 (.)
Constant	6.15*** (0.17)
Adj. R-squared	0.23
N	567

Alternative second stage

	(1)	(2)	Democracy Index (3)	(4)	(5)	(6)
(uninstrumented)Log of GDP	1.52** (0.60)	1.77* (0.97)	2.12* (1.15)	1.46 (1.06)	1.46 (1.06)	1.46 (1.06)
Population in 1000s				-0.00*** (0.00)	-0.00*** (0.00)	-0.00*** (0.00)
Ethnic Fractionalization				0.00 (.)	0.00 (.)	0.00 (.)
Religious Fractionalization				0.00 (.)	0.00 (.)	0.00 (.)
Constant	-7.59** (3.55)	-9.13 (5.89)	-11.74 (7.02)	-6.21 (6.82)	-6.21 (6.82)	-6.21 (6.82)
Country Fixed Effects	No	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	No	No	Yes	Yes	Yes	Yes
N	525.00	525.00	525.00	525.00	525.00	525.00

References

1. Acemoglu, Daron, Suresh Naidu, Pascual Restrepo, and James A. Robinson. "Democracy Does Cause Growth." *Journal of Political Economy* 127, no. 1 (2019): 47–100. <https://doi.org/10.1086/700936>.
2. Asiedu, Elizabeth, and Donald Lien. "Democracy, Foreign Direct Investment and Natural Resources." *Journal of International Economics* 84, no. 1 (2011): 99–111. <https://doi.org/10.1016/j.jinteco.2010.12.001>.
3. Brückner, Markus, Antonio Ciccone, and Andrea Tesei. "OIL PRICE SHOCKS, INCOME, AND DEMOCRACY." *The Review of Economics and Statistics* 94, no. 2 (2012): 389–99. <http://www.jstor.org/stable/23262078>.
4. Kersting, Erasmus, and Christopher Kilby. "Aid and Democracy Redux." *European Economic Review* 67 (2014): 125–43. <https://doi.org/10.1016/j.euroecorev.2014.01.016>.
5. Miguel, Edward, Shanker Satyanath, and Ernest Sergenti. "Economic Shocks and Civil Conflict: An Instrumental Variables Approach." *Journal of Political Economy* 112, no. 4 (2004): 725–53. <https://doi.org/10.1086/421174>.