Democratization's Heterogeneous Effects on Child Mortality: A Longitudinal Analysis of New Data, for 181 countries, 1970-2009

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Abstract

Current empirical literature on the effects of democracy on child mortality remains inconclusive; some studies show strong beneficial effects while others do not. We revisit this debate using a new statistical approach that explicitly distinguishes several types of effects that were combined in previous studies and a new complete data set. We find that while the average effect of democratization is negligible, there is a substantial amount of between-country variation in its effects. In some Sub-Saharan African countries democracy has long-term beneficial effects on child mortality, while in many Latin American countries the effect of democracy is neutral or even deleterious. Moreover, in some former communist countries the introduction of democracy leads to short term deleterious effects followed by beneficial long term effects.

1 Introduction

Which form of government is most responsive to its citizens' needs, particularly to the needs of the poor? Scholars and policymakers alike have argued that democracies provide more services to the poor than non-democracies (Meltzer and Richard, 1981; Acemoglu and Robinson, 2000). Studies have found that in comparison to other forms of government, democracies increase calorie intake (Blaydes and Kayser, 2011), prevent famine (Sen 1981, 1999), improve access to electricity (Min, 2015; Brown and Mobarak, 2009), increase spending on primary education (Stasavage, 2005), and fund public services more effectively (Avelino et al., 2004). However, while democracies can be better at funding social services than non-democracies, it can be the case that the additional spending is not reaching those most in need (Filmer and Pritchett, 1999). Child mortality has often been used as a proxy for population well-being, especially among the poor, due to its concentration among low income families (Ross, 2006). It is possible to significantly reduce child mortality in poor countries through the introduction of relatively inexpensive medical technology(Black et al., 2003; Jones et al., 2003; Bryce et al., 2003; Victora et al., 2003). Thus investigating the effect of regime type on child mortality can help us understand whether democratic governments are efficiently providing essential health services to those in need.

Previous cross-national studies on early-life mortality and democracy have proven inconclusive. Przeworski et al. (2000) found that democracies are associated with better health outcomes, including lower infant mortality. Lake and Baum (2001) argued that a transition from complete autocracy to complete democracy is associated with a substantial reduction in infant mortality. However, Ross (2006) found that, once missing data

are accounted for, democracy is not associated with lower child mortality. Gerring et al. (2012) found evidence for the long term beneficial effects of democracy on health. Similarly, Kudamatsu (2012) found that democratization was followed by infant mortality reductions in Sub-Saharan Africa. (Garcia, 2014) argues that null findings from previous studies are model dependent and that democracy is actually associated with lower child mortality. Pieters et al. (2016) studied the effect of democracy on child mortality for 24 transitions from dictatorships to democracies and found that only a few transitions provided beneficial effects. However, they did not study most democratization episodes in recent decades. Thus, it is unclear whether democracy has any effects on mortality, and of so, what those effects are.

Previous studies have been limited by data quality concerns such as missing data and measurement error (Ross, 2006). Rajaratnam et al. (2010) compared three lists of the ten countries with the fastest rates of decline in child mortality between 1990 and 2007. One of the lists was from UNICEF in 2008, another was from UNICEF in 2009, and the third was from the UN Population Division (UNPD) in 2009. These three lists had only three countries in common: Portugal, Vietnam, and the Maldives. In 2008, UNICEF reported that Thailand had the fastest rate of decline in the world. However in 2009, Thailand was ranked 47th from UNICEF and fourth from the UNPD (Rajaratnam et al., 2010). The differences in the country rankings indicates that national averages of child mortality is not being estimated accurately.

Beyond data quality concerns, many previous cross-national studies did not empirically model whether the association between democratization and health outcomes varies across countries. Instead, these studies have typically focused on average effects of democracy across all countries. However, there is no reason to assume a priori that the

introduction of democratic reforms in different countries will lead to similar reductions in child mortality. In fact, many studies identify beneficial effects of democracy on human welfare in Sub-Saharan Africa (Kudamatsu, 2012; de Kadt and Wittels, 2016) but not in formerly communist countries (UNICEF, 1997; Safaei, 2012). In addition, recent studies have found heterogeneous effects of democratization on economic development (de Kadt and Wittels, 2016) and agricultural and food policies (Olper et al., 2013). Finally, short term effects can be different from long term effects due to transition costs (Hellman, 1998) and thus should be considered separately. Thus the focus on the average effects may hide substantively important heterogeneity in the effects of democracy on child mortality by combining short and long term effects across all transitions.

In this study we use a new data set provided by Rajaratnam et al. (2010) to make two key contributions. Methodologically, we employ a longitudinal random effects model that captures heterogeneous effects of democracy on child mortality at the country level. While random effects models are becoming increasingly popular in Political Science (Shor et al., 2007; Gelman et al., 2007; Park et al., 2004; Pang, 2010; Park, 2012; Western and Jackman, 1994; Western, 1998; Beck and Katz, 2007; Lax and Phillips, 2012; Ghitza and Gelman, 2013; Fairbrother, 2014; Stegmueller, 2013; Bell and Jones, 2015; Clark and Linzer, 2015; Fairbrother, 2014), our model introduces three key innovations. First, it allows each one of the 175 countries included in our data to have its own baseline level and over time trends in child mortality thus relaxing the parallel time trends assumption assumed by statistical models used by many previous studies and unlikely to be true. Second, for each one of the 71 transitional countries in our data, we separately identify short and long term effects of democracy on child mortality, a distinction that has not been previously made. Finally, for the 55 democratic transitions in our data that lasted

long enough we construct counterfactual scenarios that estimate what the trends in child mortality would have looked like in the absence of democratic transitions and how many lives were saved under democracy.

This study also makes a substantive contribution to the study on the relationship between health and regime type and open important new research questions. We show that averaged across all countries, the association between democracy and child mortality is not statistically nor substantively significant. While this seems to suggest a null causal effect of democracy on child mortality, there is a large amount of between country variation in this association. For example, while in Madagascar democracy reduced mortality by around 29% in Chile it increased mortality by 48%. Sub-Saharan Africa democracy was either very successful or neutral in reducing child mortality. However in many Latin American countries, democratization made the over time reductions in mortality slower than they under political instability or authoritarian rule. Finally, in many Eastern European countries, we find short term deleterious effects of democratization followed by long term beneficial effects. These results help resolve and reconcile the incongruous findings of prior work on democratic reforms because they show that there is indeed a large variation on its the effects of democracy on health and that this variation is hidden by pooling together all these disparate results. Our results also opens a broad theoretical and policy question: what explains the heterogeneous effects of democracy?

In Section 2, we briefly discuss why we should expect variability in the effects of democracy on child mortality in different parts of the world. In Section 3, we discuss the challenges in making causal inferences using observational data in the context of this study as well as the role of possible mediators and confounding factors. In Section 4 we present a detailed description of the data. In Section 5 we introduce our methodology

and briefly discuss the differences between our methods and more commonly used approaches. In Section 6 we present the results from our analyses. In Section 7, we present a discussion of our results and in Section 8 we provide some concluding remarks.

2 Democracy, Early-life Mortality, and Heterogeneous Effects

While there is a substantial body of literature on how political reforms influence government policies that affect the poor (Meltzer and Richard, 1981; Acemoglu and Robinson, 2000), theory does not predict that new democracies will be able to equally provide services for those in need. For example, the median voter model (Meltzer and Richard, 1981) is often invoked to illustrate the mechanism by which democracies may benefit a larger fraction of the population than autocracies and predicts that democracies tend to redistribute from the rich to the poor. However, the median voter model also predicts that this redistribution will be greater with greater income inequality. Similarly, Ross (2006) notes that democracy may only improve the health of the poor in the poorest countries, where both poor and middle class citizens are plagued by high levels of child mortality (Wagstaff, 2002; Houweling et al., 2005).

The median voter model is a simplified model of politics and may not account for other political factors that also induce heterogeneity in democracy effects on child mortality between countries (Nelson, 2007). The choice of electoral system, disagreement in public support for public policies, and populist governments may hinder the implementation of complex public health reforms in many newly democratized countries. Hellman

(1998) suggests that in Eastern Europe political and economic reforms may cause trends in mortality to follow a J-curve, where they rise precipitously after the reforms before long term improvements are made. Recent studies have also found that democratization has had heterogeneous effects on a variety of outcomes such as economic output (de Kadt and Wittels, 2016) and food policies (Olper et al., 2013).

3 The causal effect of democracy on child mortality

Randomization of the treatment is often considered the gold standard of causal inference Holland (1986); Angrish and Pischke (2009). Because countries are not randomly assigned to different political regimes, it is important to understand the main challenges in identifying the causal effect of democracy on child mortality. We discuss the main confounders or mediators of the the causal effect of democracy on health in cross-national studies.

Modernization theory suggests that both child mortality reductions and democratization can be a byproduct of socioeconomic modernization. (Lipset, 1959) hypothesized that, as a country develops, per capita income increases and population becomes more educated, its citizens no longer tolerate repressive political regimes. Suppose that democracy reduces child mortality via the promotion of education in women, which has a well known association with child mortality (Gakidou et al., 2010). Then controlling for maternal education will take away some of the beneficial effects of democracy on child mortality. This phenomenon is sometimes referred to as post treatment bias (Gelman

and Hill, 2006, Chapter 10). There are several studies that estimate the effects of democracy on the variables stressed by modernization theory, such as maternal education and income per capita (Acemoglu et al., 2008). Thus whether we should control for these variables in a statistical model depends on what type of effect one wants to estimate. We address this concern by comparing the results from statistical models that control for these variables with other that don't. We also discuss the role of foreign aid in mediating the effects of democracy on health in African in the appendix.

4 New Data on Child Mortality

The data made available by Rajaratnam et al. (2010) are from an intensive 3-year data collection effort in 187 countries from 1970 to 2009. They collected data from vital registration systems, summary birth histories, and complete birth histories. These data include recent estimates for Child Mortality rates and newly collected data on income (GDP), maternal education, and HIV prevalence for 175 countries from 1970 to 2009. The resulting data are 16,174 country-level measurements for 7480 country-years. Each country-year can have multiple data sources, and the mortality rates were constructed by using Gaussian process regression to average the data, thus the data are complete and much less subject to measurement error than previously available datasets. Most of their primary data sources were collected by international agencies that are independent from local governments, such as the Demographic Health Surveys (DHS) funded by USAID and Multiple Indicators Cluster Surveys (MICS) funded by UNICEF. For this reason, political manipulation of the data is much less of a concern than for the data used by Ross (2006). A list of all the data sources is provided in the online appendix for

Rajaratnam et al. (2010).

The present study also uses new data on maternal education (Gakidou et al., 2010), a covariate that to our knowledge has not been included in previous studies on democracy and early-life mortality. Researchers have compiled 915 censuses and nationally representative surveys, and estimated mean number of years of education by age and sex for 175 countries between 1970 and 2009. Similar to the new data set on child mortality, this is a high resolution data set with no missing observations and lower measurement error than in previously available data.

4.1 Measuring Democracy and Identifying Stable Transitions

To measure regime type, we use the well-established data set developed by Przeworski et al. (2000) and extended by Cheibub and Gandhi (2010). It is a binary measure that is highly comparable across countries, based on objectively observable characteristics that uses free elections as the main criteria for determining whether a country can be considered democratic or not.

We say that a country has experienced a " stable democratic transition" if it transits from dictatorship to democracy and never transits back. Examples of such countries in our dataset are Brazil, which transited in 1985, and Latvia in 1991. In contrast, "unstable democratic transitions" are those in which after transiting to democracy, they transited back to dictatorships. The most extreme example of unstable democratic transitions is Thailand, which had four transitions from dictatorship to democracy, some of which only lasted for one year. Some countries, like Argentina, briefly transited to

democracy for two years, then transited back to dictatorship until finally becoming stable democracy in 1981. In these cases, we are able to analyze in details the effect of the second democratic transition, but not the first.

We conduct two separate analyses, one using the original coding from Cheibub and Gandhi (2010) and another in which we recode shorter, unstable periods of democracy to dictatorships 1. In the original coding of democracy, there are 71 countries for which we will be estimating a overall democracy effect. For countries with multiple transitions, we treat each one as having an equivalent effect on mortality. For the analysis that uses the recoded data, we will be estimating the democracy effect for 55 countries, and we are able to investigate the heterogeneous effects in detail.

5 Methods

5.1 Statistical Models from Previous Studies

Many of the previous previous cross-national studies on democracy and child mortality have used fixed effects models (Lake and Baum, 2001; Ross, 2006; Przeworski et al., 2000)*. The basic structure of these models is

$$Y_{j,t} = \gamma_j + \delta_t + \alpha \mathrm{D}_{j,t-1} + X_{j,t-1} + \epsilon_{j,t} \tag{1}$$

$$\epsilon_{j,t} \sim N(0, \sigma^2)$$

where for country j in year t, $Y_{j,t}$ is the log of child mortality, $\mathrm{D}_{i,t-1}$ is a binary indicator for country j being a democracy in year t, and $X_{j,t-1}$ is a vector of covariates containing income per capita, maternal education, and HIV prevalence lagged by one year. In

*For conflicting definitions of fixed and random effects effects see Gelman and Hill (2006).

Country	Transition Year	Country	Transition Year
Albania	1991	Malawi	1994
Argentina	1983	Mali	1992
Armenia	1991	Mexico	2000
Bangladesh	1986	Moldova	1991
Benin	1991	Mongolia	1990
Bolivia	1982	Nicaragua	1984
Brazil	1985	Niger	2000
Bulgaria	1990	Nigeria	1999
Cape Verde	1990	Panama	1989
Chile	1990	Paraguay	1989
Croatia	1991	Peru	2001
Cyprus	1983	Philippines	1986
Czech Republic	1989	Poland	1989
Ecuador	1979	Portugal	1976
El Salvador	1984	Romania	1990
Estonia	1991	Sao Tome and Principe	1991
Georgia	2004	Senegal	2000
Ghana	1993	Serbia	2000
Greece	1974	Sierra Leone	1998
Grenada	1984	Slovakia	1989
Guatemala	1986	Slovenia	1991
Honduras	1982	Spain	1977
Hungary	1990	Sri Lanka	1989
Indonesia	1999	Suriname	1991
Kenya	1998	Turkey	1983
Latvia	1991	Ukraine	1991
Lithuania	1991	Uruguay	1985
Madagascar	1993		

Table 1: *List of countries with year of stable democratic transition.*

(1), γ_j is an intercept term for country j, δ_t is a fixed effect for year t, β is a vector of regression coefficients multiplying $X_{j,t-1}$, and α estimates the average difference in log mortality between dictatorships and democracies. Since this model ignores the dependence structure between observations within countries and years, the usual standard errors do not provide appropriate coverage and sandwich estimators are used instead.

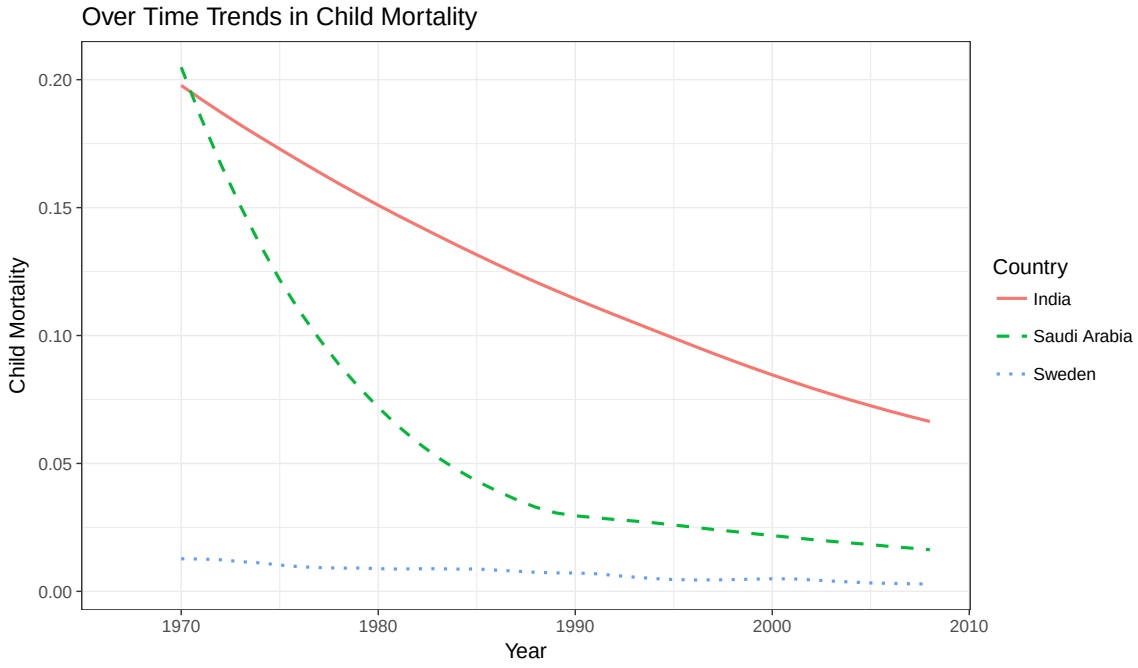

Figure 1: *Over time trends in child mortality for India, Saudia Arabia, and Sweden.*

To interpret this model as causal we assume that, conditional on the controls, there is no omitted variable that simultaneously increases the probability of democratization and reduces the probability of child mortality. Additionally, there are three limitations with the model in (1) as applied to our study. First these models assume parallel trends in child mortality between countries in the absence of democratization (Angrish and Pischke, 2009). While this assumption cannot be tested, it is unlikely to be the case. We plot over time rates of child mortality for Sweden, India, and Saudi Arabia in Figure

1, and can see that the trends do not appear to be parallel. To further illustrate this point, we plot the trends for all countries in the appendix. Another limitation is that the effect of democracy, α, does not vary between countries making it impossible to estimate heterogeneous effects. Finally, this model also does not distinguish between short and long term effects for each country.

5.2 Identifying Heterogenious Effects of Democracy on Child Mortality

We extend the model in (1) to decompose the effect of democracy on child mortality into short and long term effects by employing bent lines. Bent lines are continuous functions that are linear in the intervals, but allow the slope and intercepts to change from one interval to the next (Singer and Willett, 2003; Weiss, 2005). We define intervals by the introduction of democracy in previously authoritarian countries. The basic framework for the bent line is illustrated in Figure 2, with hypothetical data that mimics actual mortality data on the log-scale. Trajectories for three countries are illustrated. Generally, mortality decreases over time for all countries, but dictatorships have the highest average levels while stable democracies have the lowest, and transitional countries are in between. (see Figure 1 in the appendix).

For each country that experience democratization process, we model whether democratic transitions in previously authoritarian regimes further accelerate the reduction in child mortality (long term effects) and whether the introduction of democracy changes levels of child mortality at the time of the transition (short term effects). The model

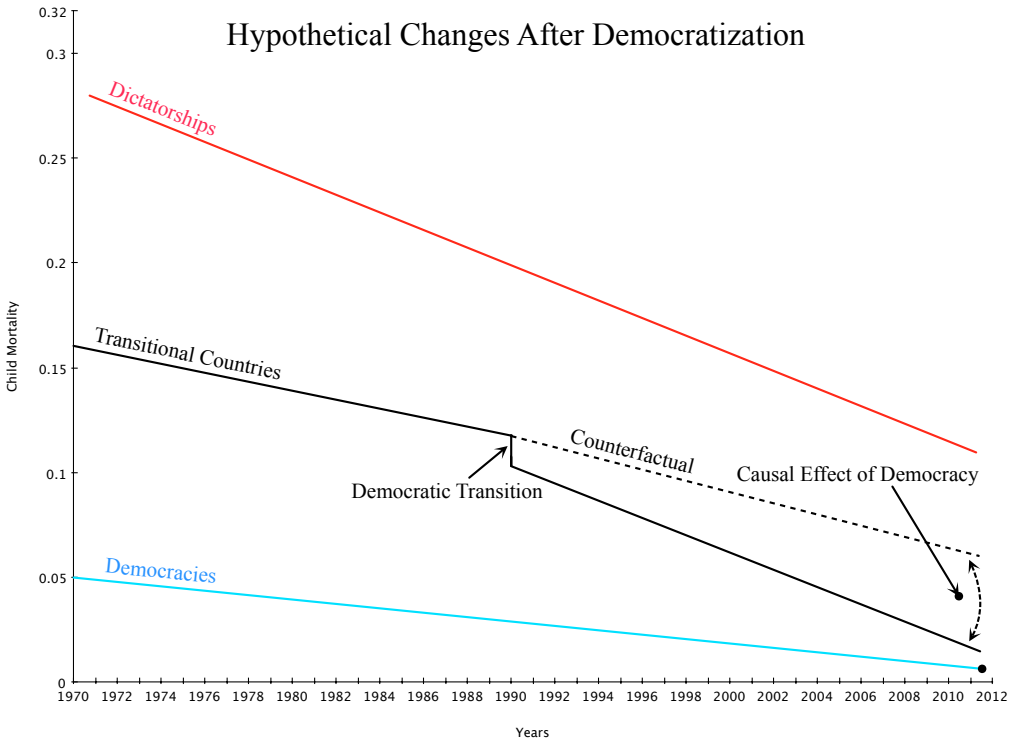

Figure 2: *Hypothetical time trends in child mortality for three categories of countries: democracies, dictatorships, and those which transition. For simplicity, the transitional group is modeled as experiencing a single transition from dictatorship to democracy. The dotted lines following the transition represents the counterfactual scenario (i.e. without the democratic transition).*

graphically depicted in Figure 2 can be written as

$$Y_{j,t} = \pi_{1j} + \pi_{2j} * \text{time}_{jt} + \pi_{3j} * \text{D}_{jt} + \pi_{4j} * \text{Dtime}_{jt} + \beta X_{jt} + \epsilon_{jt} \quad (2)$$

Where for country j at time t, Y_{jt}, $\boldsymbol{X}_{jt}$, $\boldsymbol{\beta}$, ϵ_{jt}, and D_{jt} are defined as in Equation (1), time_{jt} is time from the first record, and Dtime_{jt} is the number of years from the transition. We do not use lagged variables for two reasons. First, successive time points are highly correlated. Second using lagged data forces us to drop the first record, and we prefer to use all available data. This is because keeping all observations helps us to make more precisely estimate some of the key quantities of interest. The baseline intercept and the linear time trends for each country j are π_{1j} and π_{2j}, respectively. For democratization, the short term effects are the π_{3j} and the long term effects are the π_{4j}.

As with the model presented in (1), to interpret the model from (2) as causal we also assume that conditional on the controls, there is no omitted variable that simultaneously increases the probability of democratization and reduces the probability of child mortality. There are two a key differences between equation (1) and (2). First, while Equation (1) assumes parallel time trends in the absence of democratization, Equation (2) makes the more reasonable assumption that countries over time trajectories would have been unchanged in the absence of democratization. Second, Equation (2), allows short and long term effects of democracy to vary between countries.

Because of the number of parameters in Equation (2), unconstrained estimation procedures such as OLS will not estimate the long and short effect of democracy with enough precision to allow us to investigate heterogeneous effects. Random effects models are better than unconstrained optimization for the purpose of modeling over time trajectories and estimating predictions because these models implement partial pooling

of the data thus yielding better predictions $Y_{j,t}$ (Robinson, 1991; Reisel, 1985; Gelman, 2005; Weiss, 2005; Bell and Jones, 2015). Predictions from these models can be used to calculate counterfactual scenarios of what the child mortality rates would have been in the absence of democracy as well as how many more lives would have been saved or lost due to these political transformations. Let $\boldsymbol{\pi}_j = (\pi_{1j}, \pi_{2j}, \pi_{3j}, \pi_{4j})^T$. We treat $\boldsymbol{\pi}_j$ as random and estimate it using the following Bayesian hierarchical model,

$$\boldsymbol{\pi}_j \sim \mathrm{N}_4 \left(\boldsymbol{\mu}, \boldsymbol{\Sigma} \right) \tag{3}$$

$$\boldsymbol{\mu} \sim \mathrm{N}_4 \left(\boldsymbol{\mu}_0, \boldsymbol{I}_4 \right) \tag{4}$$

$$\boldsymbol{\Sigma}^{-1} \sim \text{Wishart} \left(\frac{1}{4} \boldsymbol{I}_4, 4 \right), \tag{5}$$

where $\boldsymbol{\mu}$ is the prior mean vector for $\boldsymbol{\pi}_j$, $\boldsymbol{I}_4$ is the 4×4 identity matrix, $\boldsymbol{\Sigma}$ is an unstructured covariance matrix, and $\boldsymbol{\mu}_0 = (-3, -0.5, 0, 0)$ is the mean of the hyperprior for $\boldsymbol{\mu}$. The prior distribution for $\boldsymbol{\mu}$ gives each country a prior mean mortality rate of about 5% at baseline, which decreases multiplicatively by 40% each year. Further, the model says a priori that democracy will have no effect on the mortality rate for any of the countries. However the hierarchical structure allows us to estimate the $\boldsymbol{\pi}_j$ for each country as well as the correlation between the $\boldsymbol{\pi}_j$. Thus, the model will estimate different baseline mortality rates, log-linear trends, and short and long term effects for each country, which also allows us to estimate what the mortality rate would have been had the country never democratized as well as how many lives were saved or lost due to democratization.

6 Results

Table 2 presents regression coefficients for fixed effects as well as random effect variances. We present the results from different models specifications with and without covariates and with and without the recoded version of democracy. For each of these models, point estimates are presented along with 95% credible intervals. In all model specifications, we find that the credible intervals for the short term and long term effects contain zero, suggesting that the average effect of democracy across all countries is not significant. However, the random effect variances are large in comparison to the average effects, suggesting that there is a substantial amount of heterogeneity between countries. Table 2 also shows that while covariates tend to affect the baseline mortality rate and time trends, the short term and long term effects are relatively unaffected, suggesting that the effects we see are not mediated by covariates.

Figure 3 shows the random short term and long term democracy effects for each country from our preferred model specification (recoded version of democracy and no covariates). Consistent with the results from Table 2, there is a large amount of heterogeneity in the effects of democracy on child mortality between countries. While the average of the point estimates is centered around zero, we can see that about 20% of the countries have statistically significant short term effects while the figure is around 50% for the long term effects. Short term effects tend to be larger in magnitude than long term effects since the long term effects are multiplicative in years, and thus accumulate over time. The figures are ordered by magnitude and show that whether a country has a large short term effect is not indicative of whether it will have a large long term effect. Thus, the short and long term effects are not strongly correlated and it is important

Parameter	No Covariates Old Democracy	No Covariates New Democracy	Covariates Old Democracy	Covariates New Democracy
Fixed Effects				
Intercept	-2.36 (-2.50, -2.22)	-2.36 (-2.50, -2.22)	-1.52 (-1.67, -1.37)	-1.52 (-1.68, -1.38)
Time	-0.03 (-0.03, -0.03)	-0.03 (-0.04, -0.03)	-0.026 (-0.03, -0.02)	-0.03 (-0.03, -0.02)
Short Term	0.01 (-0.02, 0.03)	0.01 (-0.026, 0.04)	-0.01 (-1.94, 2.15)	-0.01 (-0.05, 0.02)
Long Term	-0.01 (-0.02, 0.01)	-0.01 (-0.03, 0.01)	-0.01 (-0.03, 0.01)	-0.01 (-0.03, 0.01)
HIV Prevalence	–	–	1.44 (1.29, 1.61)	1.48 (1.32, 1.64)
Maternal Education	–	–	-0.05 (-0.07, -0.04)	-0.05 (-0.07, -0.04)
GDP	–	–	-0.08 (-0.10, -0.07)	-0.08 (-0.10, -0.07)
Random Effect Variances				
Error Variance	0.005 (0.005, 0.005)	0.005 (0.005, 0.005)	0.005 (0.005, 0.005)	0.005 (0.005, 0.005)
Intercept	0.85 (0.68, 1.05)	0.85 (0.68, 1.05)	0.48 (0.38, 0.60)	0.47 (0.37, 0.60)
Time	0.002 (0.001, 0.002)	0.002 (0.001, 0.002)	0.002 (0.001, 0.002)	0.002 (0.001, 0.002)
Short Term	0.01 (0.01, 0.02)	0.01 (0.01, 0.02)	0.35 (0.03, 1.74)	0.013 (0.01, 0.02)
Long Term	0.004 (0.003, 0.006)	0.005 (0.004, 0.008)	0.005 (0.003, 0.006)	0.005 (0.004, 0.008)

Table 2: *Results for the fixed and random effects components for four specifications of the hierarchical longitudinal model. Point estimates are presented along with 95 % pointwise credible intervals in paranthesis.*

to include both effects in the model. The qualitative results are similar irrespective of whether or not we include covariates in the model.

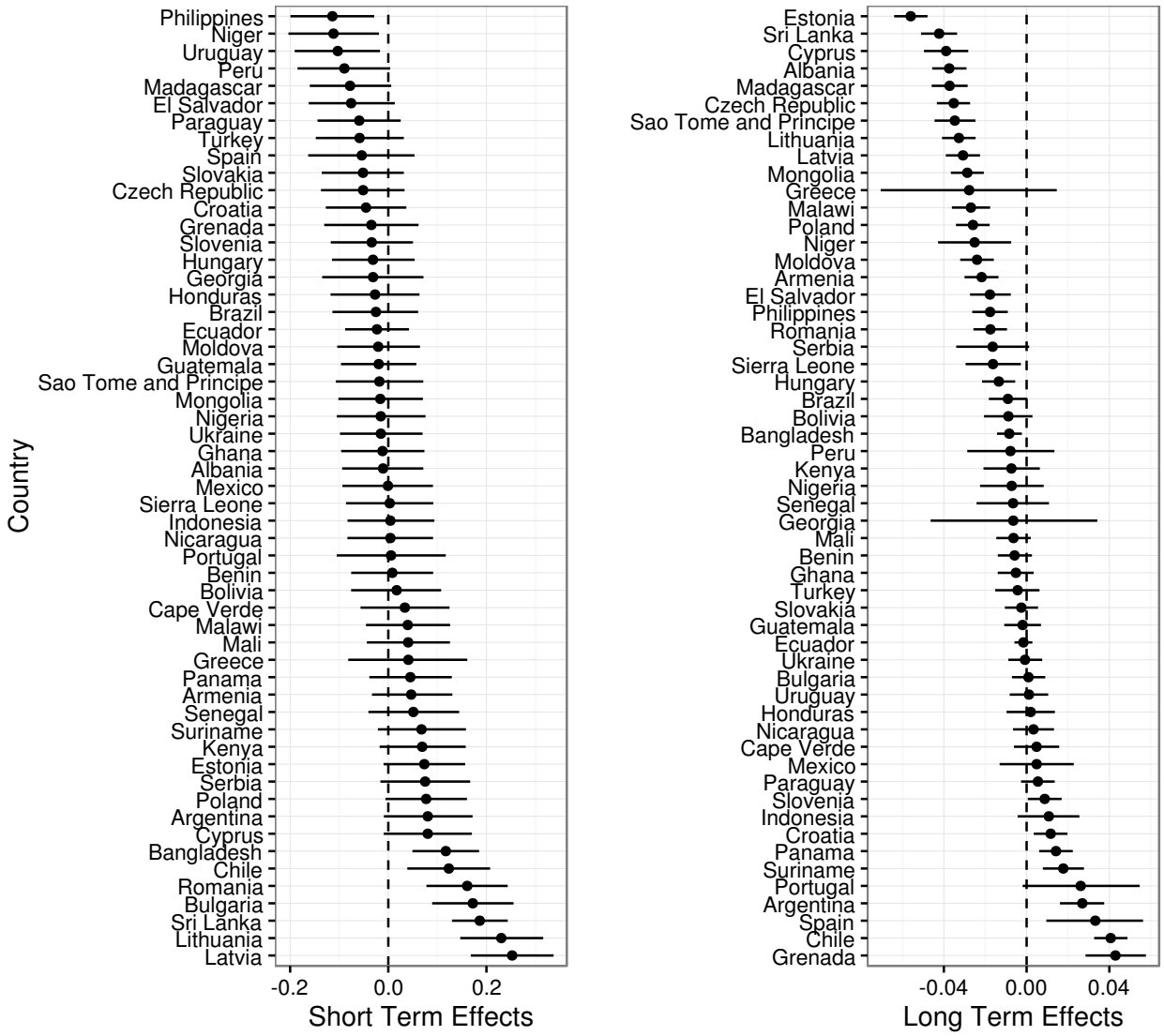

Figure 3: *Dot Plots for the short term effects (left) and long term effects (right) from model without covariates, with dotted vertical lines at zero.*

To understand how the short term effects impact mortality, we estimate the in-sample mortality rates immediately prior to and immediately after democratization. We also estimate the counterfactual post-democratization rate as well as the difference between

the in-sample and counterfactual post-democratization rates. The results are shown in 3 for countries with significant short term effects. The introduction of democracy immediately reduced child mortality in the Philippines, in Niger, and Uruguay. However, in Sri Lanka, Chile, and Bangladesh, as well as many European countries including Latvia, Lithuania, Bulgaria, and Romania, the introduction of democracy was followed by a short term *increase* in child mortality.

Country	In-Sample Mortality.Rate Pre.Democratization	In-Sample Mortality.Rate Post.Democratization	Counterfactual Mortality Rate Post.Democratization	Percent Change
Bangladesh	0.15 (0.15, 0.16)	0.17 (0.16, 0.17)	0.15 (0.14, 0.15)	12.5 (5.04, 20.3)
Bulgaria	0.02 (0.02, 0.02)	0.02 (0.02, 0.02)	0.02 (0.02, 0.02)	18.9 (9.35, 29.1)
Chile	0.02 (0.02, 0.02)	0.02 (0.02, 0.02)	0.02 (0.01, 0.02)	13.2 (3.95, 23.1)
Latvia	0.02 (0.02, 0.02)	0.02 (0.02, 0.02)	0.02 (0.02, 0.02)	28.8 (18.3, 40.0)
Lithuania	0.02 (0.01, 0.02)	0.02 (0.02, 0.02)	0.01 (0.01, 0.02)	26.0 (15.8, 37.1)
Niger	0.25 (0.24, 0.27)	0.22 (0.21, 0.24)	0.25 (0.24, 0.26)	-10.5 (-18.4, -1.89)
Philippines	0.07 (0.07, 0.08)	0.06 (0.06, 0.07)	0.07 (0.06, 0.07)	-10.7 (-18.1, -2.83)
Romania	0.03 (0.03, 0.03)	0.03 (0.03, 0.04)	0.03 (0.03, 0.03)	17.6 (8.08, 27.5)
Sri Lanka	0.03 (0.03, 0.04)	0.04 (0.04, 0.04)	0.03 (0.03, 0.03)	20.5 (13.9, 27.6)
Uruguay	0.03 (0.03, 0.04)	0.03 (0.03, 0.03)	0.03 (0.03, 0.04)	-9.70 (-17.4, -1.68)

Table 3: *Detailed look at the short term effects of Democracy on Child Mortality. Only countries with statistically significant changes were included.*

Table 4 shows the estimated yearly change in mortality rates prior to and immediately following the introduction of democracy as well as the corresponding 10-year changes. Short term effects notwithstanding, child mortality generally decreased over time in all

countries. In many African and European countries, the rate of decline was more rapid after the introduction of democracy. However, in many Latin American countries the introduction of democracy attenuated the rate of decline.

	Yearly Change Pre Democracy	Yearly Change Post Democracy	10 Year Change Under Democracy	10 Year Change Under Dictartorship
Albania	1.63 (1.13, 2.11)	5.24 (4.65, 5.82)	41.58 (37.87, 45.10)	15.09 (10.76, 19.24)
Argentina	6.06 (5.12, 6.98)	3.49 (3.15, 3.84)	29.92 (27.39, 32.44)	46.40 (40.85, 51.48)
Armenia	3.19 (2.72, 3.67)	5.27 (4.69, 5.86)	41.78 (38.12, 45.36)	27.65 (24.07, 31.17)
Bangladesh	3.62 (3.30, 3.93)	4.42 (3.94, 4.89)	36.35 (33.11, 39.45)	30.80 (28.48, 33.03)
Chile	8.52 (8.04, 9.01)	4.72 (4.16, 5.27)	38.34 (34.61, 41.83)	58.94 (56.73, 61.10)
Croatia	5.32 (4.86, 5.78)	4.21 (3.63, 4.80)	34.94 (30.89, 38.84)	42.10 (39.23, 44.88)
Cyprus	2.79 (1.83, 3.75)	6.50 (6.15, 6.84)	48.92 (47.01, 50.77)	24.52 (16.87, 31.74)
Czech Republic	3.06 (2.50, 3.62)	6.42 (5.91, 6.92)	48.49 (45.64, 51.18)	26.71 (22.35, 30.83)
El Salvador	3.96 (3.10, 4.81)	5.65 (5.29, 6.01)	44.07 (41.91, 46.21)	33.17 (27.04, 38.93)
Estonia	1.15 (0.66, 1.64)	6.53 (5.95, 7.10)	49.09 (45.83, 52.14)	10.86 (6.38, 15.27)
Grenada	6.92 (5.63, 8.22)	2.84 (2.47, 3.22)	25.01 (22.10, 27.89)	51.07 (43.98, 57.61)
Hungary	3.99 (3.47, 4.49)	5.27 (4.72, 5.81)	41.78 (38.34, 45.01)	33.42 (29.79, 36.81)
Latvia	1.68 (1.18, 2.17)	4.66 (4.06, 5.26)	37.89 (33.92, 41.77)	15.55 (11.22, 19.70)
Lithuania	2.43 (1.94, 2.91)	5.57 (4.98, 6.15)	43.59 (40.02, 47.01)	21.76 (17.78, 25.55)
Madagascar	0.90 (0.48, 1.32)	4.53 (3.82, 5.22)	37.03 (32.23, 41.51)	8.66 (4.68, 12.43)
Malawi	2.34 (1.95, 2.74)	4.94 (4.16, 5.71)	39.69 (34.62, 44.43)	21.1 (17.85, 24.26)
Moldova	2.95 (2.47, 3.42)	5.25 (4.67, 5.83)	41.66 (37.98, 45.18)	25.85 (22.11, 29.41)
Mongolia	2.32 (1.80, 2.83)	5.08 (4.52, 5.64)	40.60 (37.06, 44.06)	20.88 (16.63, 24.99)
Niger	1.30 (1.01, 1.58)	3.74 (2.06, 5.38)	31.46 (18.77, 42.50)	12.22 (9.64, 14.76)
Panama	3.38 (2.83, 3.94)	2.00 (1.48, 2.52)	18.29 (13.87, 22.51)	29.09 (24.94, 33.08)
Philippines	1.59 (0.88, 2.30)	3.31 (2.90, 3.73)	28.59 (25.52, 31.65)	14.76 (8.45, 20.77)
Poland	3.24 (2.70, 3.79)	5.72 (5.22, 6.22)	44.51 (41.49, 47.40)	28.06 (23.91, 32.05)
Romania	2.58 (2.05, 3.09)	4.27 (3.71, 4.83)	35.34 (31.50, 39.03)	22.96 (18.7, 26.93)
Sao Tome	0.30 (-0.43, 1.02)	3.70 (3.09, 4.31)	31.36 (26.96, 35.61)	2.86 (-4.37, 9.74)
Sierra Leone	1.83 (1.51, 2.15)	3.41 (2.15, 4.63)	29.20 (19.52, 37.73)	16.87 (14.13, 19.53)
Slovenia	6.61 (6.16, 7.07)	5.79 (5.19, 6.38)	44.92 (41.34, 48.30)	49.54 (47.06, 51.98)
Spain	7.81 (5.63, 9.88)	4.70 (4.45, 4.96)	38.23 (36.57, 39.85)	55.39 (44.00, 64.67)
Sri Lanka	2.81 (2.37, 3.25)	6.83 (6.35, 7.32)	50.71 (48.12, 53.26)	24.77 (21.34, 28.13)
Suriname	2.83 (2.12, 3.54)	1.09 (0.47, 1.72)	10.37 (4.56, 15.92)	24.92 (19.29, 30.30)

Table 4: *Long Term effects of democracy on child mortality. Only countries with significant changes shown. In each column, changes are multiplicative.*

To help us understand how short and long and term effects jointly effect mortality over time, we estimate the predicted mortality rates by year for each country and plot

them in Figures 4 – 7. In each figure, we plot the empirical mortality rate (dots), in-sample rate (black), and counterfactual rate (red). In general, the predicted in-sample rates closely track the empirical data for all countries, suggesting that our model fits the data well.

Predictions for eastern Europe are plotted in Figure 4. In Croatia, Serbia, Slovakia, Slovenia, Turkey and Ukraine, the in-sample and counterfactual rates have a large amount of overlap, suggesting a null effect of democratization. In Albania, Czech Republic, and Moldova we see an immediate drop in the mortality rate in addition to greater reductions over time. In several eastern European countries, democratization led to short term increases in child mortality followed by larger long term decreases. This is especially striking in the Baltic countries. In Latvia, Lithuania, Bulgaria, and Romania the short term increase was large enough that it took several years for the mortality rate to reach the pre-democracy levels. In Bulgaria, the effect is so large that after democratization, the in-sample predicted line never crosses the counterfactual line.

Predictions for Africa are plotted in Figure 5. The largest improvements in child mortality following democratic transitions were seen in Sub-Saharan Africa. Notable examples are Madagascar, Malawi, Niger, and Sao Tome and Principe. However, in other countries such as Ghana, Kenya, Mali, Nigeria, we did not see any significant improvements. As we show in the appendix, the beneficial effects of democracy are not mediated by foreign aid. We did not see any deleterious effects of democracy in any of the African countries.

Predictions for Latin America are plotted in Figure 6. No distinguishable changes in child mortality trajectories after democratization were found in most countries, however,

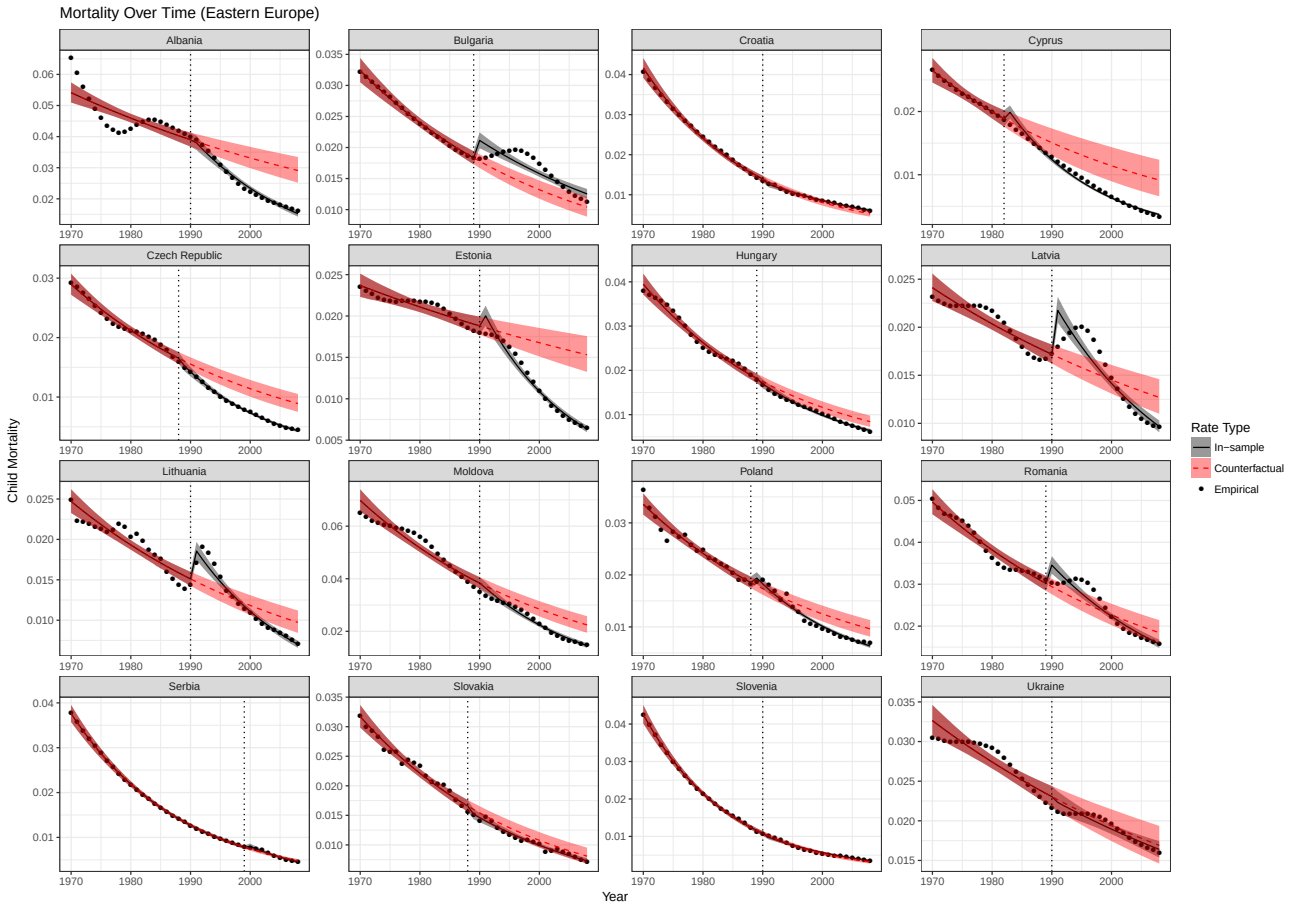

Figure 4: *Empirical mortality rate (dots) along with predicted in-sample (black) and counterfactual (red) mortaliity rates for eastern European countries.*

consistent with Table 4, small attenuations in the over-time decrease in the mortality rate were seen in Argentina, Chile, Parama, and Suriname.

Predictions for other countries around the world are plotted in Figure 7. The only countries that show improvements in child mortality after democratization are Armenia, Mongolia, and the Philippines

In addition to estimating the short term and long term effects, we look at each country's period of democratization and use the model to calculate the counterfactual number of deaths that would have occurred had the country not democratized as well as

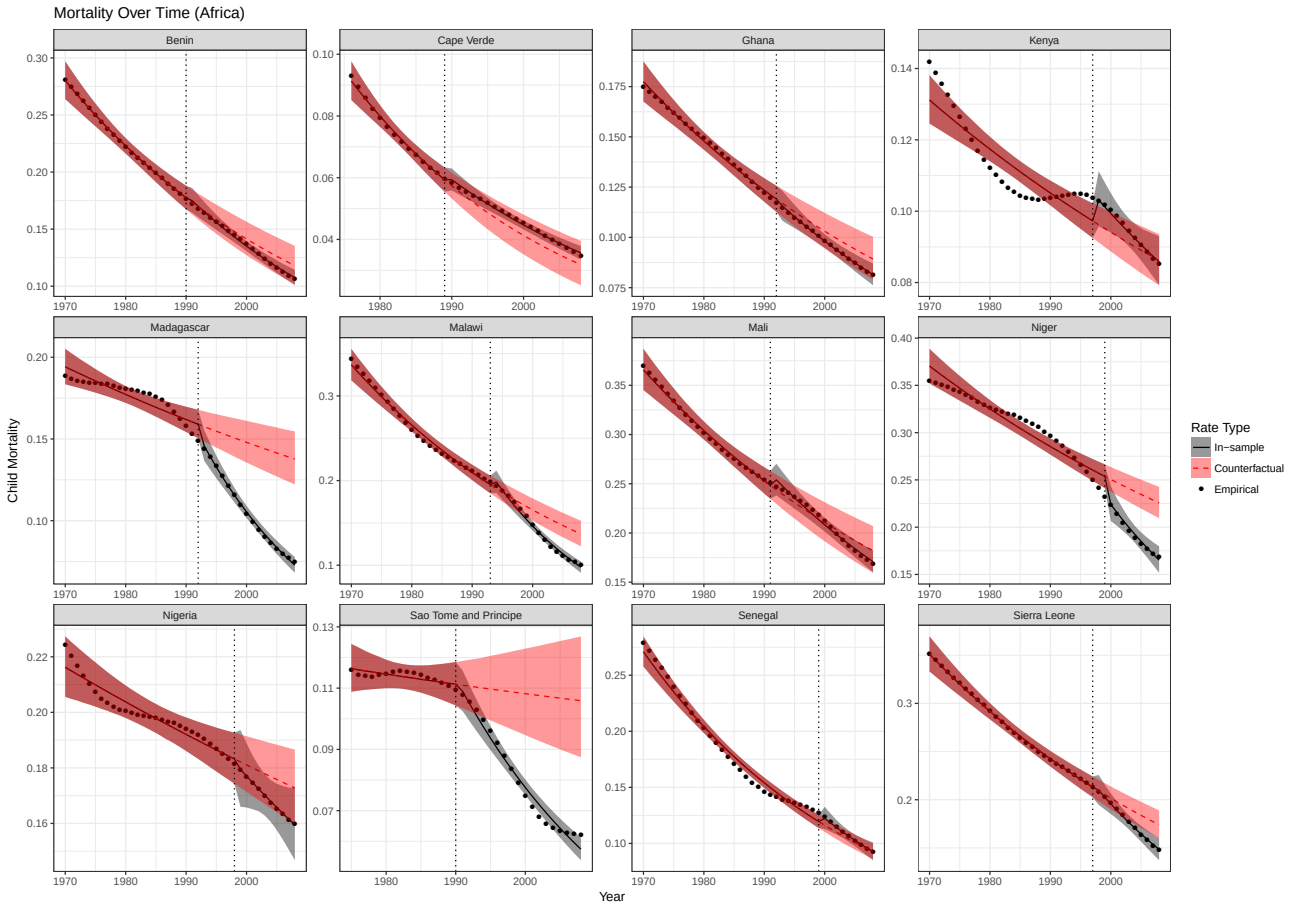

Figure 5: *Empirical mortality rate (dots) along with predicted in-sample (black) and counterfactual (red) mortaliity rates for African countries.*

the percent difference between the in-sample and counterfactual estimates of the number of lives lost. The results of this analysis are presented in Table 5. Only countries with a significant number of lives saved or lost are presented. The model estimates the number of total deaths quite accurately, and the effects vary widely from country to country. In Madagascar for example democracy decreased the number of deaths by 29%, but in Chile democracy actually increased the number of deaths by almost 50%. This is consistent with the information presented in Figures 4 – 7.

Country	Observed Deaths	Predicted Deaths	Counterfactual Difference	Percent Difference
Madagascar	1,061,360	1,063,947 (1,027,722, 1,101,802)	442,663 (311,424, 586,774)	29.2 (22.4, 35.8)
Estonia	3,274	3,286 (3,172, 3,404)	1,249 (808, 1,721)	27.4 (19.6, 34.5)
Czech Republic	18,962	19,023 (18,383, 19,707)	6,973 (4,325, 9,966)	26.6 (18.5, 34.6)
Sao Tome and Principe	7,127	7,132 (6,901, 7,374)	2,555 (1,378, 3,860)	26.1 (16.1, 35.3)
Philippines	2,167,128	2,172,556 (2,108,697, 2,237,590)	748,490 (351,669, 1,194,157)	25.2 (13.9, 35.6)
Cyprus	2,799	2,812 (2,725, 2,903)	883 (303, 1,561)	23.3 (9.73, 35.7)
Albania	27,947	27,862 (26,879, 28,867)	8,262 (4,874, 11,856)	22.7 (14.8, 30.1)
El Salvador	195,247	195,528 (189,566, 201,725)	52,220 (16,752, 92,146)	20.6 (7.86, 32.1)
Mongolia	69,829	69,992 (67,600, 72,447)	17,213 (8,649, 26,479)	19.5 (10.9, 27.6)
Niger	1,143,984	1,149,242 (1,096,034, 1,204,470)	274,399 (174,712, 376,760)	19.2 (13.0, 25.1)
Moldova	24,680	24,795 (23,940, 25,695)	4,804 (2,083, 7,634)	16.1 (7.69, 23.8)
Malawi	1,177,736	1,175,054 (1,133,043, 1,217,587)	173,894 (58,610, 294,323)	12.7 (4.66, 20.2)
Hungary	22,397	22,490 (21,735, 23,272)	3,088 (627, 5,808)	11.9 (2.68, 20.7)
Peru	165,357	166,300 (158,078, 174,807)	20,299 (7,077, 33,801)	10.8 (4.00, 17.3)
Armenia	32,685	32693 (31545, 33865)	3312 (6, 6900)	9 (0.02, 17.5)
Panama	32,252	32,236 (31,229, 33,249)	-5,003 (-8,082, -1,845)	-18.8 (-33.0, -6.11)
Bulgaria	24,387	24,428 (23,630, 25,243)	-3,995 (-6,093, -1,757)	-19.9 (-32.8, -7.84)
Suriname	7,806	7,792 (7,540, 8,052)	-1,473 (-2,257, -636)	-23.8 (-40.4, -9.02)
Grenada	1,449	1,455 (1,412, 1,499)	-391 (-574, -176)	-38.0 (-64.8, -13.8)
Argentina	438,430	437,875 (425,669, 450,543)	-127,436 (-174,605, -72,878)	-42.0 (-65.7, -20.1)
Chile	63,905	63,677 (61,605, 65,838)	-20,651 (-25,012, -16,091)	-48.3 (-63.5, -34.3)

Table 5: *Estimated number of children saved or lost by the introduction of democracy. Results for the model with the recoded version of democracy without covariates. Point estimates are presented along with 95 % credible intervals for countries with statistically significant results. Estimates are only for democratic years. Predicted deaths refers to the in-sample predicted number of child deaths under democracy. Counterfactual difference estimates how many more or deaths would have occured had the country not democratized. Percent difference is the counterfactual difference presented as the proportion of all deaths. Negative numbers for the counterfactual and percent differences mean that democracy caused an increase in lives lost.*

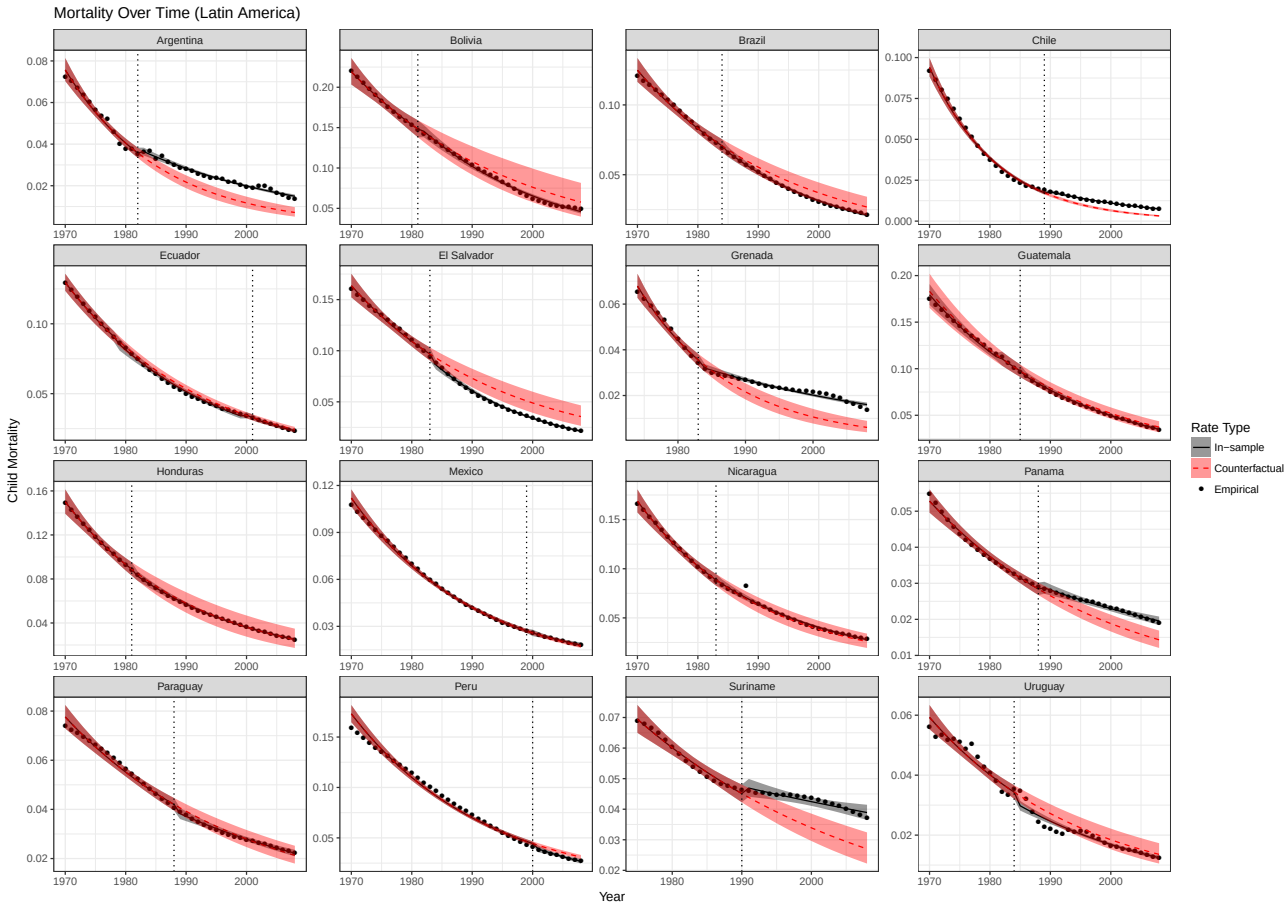

Figure 6: *Empirical mortality rate (dots) along with predicted in-sample (black) and counterfactual (red) mortaliity rates for Latin American countries.*

7 Discussion

Short-term deleterious effects in eastern Europe can likely be explained by abrupt regime changes or transitions to capitalist economies. It has been documented that even countries that never became fully democratic but opened their economies, such as Russia, also experienced sudden increase in mortality following economic liberalization. UNICEF (1997) reports that in many countries in central and Eastern Europe democratic transitions were followed by reduced economic growth and increased poverty and adult mortality. Incidence of diseases, such as anemia in pregnant women, and tuber-

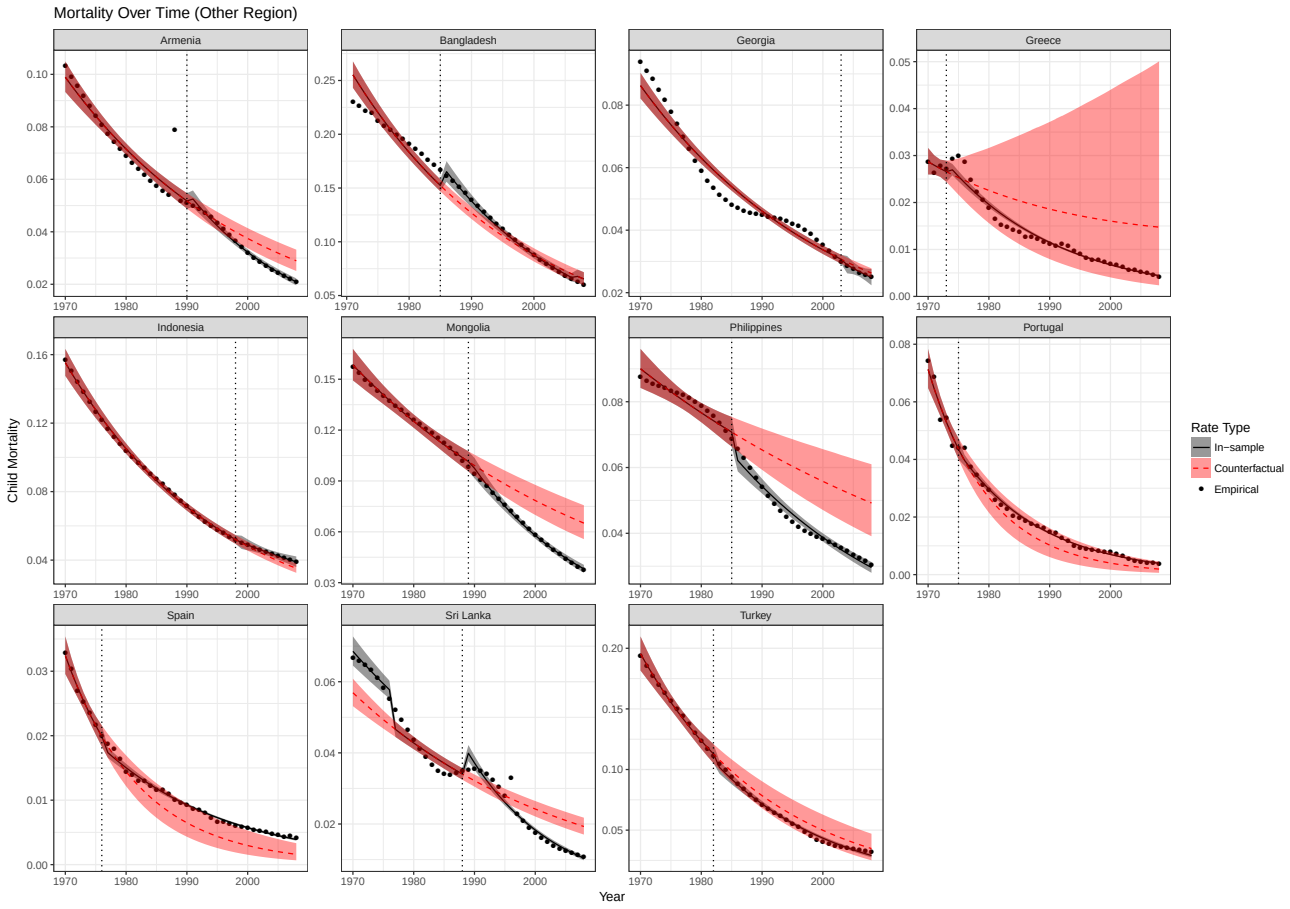

Figure 7: *Empirical mortality rate (dots) along with predicted in-sample (black) and counterfactual (red) mortaliity rates from other countries around the world.*

culosis among children also increased. Thus, it is plausible that the transition for a market economy adversely affected child mortality and that these negative effects were concentrated in certain countries (Safaei, 2012). Our results for Eastern Europe are also consistent with Hellman (1998) who identifies short term effects deleterious effect of transitions on human well-being before long term improvements.

Long term beneficial effects on Sub-Saharan Africa are also consistent with previous studies (Kudamatsu, 2012). However, we considerably expand on previous findings because we find a large variation on the effects of democracy on health in Sub-Saharan

Africa that were not previously documented. In fact, most countries in Sub-Saharan Africa show no improvement in health following democratization episodes. In the appendix, we also identify that the the effects cannot be attributable to of foreign aid boosts.

Our results for Latin America are particularly surprising. Early work on democracy and social spending in Latin America suggests that democracy has a strong positive association with social and health spending (Brown and Hunter, 1999; Huber et al., 2008). However, our results suggest that the additional social and health spending during the democratic period did not improve health outcomes. These results also challenge the assumption that increase in social and health spending necessarily leads to better social and health outcomes (Filmer and Pritchett, 1999).

Overall, the effects predicted by our model are consistent with the raw data, which further suggests that these results are not spurious results. Our results also show that while HIV prevalence, per capita income and maternal education are important predictors of child mortality, they do not confound the effect of democracy on child mortality.

8 Conclusion

Our findings provide additional evidence to support a growing literature on the importance of heterogeneous effects of democracy on a variety of outcomes (Olper et al., 2013; de Kadt and Wittels, 2016; Pieters et al., 2016). By explicitly modeling the heterogeneous effects of democracy, our finding also consolidate disparate results from the previous studies. For example, our results are simultaneously consistent with the the literature on the beneficial effects of democratization for human welfare in Sub-

Saharan Africa (Kudamatsu, 2012; de Kadt and Wittels, 2016) but not in Eastern Europe (UNICEF, 1997; Safaei, 2012). More broadly, our results suggest that we should caution against pooling the effect of democracy across all countries and that conflicting results from the previous literature are at least partially due to pooling effects across all countries. Context matters and we should not treat the average effect of democracy across all countries as representative of the effects in each individual country. Our results suggest that democracy by itself will not necessarily lead to improved health outcomes, but it is important to understand the characteristics of the democracies that did improve. Future work needs to be done to understand the source of the variation on the effects of democracy on health.

One of the main benefits our approach is its simplicity and intuitiveness. While the random effects structure of our models is complex, the key quantities of interested are estimated using a straightforward functional form with log linear pre-transition time trends and log-linear deviations in the trends after democratization. Similarly, the short term effects are intercept shifts after the transition. In particular, we are not using complex functional forms such as splines that could potentially lead to overfitting. Further, if we compare the predicted deaths with the actual deaths in Table 5 or look at how closely our predicted lines in Figures 4 – 7, we can see that our model fits the data quite well, which strengthens our confidence in the results.

The longitudinal approach developed in this paper has broader applicability to other cross-national studies. It can be especially useful when researchers suspect that heterogeneous effects are important or when they do not believe in parallel time trends. The ability of our model Bayesian hierarchical model to generate counterfactual scenarios can also be useful for the study of heterogeneous effects of democratic transitions on

several other outcomes.

The present study shares some limitations with other cross-national studies on regime type and health. First, it is difficult to establish causal relationships with observational data alone. We must always be wary that some unobserved factor can both cause a country to democratize while at the same time reducing child mortality. Second, our results rests on the assumption that pre-transition trends would not have changed in the absence of the democratic transitions. While we cannot verify that the estimated counterfactual trend is equivalent to the actual counterfactual trend, our model allows us to quantify our uncertainty, and seems more reasonable than the usual assumption of parallel trends over time. Finally, our methodology was also unable to investigate multiple transitions countries with the same level of detail as countries which transit from authoritarian rule to democracy only once and stayed as democracy.

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Online Appendices for

Democratization's Heterogeneous Effects on

Child Mortality:

A Longitudinal Analysis of New Data, for 181 countries,

1970-2009

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Appendix 1: Detailed Data Summaries

To visualize the new data, we stratify the sample of countries based on per capita income levels at the baseline of the study (in 1970) and political history. For income, countries were divided into three categories based on per capita income in 1970, with roughly the same number of countries in each category: low (below $2000), middle (between $2000 and $9000) and high (above $9000). For political history, we stratify countries into four categories: always democratic, one time transition to democracy, multiple democratic transitions and always dictatorships. In total, there are 12 clusters, two of which have no members (high income with one-time transitions and high income with multiple transitions). Figure 1 displays child mortality rates for countries by cluster. Each line represents a country trajectory, and each panel is a cluster. Different colors indicate different political regimes. As the figure demonstrates, child mortality has declined globally since 1970, irrespective of income and regime type. Except for a few jumps, such as genocides in Rwanda, Armenia and Cambodia, trends over time are very smooth. Overall mortality rates are higher for dictatorships than for democracies, regardless of the year, however the discrepancies tend to decrease over time.

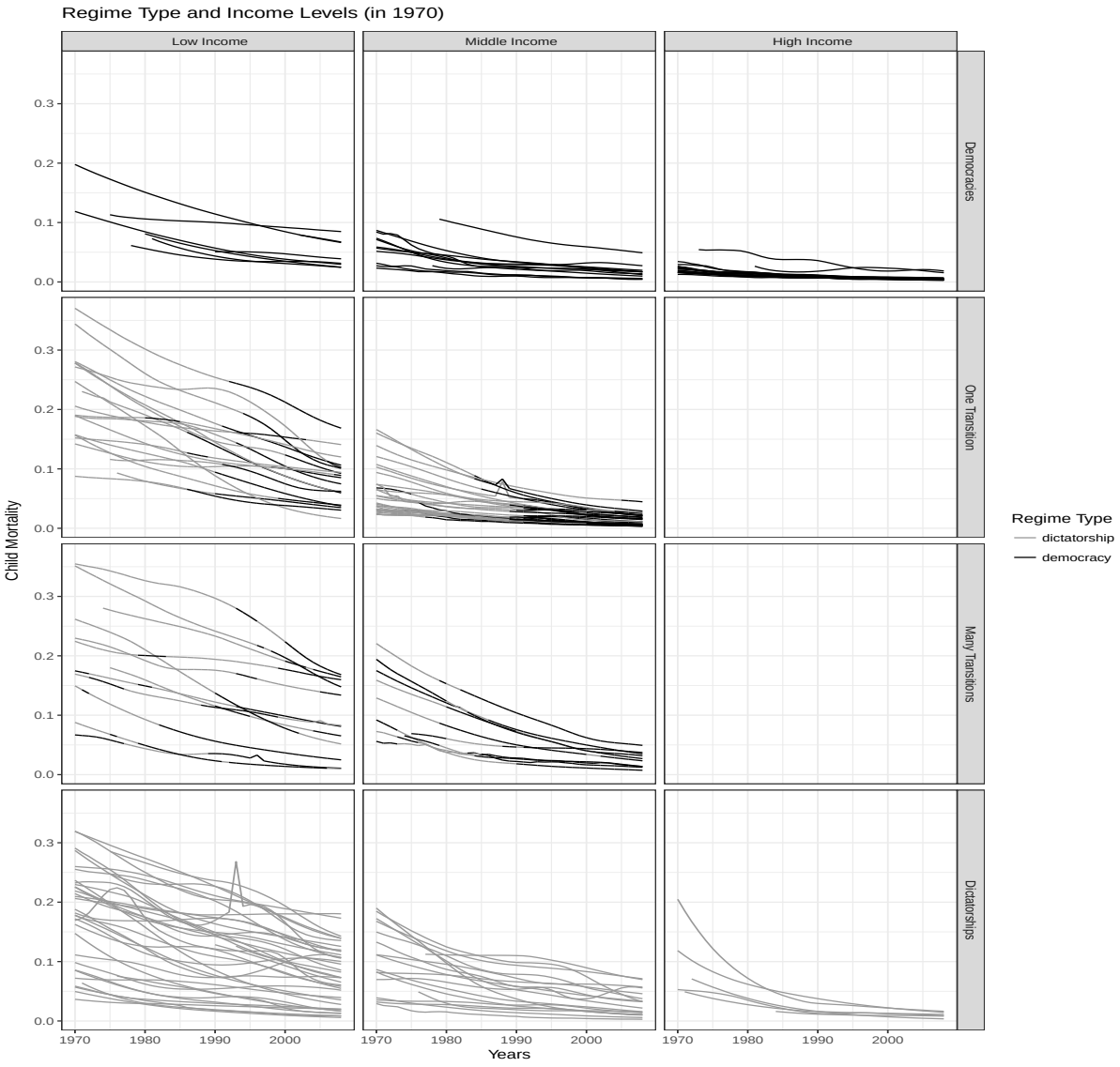

Figure 1: *Trajectories of child mortality rates over time for all countries. Countries are clustered by income and political regime type.*

To investigate the effect of democratization on long term trends in child mortality, we plot the mortality rate over time for countries with a single transition to democracy in Figure 2. Each country can transition in a different year, so the trajectories have been centered at each country's year of democratization.

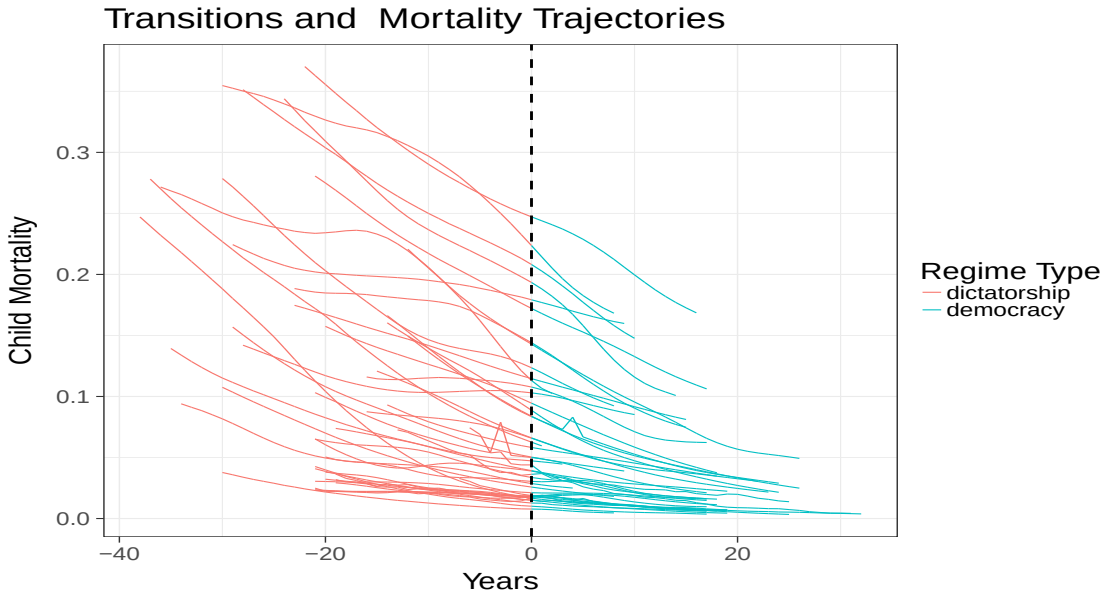

Figure 2: *Mortality rates as a function of time (in years) to and from the democratic transition. Each line is a county trajectory and the dotted vertical line at zero represent the time of the transition.*

We have data on 145 countries going back to 1970. Of these, 30 (21%) started as stable democracies, 108 (74%) started and stayed as dictatorships, and 7 (5%) started as unstable democracies. Over the next 38 years, 30 new independent governments formed (Table 6). Of these, 12 (40%) started and stayed as democracies, 16 (53%) started as dictatorships, and 2 (6%) started as democracies and transited back to dictatorships. In total, we have 124 dictatorships, 47 (38%) of which eventually transited to stable democracies, and 9 unstable democracies, 8 (89%) of which went on to become stable democracies.

Half of the 124 countries that started as dictatorships in 1970 transited at least once. Of these, 48 transited exactly once, 12 transited twice, one (Suriname) transited three times, and one (Thailand) transited four times. Of the 48 that transited only one time, 39 (41%) of those transitions were into stable democracies. Of the 14 that transited at least twice, 8 (57%) eventually transited into stable democracies. Thus, in total, out of all the countries that underwent at least one period of democracy during the study, 75% became stable democracies indicating that if a country transits at all, it is likely to become to end up as a stable democracy.

For some countries, the health and political data do not match. Countries from the former Soviet Union, such as Ukraine, are counted as separate countries for the child mortality data but as a single entity for the political data. For these cases, we used each country's individual health data, but kept the regime type the same across all countries.

Yugoslavia is more complex. Separate health information is available for Serbia, Bosnia and Herzegovina, Montenegro, Croatia, and Slovenia, but not for Kosovo. We kept the health data separate, but used the political indicators of Yugoslavia for all countries except for Bosnia and Herzegovina and Montenegro. After the end of the communist rule, we use the coding

from Cheibub and Gandhi (2010). We keep information from Montenegro after 2006 and Bosnia and Herzegovina after 1991.

Germany has no separate health data for West and East Germany before the re-unification, yet it is not reasonable to treat both countries as if they were under the same political regime before that time. However, most of the health information was drawn from West Germany, so we also used the political information West Germany before the re-unification. An alternative would be to remove all data from Germany before re-unification but this seems less optimal than our solution.

Some countries, especially in Africa, were colonies until very recently. Thus, they are not present in these data based on political indicators until some time after 1970, and we included all country-years just after independence from colonial rule. A full list of these countries with their years of independence can be found in table 1. For Vietnam, we have data from the end of the war in 1976.

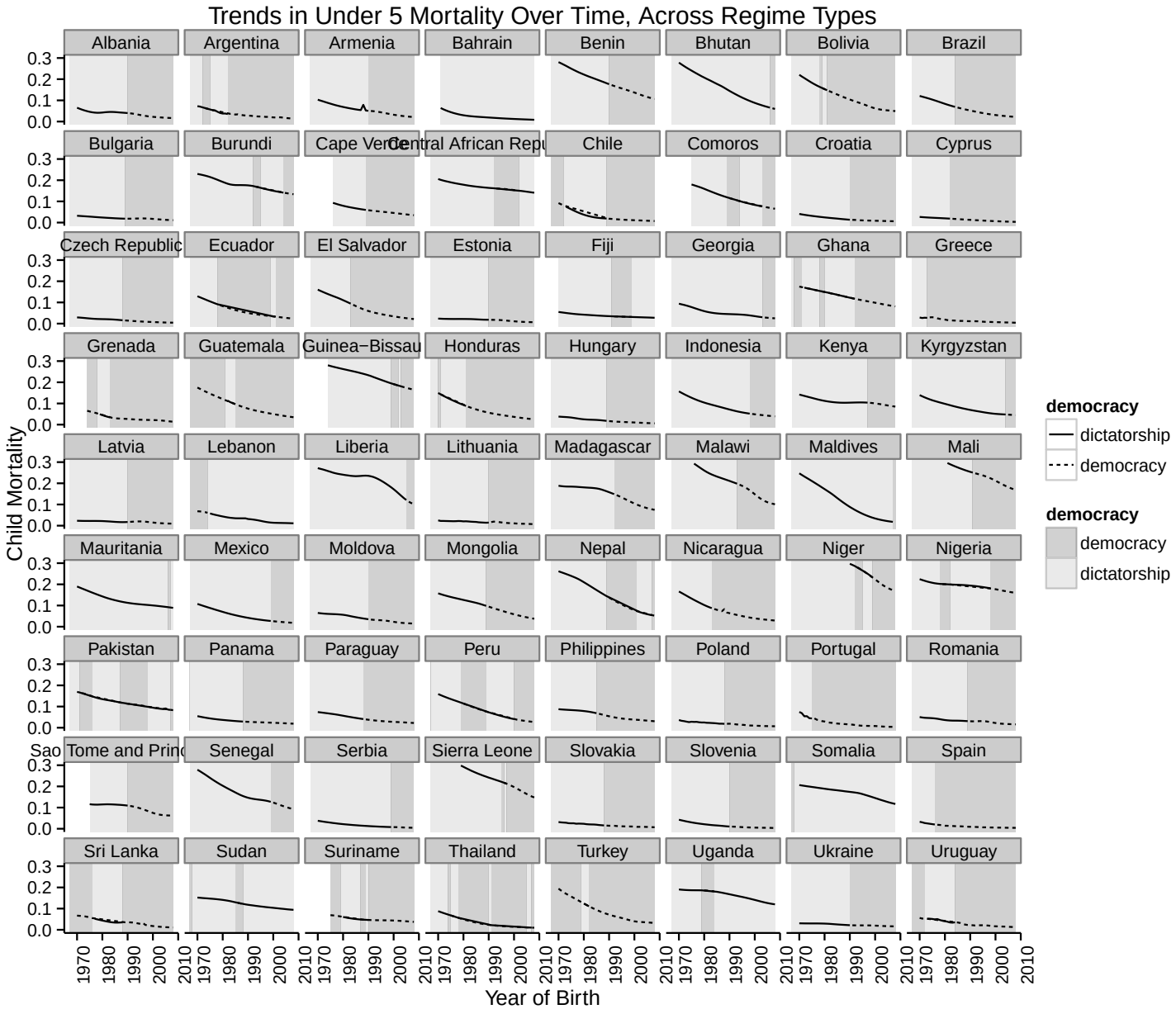

Figure 3: *Trends in Child Mortality in transition using orginal code of democracy from Przeworski at al..*

Country	Independence	Country	Independence
Angola	1974	Micronesia	1990
Bahrain	1970	Mozambique	1974
Bangladesh	1970	Namibia	1989
Belize	1980	Papua New Guinea	1974
Cape Verde	1976	Qatar	1970
Comoros	1974	Seychelles	1975
Djibouti	1976	Solomon Islands	1977
Dominica	1977	Suriname	1974
Eritrea	1992	Swaziland	1968
Guinea-Bissau	1974	Timor Leste	2001
Kiribati	1978	Tonga	1969
Marshal Islands	1989	United Arab Emirates	1971
Mauritius	1968	United Arab Emirates	1971
		Yemen	1989

Table 1: *List of countries that were not independent in 1970. Source: Cheibub at all (2010)*

Appendix 2: Foreign Aid in Sub-Saharan Africa

If foreign aid facilitates greater reductions in child mortality, it is due to increased pressure of resources from donors, and not for changes in the political system. Kudamatsu (2012) discussed how military coups against democratic governments in the 1990s were either suppressed by foreign intervention, such as in Comoros in 1995 and Lesotho in 1994 and 1998, or immediately followed by fresh multiparty elections due to donor pressure such as in Niger in 1996. Dunning (2004) found that it was only after the Soviet Union withdrew its financial support to African countries 1986 that the amount of Official Development Assistance (ODA) became positively correlated with the degree of democracy in Africa.

We use data on foreign aid from Kudamatsu (2012) to investigate whether the inclusion of foreign aid variables affects the results for Sub-Saharan Africa. The variables we include are total Official Development Assistant (ODA), ODA for the health sector (ODAH), and ODA for the water and sanitation (ODAWS). Figures 4, 5 and 6 display trends over time in foreign aid for each one of these variables. These figures show very little evidence that foreign aid flows increased after the introduction of democracy. In transitional countries where we do see a steady increase over time such as Malawi and Ghana, the post-democracy trend is very similar to the pre-democracy trend. Zambia and Mozambique also increase in ODA over time, although these countries were never democratic. Similar patterns can be found for ODAH and ODAWS.

Table 2 shows the results for the regression models, where all foreign aid variables are lagged one year. We included country level random effects in all models, but these have been omitted from the table. Model 1 is our baseline model because it does not include any foreign

aid variables. In Model 2, which includes total ODA, the short term effect seems to increase in magnitude, however, it also reduces the number of non-missing values from 1511 to 1400. To determine whether the effect on the short term effects is being driven by the ODA variable or reduced missing data, we fit Model 1 to the 1400 observations in Model 2. This model, which we call Model 3 shows that differences between Models 1 and 2 are largely due to the missing data. We repeat the same exercise using the additional variables ODAH (Models 4 and 5) and ODAWS (Models 6 and 7). In all cases the change in the regression coefficients are due to the missing data, not to the introduction of the variables related to foreign aid. Table 6 shows the details of the missing data.

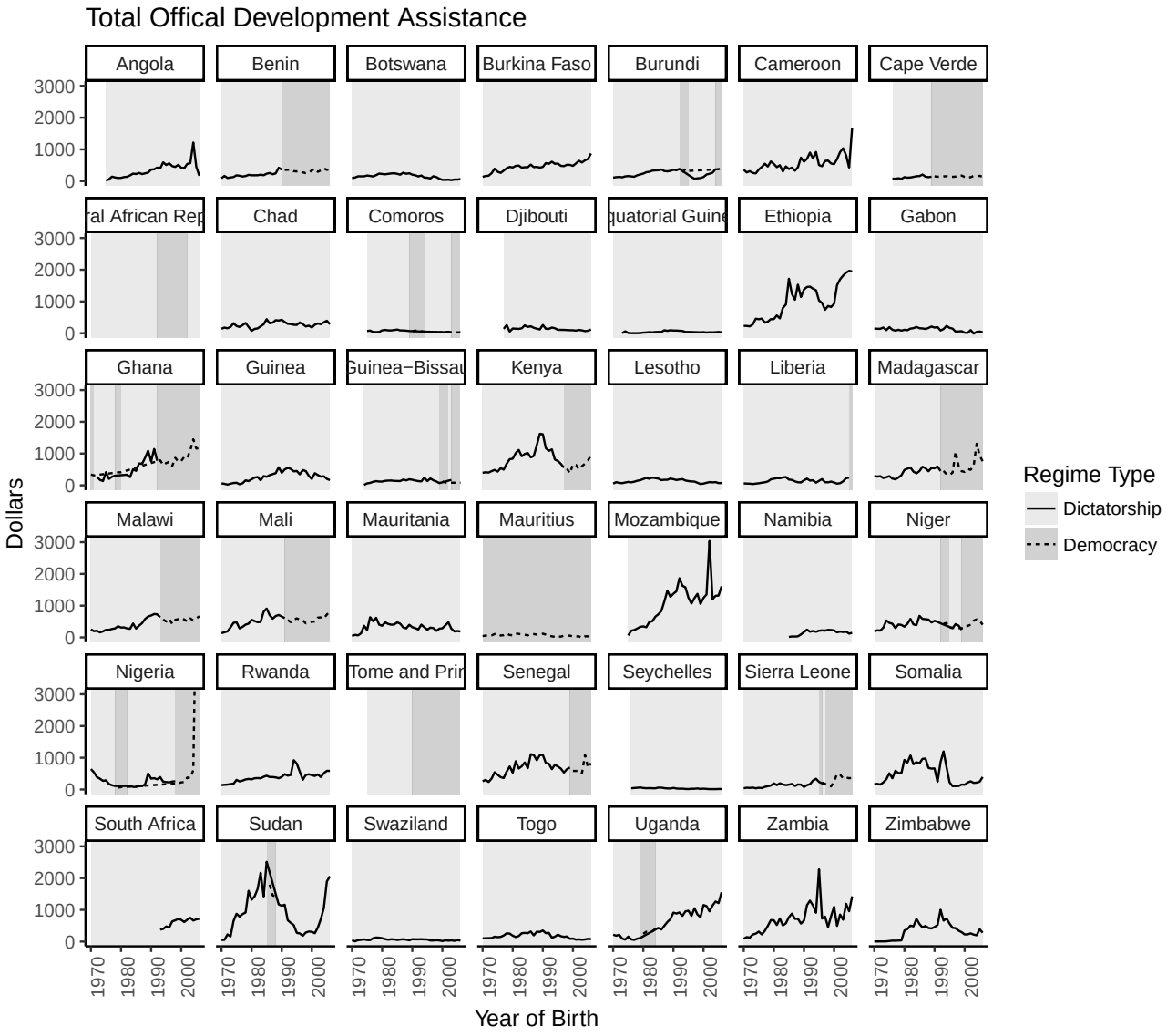

Figure 4: *Total official development assistance by country in Sub-Saharan Africa.*

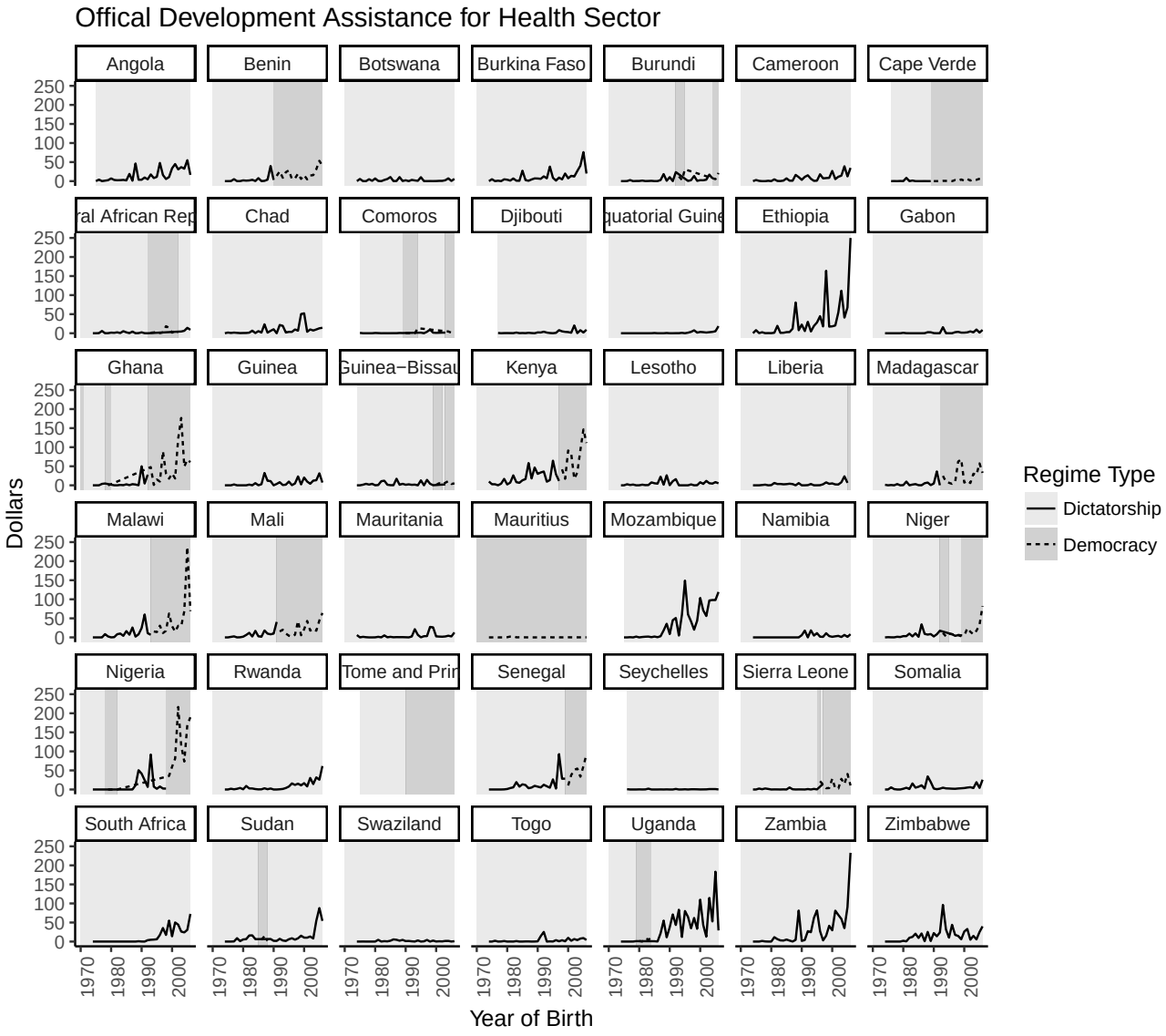

Figure 5: *Official development assistance dedicated to the health sector in Sub-Saharan Africa.*

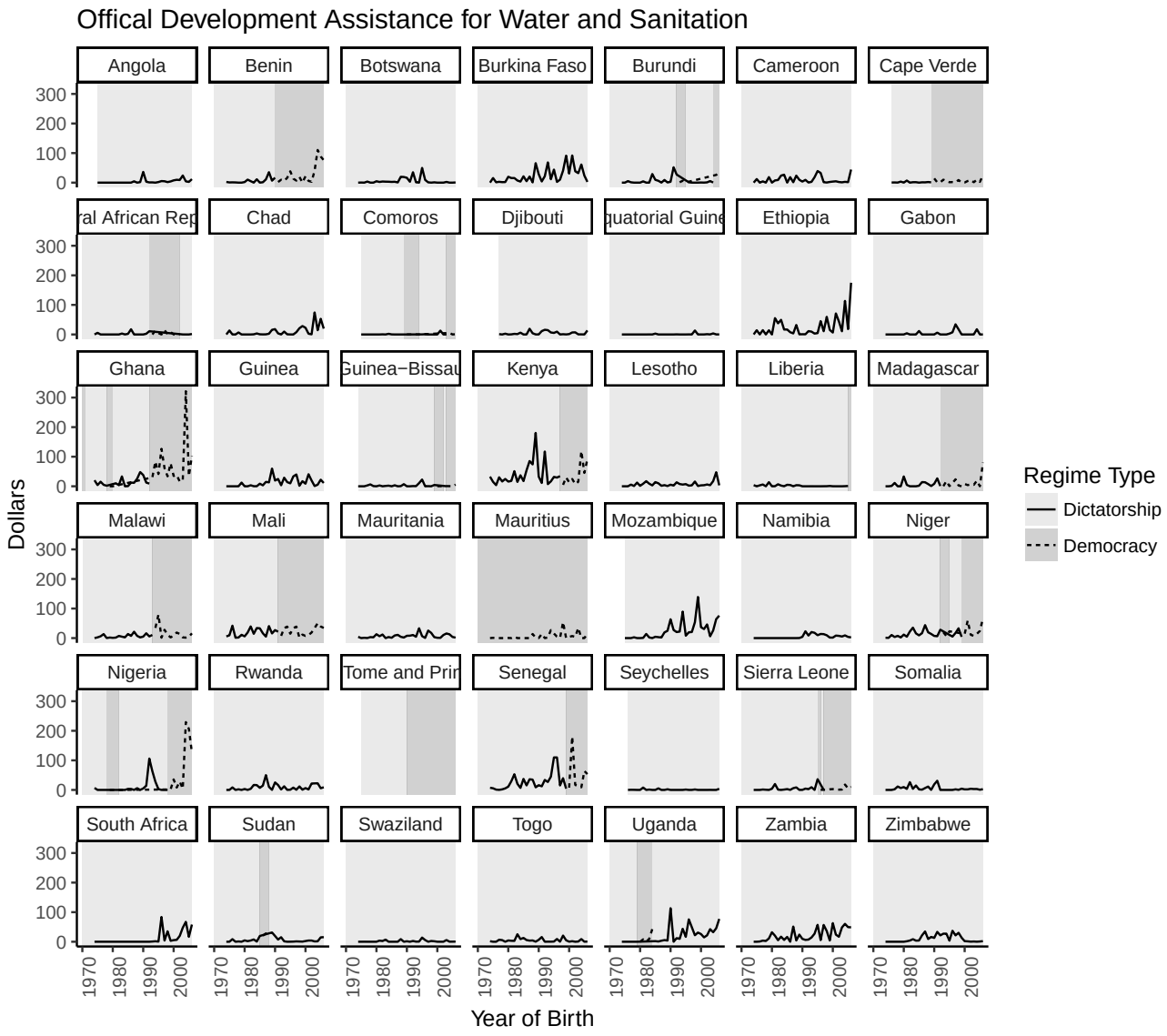

Figure 6: *Offical development assistance dedicated to water and sanitation in Sub-Saharan Africa.*

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
(Intercept)	−1.0154***	−1.0023***	−0.9992***	−1.0328***	−1.0332***	−1.0332***	−1.0332***
	(0.0948)	(0.0963)	(0.0962)	(0.0966)	(0.0966)	(0.0967)	(0.0966)
time	−0.0135***	−0.0135***	−0.0135***	−0.0105***	−0.0106***	−0.0106***	−0.0106***
	(0.0020)	(0.0020)	(0.0020)	(0.0021)	(0.0021)	(0.0021)	(0.0021)
democracy.mjf	−0.0042	−0.0049	−0.0057	−0.0052	−0.0054	−0.0054	−0.0054
	(0.0181)	(0.0200)	(0.0199)	(0.0181)	(0.0181)	(0.0181)	(0.0181)
new.time.mjf	−0.0085*	−0.0055	−0.0053	−0.0059	−0.0057	−0.0057	−0.0057
	(0.0042)	(0.0042)	(0.0042)	(0.0040)	(0.0040)	(0.0040)	(0.0040)
maternal_educ	−0.0752***	−0.0801***	−0.0805***	−0.1026***	−0.1009***	−0.1009***	−0.1009***
	(0.0159)	(0.0162)	(0.0163)	(0.0167)	(0.0166)	(0.0166)	(0.0166)
hiv_prev	1.5964***	1.6631***	1.6647***	1.4700***	1.4744***	1.4743***	1.4744***
	(0.0823)	(0.0880)	(0.0879)	(0.0875)	(0.0871)	(0.0875)	(0.0871)
log(IHME_usd_gdppc)	−0.0770***	−0.0787***	−0.0790***	−0.0724***	−0.0725***	−0.0725***	−0.0725***
	(0.0115)	(0.0119)	(0.0119)	(0.0119)	(0.0119)	(0.0119)	(0.0119)
lag1.oda_real		0.0000					
		(0.0000)					
lag1.aid.health				0.0001			
				(0.0001)			
lag1.aid.water						0.0000	
						(0.0001)	
AIC	-3377.2372	-3023.7579	-3047.8734	-2961.3705	-2979.7230	-2961.0156	-2979.7230
BIC	-3281.4677	-2924.0905	-2953.4516	-2862.5341	-2886.0885	-2862.1792	-2886.0885
Log Likelihood	1706.6186	1530.8790	1541.9367	1499.6852	1507.8615	1499.5078	1507.8615
Num. obs.	1511	1402	1402	1342	1342	1342	1342

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 2: *This table illustrates the effect of adding the predictors for foreign aid (ODA, ODAH,ODAWS), lagged 1 year, on the regression coefficients from our preferred specification. Model 1 is the baseline model. Models 2, 4, and 6 include ODA, ODAH, and ODAWS respectively. Models 3, 5, and 7 fit the the baseline model to the non-missing data in models 2, 4, and 6, respectively.*

Country	ODAH	ODA	ODAW	ODAH	ODA	ODAW
Angola	1	1	1	Malawi	5	0	5
Benin	5	0	5	Mali	5	0	5
Botswana	5	0	5	Mauritania	5	0	5
Burkina Faso	5	0	5	Mauritius	5	0	5
Burundi	5	0	5	Mozambique	0	0	0
Cameroon	5	0	5	Namibia	5	14	5
Cape Verde	0	0	0	Niger	5	0	5
Central African Republic	5	37	5	Nigeria	5	0	5
Chad	5	0	5	Rwanda	5	0	5
Comoros	0	0	0	Sao Tome and Principe	31	31	31
Djibouti	0	0	0	Senegal	5	0	5
Equatorial Guinea	5	4	5	Seychelles	0	0	0
Ethiopia	5	0	5	Sierra Leone	5	0	5
Gabon	5	0	5	Somalia	5	0	5
Ghana	5	0	5	South Africa	5	24	5
Guinea	5	0	5	Sudan	5	0	5
Guinea-Bissau	0	0	0	Swaziland	5	0	5
Kenya	5	0	5	Togo	5	0	5
Lesotho	5	0	5	Uganda	5	0	5
Liberia	5	0	5	Zambia	5	0	5
Madagascar	5	0	5	Zimbabwe	5	0	5

Table 3: *Missing data for total official development assistance, development assistance for health and development assistant for health and sanitation.*

Appendix 3: Autoregressive models and Random Effects for Time

Because of temporal correlation, log linear models for child mortality are often estimated by substituting independent normal errors with autoregressive process. Briefly, we say that ϵ_{jt} follows an autoregressive process of order p if,

$$\begin{aligned} \epsilon_{jt} &= \sum_{i=1}^{p} \phi_i \epsilon_{t-i} + \nu_{jt} \\ \nu_{jt} &\sim N(0, \sigma_\nu^2), \end{aligned} \tag{1}$$

where appropriate constraints have been placed on the ϕ_i to make the process stationary.

We experimented with this approach by modeling the residual errors in our model with an AR(1) process. However, this approach ended up not being feasible. For country j, let $\boldsymbol{Z}_j$ be a design matrix with rows $\boldsymbol{z}_{jt}^T = (1, \text{time}_{jt}, D_{jt}, \text{Dtime}_{jt})$ for $\boldsymbol{\pi}_j$. Also let $\boldsymbol{y}_j = (y_{j1}, \ldots, y_{jn_j})$ and $\boldsymbol{\epsilon}_j = (\epsilon_{j1}, \ldots, \epsilon_{jn_j})$, where n_j is the number of time points for country j. Then the covariance matrix for $\boldsymbol{y}_j$ is

$$\begin{aligned} \text{Var}\left(\boldsymbol{y}_j\right) &= \text{Var}\left(\boldsymbol{Z}_j \boldsymbol{\pi}_j + \boldsymbol{\epsilon}_j\right) \\ &= \boldsymbol{Z}_j \boldsymbol{\Sigma} \boldsymbol{Z}_j^T + \text{Var}\left(\boldsymbol{\epsilon}_j\right) \end{aligned}$$

Thus, correlation between measurements in a country depends both on the random effects and the AR(1) correlation. These two components of the correlation are highly collinear, which makes the convergence of the model poor. This is a well-known problem in the spatial literature known as spatial confounding (Hodges and Reich, 2010)*. We experimented with

*We thank Robert Weiss and Jim Hodges for pointing us to the appropriate literature.

different software, using the `lme` package in `R` for maximum likelihood estimation and JAGS and Stan for Bayesian estimation, and none of the models achieved convergence. Our code is available upon request.

Another issue is that the key quantities of interest in our analyses are the baseline mortality rates and trends over time for each country as well as the post-democracy deviations. Adding an auto-regressive structure to the models' residual could potentially take a large part of the heterogeneity that we want to model via the random effects and treat it as unexplained correlation. Thus, even if it were possible to have both random effects and autoregressive processes in our model, it is not desirable to do so unless we believe that the random effects do not explain a large part of the within-country correlation.

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