Fertility Decline and Rainfall Variation in Malawi

Monica Grant, Katherine Curtis, Audrey Dorelien, and Rachel Rosenfeld

Abstract

In resource poor settings, many households are dependent on the local environment for their livelihoods. To the extent that studies have connected environmental conditions to fertility outcomes, most have focused on situations of persistent environmental degradation, such as deforestation, biodiversity loss, declining land quality, and land availability. Rainfall variation, however, may have different consequences than persistent environmental degradation. For societies on the cusp of the fertility transition, exposure to rainfall shocks may prompt short-run fertility declines. Increased educational attainment and access to contraception may facilitate this process. However, if these shocks are perceived as becoming more frequent, or rainy seasons are perceived as becoming increasingly less predictable, longer-run disruptions in fertility and family processes may result. We will use data from the IPUMS-DHS for Malawi with integrated rainfall measures to examine how sub-national changes in fertility are associated with rainfall variation over time.

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In resource poor settings, many households are dependent on the local environment for their livelihoods. Environmental shocks—e.g., floods and droughts—decrease local livelihood options and increase the riskiness of existing livelihood strategies (Agrawal and Perrin 2008). Scholars have traditionally focused on adaptive responses such as the diversification of economic activities, increased household labor supply, decreased consumption, community risk pooling, and temporary and/or permanent migration (Dercon 2002; Agrawal and Perrin 2008; Sherbinin et al. 2008). Scholars have given less attention to reproductive responses to environmental shocks. To the extent that studies have connected environmental conditions to fertility outcomes, most have focused on situations of persistent environmental degradation, such as deforestation (Carr 2005; Rosero-Bixby and Palloni 1998), biodiversity loss (Brauner-Otto 2014), declining land quality (Sasson and Weinreb 2017; Biddlecom, Axinn, and Barber 2005; Ghimire and Mohai 2005), and land availability (Carr, Pan, and Bilsborrow 2006; Behrman 2017; Ghimire and Hoelter 2007). These models often approach fertility as a household risk diversification strategy: perceived environmental decline or scarcity is associated with higher fertility because children's future labor is framed as a resource that families can use to insure against declining environmental conditions or to secure land when tenure is uncertain (Sherbinin et al. 2008).

Rainfall variation, however, may have different consequences than persistent environmental degradation. Within the life course, rainfall shocks are relatively fleeting events that may create only short-run disruptions in reproductive decision-making. For example, most studies of the association between rainfall and fertility have focused on patterns of birth seasonality in populations dependent on subsistence activities and that practice natural fertility (Bailey et al. 1992; Philibert et al. 2013; Panter-Brick 1996; Appiah-Yeboah et al. 2001; Leslie and Fry 1989; Becker 1981). Rainfall has direct and indirect effects on fecundability, coital frequency, and fetal loss (Menken 1979; Panter-Brick 1996). These biological and behavioral mechanisms are the result of monthly variations in rainfall that shape agricultural cycles, which in turn influence food availability, workload intensity, socio-cultural practices, and labor migration (Panter-Brick 1996; Philibert et al. 2013; Dorelien 2016). Few studies, however, have investigated the impact of inter-annual variation in rainfall on reproductive outcomes or the consequences of rainfall shocks for reproductive decision-making (Grace et al. 2017; Pitt and Sigle 1997; Appiah-Yeboah et al. 2001; Simon 2017).

When drought leads to crop loss and food insecurity, there is emerging evidence of deliberate attempts—i.e., increased contraceptive use or abstinence—to space births or to avoid births and/or pregnancies during undesirable times, such as during hunger or monsoon seasons (Grace et al. 2017; Appiah-Yeboah et al. 2001). In contrast, exposure to drought is associated with an earlier transition to marriage for women—which may increase fertility—but a later transition to marriage for men in societies that exchange bride wealth (Corno, Hildebrandt, and Voena 2017; Hoogeveen, van der Klaauw, and van Lomwel 2011). Other studies have considered rainfall as a positive income shock and have found increased fertility in the period immediately following above average rainfalls in traditionally dry locations (Simon 2017; Pitt and Sigle 1997). For societies on the cusp of the fertility transition, exposure to rainfall shocks may prompt short-run fertility declines. Increased educational attainment and access to contraception may facilitate this process. However, if these shocks are perceived as becoming more frequent, or rainy seasons are perceived as becoming increasingly less predictable, longer-run disruptions in fertility and family processes may result.

In this paper, we use IPUMS-DHS data from Malawi to examine how rainfall variation has been associated with recent fertility decline over the period 2000-2016. In particular, we examine whether fertility declined more in districts with greater rainfall variation, and whether these associations were greater in districts with higher mean female educational attainment.

Study Context

The inter-annual variation in rainfall in southern Africa has increased since the 1960s—droughts have become more intense and widespread, while rainy periods have become shorter and with increased rainfall (Fauchereau et al. 2003; Williams, Kniveton, and Layberry 2010; Shongwe et al. 2009). Countries in the region are seen as particularly vulnerable to climate variability, given the paucity of resources and infrastructural constraints that exist even in the absence of extreme rainfall events. Malawi has had one of the most erratic rainfall patterns in Africa (World Bank 2016). Rainfall patterns are closely linked to the El Niño Southern Oscillation cycle, but there is also high spatial variability in monthly and annual rainfall across districts within Malawi by topography and location (Ngongondo et al. 2011; Kumbuyo et al. 2014). Years with high rainfall are typically followed by years with low rainfall. Indeed, the most recent El Niño cycle culminated in once-in-500-years flooding in January 2015 that affected over 1.1 million people across 15 districts, followed by a 2015-16 rainy season yielding 36.5% less than average rainfall which left an estimated 6.5 million people food insecure (World Bank 2016). Economists have estimated that Malawi loses up to 9% of its GDP during years with severe droughts (Pauw et al. 2011) while anecdotal reports from the 2015-16 season indicate that drought-related food insecurity negatively affected social relations and family dynamics with increased reports of domestic violence, spousal conflicts over land use, and spousal abandonment (World Bank 2016).

The fertility decline in Malawi also accelerated over this time period. From 1992 to 2010, the total fertility rate declined from 6.7 to 5.7 births, but from 2010 to 2015-16, the TFR declined to 4.4 (National Statistical Office (NSO) [Malawi] and ICF 2017). The most recent TFR was calculated for the three years preceding the most recent Demographic and Health Survey and included the recent period of extreme precipitation events. Educational attainment expanded following the implementation of a free primary education policy in 1994 (Riddell 2004; Kadzamira and Rose 2003). Women aged 20-24 years old completed 6.6 years of school, compared to 2.5 years for 40-44 year-olds. In contrast, men's schooling only increased from 6.0 to 7.4 years (National Statistical Office (NSO) [Malawi] and ICF 2017). Finally, since 2009 the government has enacted policies to expand access to family planning services (Digitale et al. 2017). The modern contraceptive prevalence rate of currently married women increased from 45% in 2010 to 58% in 2015-16—measured during the recent drought period (National Statistical Office (NSO) [Malawi] and ICF 2017).

Hypotheses

In this paper, we will test three hypotheses about the association between fertility decline and exposure to rainfall variation over time in Malawi. First, we hypothesize that the total fertility rate will decline faster in districts with greater rainfall variation, as families postpone childbearing during periods of environmental hardship or uncertainty. Alternately, we hypothesize that fertility will decline faster in districts less affected by rainfall variation because periods of environmental hardship will interfere with access to contraception. Finally, we hypothesize that the expansion of education in Malawi has influenced the association between the total fertility rate and rainfall variation; we expect that there will be greater fertility decline in districts exposed to rainfall variation that have high levels of educational attainment relative to districts with lower levels of educational attainment.

Data and Methods

We use data from the IPUMS-DHS for Malawi. Demographic and Health Surveys (DHS) were collected in Malawi in 1992, 2000, 2004, 2010, and 2015-16. These standardized surveys collected nationally representative data about reproductive behavior and child health. IPUMS-DHS harmonized the surveys and linked satellite estimated rainfall measures collected by the Climate Hazard group InfraRed Precipitation data archive (CHIRP) (Funk et al., n.d.). The CHIRP data provide average monthly rainfall at the cluster-level from 2000-2016 (Boyle, King, and Sobek 2017).

Our primary dependent variable is the total fertility rate (TFR) estimated annually at the district level. We use the `tfr2` module in Stata (Schoumaker 2013) to calculate this measure. There are 26 districts in Malawi, yielding 416 observations over the period 2000-2016. Our supplemental analyses will examine aggregate monthly birth rates over this period, to examine whether fluctuations in rainfall patterns are associated with shifts in birth seasonality.

Our key independent variables are rainfall measures derived from the CHIRPS data. We will aggregate the cluster-level rainfall measurements to the district level. From these aggregates, we will calculate several measures of rainfall intensity potentially relevant for fertility behaviors and subsequent outcomes. First, we will examine the total rainfall in each year in each district. Then, we will calculate the z-scores of annual rainfall relative to the long-term average for each district. Finally, to assess our central and alternative hypotheses, we will estimate the intra-annual rainfall variation for each district, in order to examine whether years with greater or lesser monthly rainfall variation are associated with greater changes in fertility. In our preliminary model, we plan to lag rainfall by one year, but will test whether different lag periods provide better model fit.

In addition to our rainfall measures, we will include other district-level variables linked to fertility as identified in previous research including percent urban, mean female educational attainment, mean socio-economic status, and infant mortality rates.

Our primary model will be a linear regression with district and year fixed effects:

$$TFR_{ij} = Rainfall_{ij} + X_{ij} + \theta_i + \theta_j + \varepsilon$$

which examines how the total fertility rate in district i and year j is associated with our rainfall measures in district i and year j, controlling for control variables Xij with district and year fixed effects. In order to test our third hypothesis, a subsequent model will include a term for the interaction between rainfall and mean female educational attainment. Our secondary analysis will substitute monthly births for the total fertility rate.

Preliminary Results

Figure 1 shows the total fertility rate by year and district over the period 2004-2015. In order to make the patterns more discernable, we also present the trends in total fertility rate by region in Figure 2 (districts in Malawi are aggregated into three regions--North, Central, South). In Figure 2, it is clear that although there was a slight decline in the total fertility rate in the first half of the time period, the pace of fertility decline increased after 2008 in all regions with a slightly earlier decline in the Northern region.

Figure 1. Total fertility rate by year and district, 2004-2015

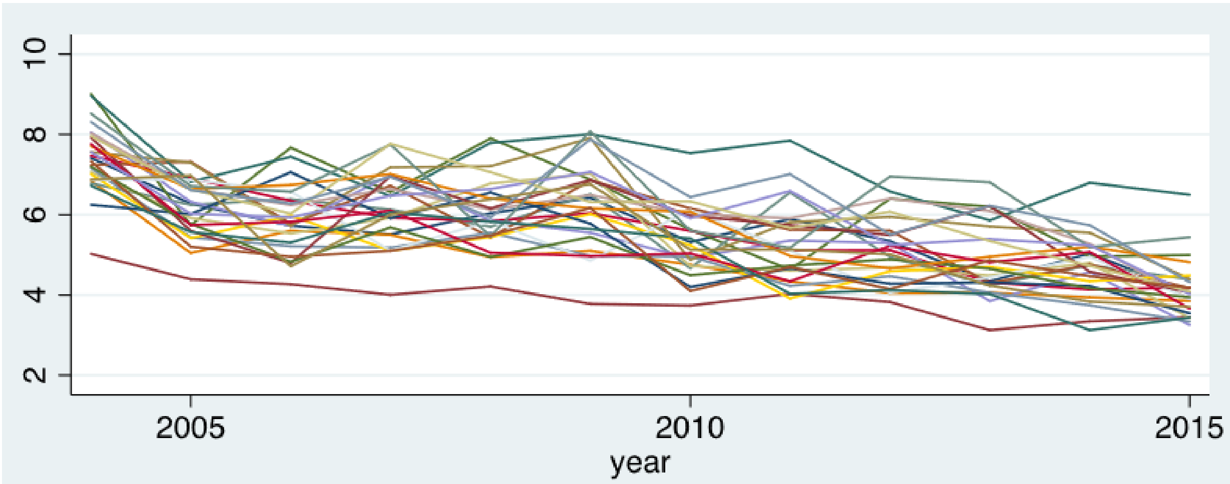
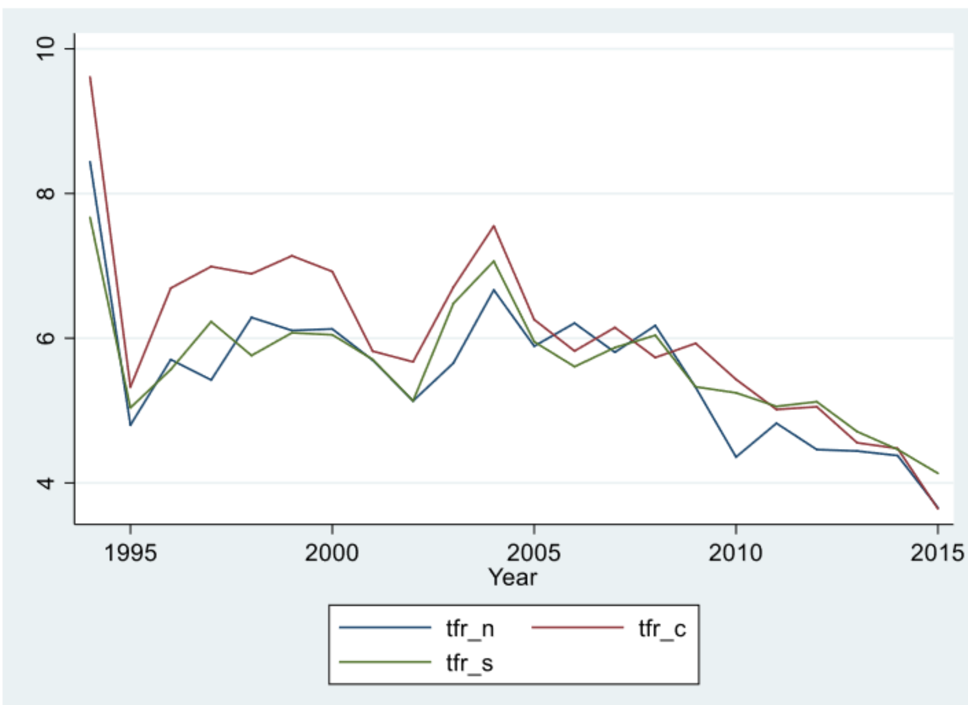


Figure 2. Total fertility rate by year and region (North, Central, South), 1994-2015



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