The Impact of AIDS Treatment on Savings and Human Capital Investment in Malawi

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Antiretroviral therapy (ART), a treatment for AIDS, is rapidly increasing life expectancy throughout sub-Saharan African countries affected by the AIDS epidemic. This change in life expectancy has potentially profound influences on life-cycle decisions. A longer life expectancy increases the value of human capital investment, while the effect on savings is theoretically ambiguous and life-cycle saving could increase or decrease. This paper uses spatial and temporal variation in ART availability to evaluate the impact of ART provision on savings and investment. We find that ART availability significantly increases savings, expenditures on education, and children's schooling, including among HIV-negative individuals who do not directly benefit from ART. These results are not driven by the direct health effects of treatment or reductions in care-taking responsibilities, but rather by reduced perceptions of mortality risk after ART has become available.
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In the past decade, antiretroviral therapy (ART), a highly effective drug treatment that slows the progression of AIDS, has become widely available in sub-Saharan Africa. The medication is rapidly reversing the steep decline in life expectancy, which had fallen by 14 years in southern Africa, due to the AIDS epidemic (UN Population Division 2012). Economic models of life-cycle consumption suggest that life expectancy plays a role in decisions about savings, investment,

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and lifetime labor supply, and has important implications for economic growth.[1] A longer life expectancy encourages human capital investment by increasing the time horizon over which the investment pays out (Ben-Porath 1967; Becker 1962). While changes in adult mortality risk are likely to affect savings decisions, the predictions from theory are ambiguous in the overall direction of the effect: Individuals may save more if they expect to live into old age when income is low, but may, in fact, save less if they expect a longer and healthier working life (Bloom, Canning and Graham 2003; Fogel 1994, 1997). Thus, the effect of life expectancy on savings is an empirical question and, to our knowledge, has not been explored at the micro-level.[2] Furthermore, identifying the causal effect of changes in life expectancy is especially challenging because life expectancy is endogenously determined by individuals' health-related behaviors, and experimental variation in life expectancy large enough to detect effects would likely pose ethical concerns.

This paper exploits the introduction of AIDS treatment in Malawi to study the impact of rapid and sustained life expectancy gains on savings and investment in human capital. Malawi was severely affected by the AIDS epidemic, with a national prevalence that peaked at 15 percent in 1997. In 2003, through support of large international donors and governments, the Malawian government started to make ART available for free, and the ART program has been expanding rapidly since. The scale-up of the program, in Malawi and elsewhere in sub-Saharan Africa, is widely regarded as a public health success and has resulted in measured declines in adult mortality (Jahn et al. 2008; Floyd et al. 2012; Payne and Kohler 2015).

The ART rollout in Malawi provides a good setting to study the effect of life expectancy on investment and related life-cycle behaviors for a number of reasons. UN-based estimates of life expectancy gains from eliminating AIDS mortality in Malawi are 12.7 years. These life expectancy gains are large, and they occur primarily as a result of changing *adult* mortality risk.[3] HIV/AIDS affects individuals after major human capital investments have been made but before they have retired from the labor market. Finally, the positive shock to life expectancy

[1] See, for example, Soares (2005); Weil (2007); Lorentzen, McMillan and Wacziarg (2008); Acemoglu and Johnson (2007); Kalemli-Ozcan (2002); Cervellati and Sunde (2013); Kalemli-Ozcan, Ryder and Weil (2000); Murphy and Topel (2006); Ehrlich and Lui (1991); de la Croix and Licandro (1999).

[2] Many studies have looked at the effect of longevity on savings in cross-country analyses, generally finding a positive correlation (Lee, Mason and Miller 2000; Bloom, Canning and Graham 2003; Zhang and Zhang 2005). Studies have also examined the effect of HIV on savings at a macro level, but no consensus has yet emerged (Bonnel 2000, Lammers, Meijdam and Verbon 2007). To our knowledge, only one other study attempts to identify the causal relationship between life expectancy and savings. Thornton (2012) finds that learning one's HIV status had only short term effects on subjective beliefs about ones' HIV status and had no impact on long-term beliefs. Thus the study was unable to detect effects on savings, expenditures, or employment.

[3] We emphasize that the life expectancy gains result from changing adult mortality risk, as distinct from infant or old-age mortality. As they do not impact the investment horizon, the latter should not impact investment decisions through the mechanism we are trying to identify (Cervellati and Sunde 2013). Macro-based studies using cross-country analysis to estimate the quantitative importance of life expectancy for human capital and growth find mixed evidence (Acemoglu and Johnson 2007; Lorentzen, McMillan and Wacziarg 2008; Bloom, Canning and Fink 2014; Hansen 2013); however, they rely on life expectancy gains resulting primarily from reductions in infant mortality.

resulting from the ART expansion is both long-term and impacts the general population. Thus, it is more informative about the effect of life expectancy on human and physical capital accumulation in the macroeconomy as a whole, which is the mechanism typically studied in growth theory (Solow 1956; Koopmans 1965; Romer 1986).

Using longitudinal survey data, we estimate the impact of ART availability on savings, expenditures on children's human capital, and children's schooling. Our identification relies on spatial variation in ART availability as measured by the respondents' distance to the ART facility. By combining precise GPS locations of households with administrative records on locations and start-of-ART-service dates for clinics, we calculate the respondents' exact distance by road to their nearest ART facility. We employ a continuous difference-in-difference strategy with individual fixed effects, comparing outcomes before and after ART became available at the facility along the distance gradient.

The survey also performed HIV testing, enabling us to estimate the effect of ART availability among the HIV-*negative* respondents, thereby minimizing concerns of estimating the direct health effects of treatment. While HIV-positive persons gain the most from treatment becoming available, HIV-negative individuals also face large gains in life expectancy through reductions in future risk.[4] Additionally, because our data contain information on self-reported mortality risk, we are in a position to conduct a unique analysis linking changes in outcomes to changes in subjective expectations. Since subjective expectations are the determining factor in decision-making, measuring subjective probabilities provides a direct test of the theory (Manski 2004).

The identifying assumption for our analysis is that individuals living near and far from ART facilities would have similar trends in absence of ART. Due to the spacial precision of the data, we able to compare households within a 15 kilometer radius, arguably providing a more plausible control group.[5] Using pre-period data, we show that trends in outcomes and other characteristics are not correlated with proximity to the ART facility. We also show that prior to the arrival of ART, areas near the facilities were similar, both in levels and trends, to areas further away along an extensive set of characteristics. Furthermore, provision of ART was not bundled with other government programs, and rich data on participation in government aid programs confirm that these were uncorrelated with distance

[4]ART increases life expectancy by reducing the mortality risk from engaging in risky sexual behavior: it reduces both the likelihood of death conditional on infection and the transmission probability. However, the effect of ART on life expectancy is mediated through the behavioral response, since individuals may increase risky sexual behavior (Lakdawalla, Sood and Goldman 2006; Wilson, Xiong and Mattson 2012; de Walque, Kazianga and Over 2012; Oster 2012; Gong 2015; Friedman 2014). In South Africa, recent evaluation of demographic surveillance data has shown that objective life expectancy has increased as a result of ART and HIV incidence has declined, suggesting that even if individuals respond by increasing risky sexual behavior, the response does not overwhelm the benefits of ART (Bor et al. 2013; Tanser et al. 2013).

[5]Other studies, such as Friedman (2014); McLaren (2010), have similarly used distance to ART facilities for identification, though their spatial comparisons are constrained due to jittering of household GPS coordinates around the true location.

to ART.

We find a strong response in savings behavior: halving the distance between a respondent and the ART facility—a reduction of approximately 6 kilometers for the average respondent—results in an increase in the propensity to report any savings by 10 percentage points. Additionally, we find that ART availability increases investment in human capital. Reducing the distance by half increases expenditures on children's education by US$2.5 (an increase of 2 percent of annual reported earnings spent on each child). We also observe substantial gains in educational attainment for children of the respondents near ART. Halving the distance to ART implies an increase in schooling by 0.3 years. While these magnitudes appear large at first glance, our subjective expectations results and implied effect of life expectancy on both schooling and saving, described shortly, are consistent with previous estimates. Our results are robust to including controls for spatial and demographic characteristics, as well as reported economic shocks and participation in other government aid programs.

While we find that ART availability increases savings and investment behavior, we do not observe changes in reported earnings, suggesting that the results are not driven by differential changes in market wages or prices. Furthermore, we do not observe increases in spending on other consumption goods such as clothing or short-term investments, such as seed, fertilizer, or other agricultural inputs. However, ART availability may improve mental health and productivity (Baranov, Bennett and Kohler 2015), we cannot rule out that some of the investment response may be due, in part, to improvements in mental health or unobserved earnings associated with a reduction in AIDS-related stress.

The magnitudes of our results are similar and remain significant among HIV-negative respondents, indicating that the results are not driven by the direct effect of respondents receiving life-saving medication. Furthermore, our results indicate that mechanisms such as household care-taking burdens from AIDS-related illness, death, and orphanhood, do not explain our findings. A likely reason for this is that, due to the slow progression of the disease, the direct health effects of the medication could only impact a small subset of the HIV-positive population over the time-frame we observe.

We find that ART availability measurably decreases self-reported mortality risk. We calculate the implied change in *subjective* life expectancy based on the impact of ART proximity on perceived mortality risk. The estimates suggest that respondents' perceptions about mortality reduction are roughly in line with UN-based estimates: reducing distance to an ART facility by 6 kilometers increases subjective life expectancy by 6.0 years. Taken together, these findings suggest that individuals actively adjust their investment decisions in response to a subjective lengthening of their investment horizon.

To interpret the magnitude of our savings and schooling results, we calculate the implied marginal effect of life expectancy on savings and schooling. Our savings results imply that a one year increase in life expectancy would increase the saving rate by 0.2 percentage points. The increases in educational attainment reported above reflect changes in life expectancy for both parents and children. Therefore, to isolate the effect of an additional year of a child's life expectancy, we exploit the differential change in life expectancy by gender. In a triple-difference approach, our estimates of the additional gain in schooling by gender imply that one additional year of life expectancy increases schooling by 0.1 years.

This study contributes to the literature in three ways. First, we investigate the consequences of expanded ART availability on life-cycle dynamics in the general population, as the benefits of ART availability are not necessarily restricted to HIV-positive individuals. Previous studies on ART have focused on the direct effect of treatment on HIV-positive persons and their households (Thirumurthy et al. 2012*a*,*b*; Zivin, Thirumurthy and Goldstein 2009), or the effect of ART on risky sexual behavior (Lakdawalla, Sood and Goldman 2006). Second, our human capital results add to a growing empirical literature on the impacts of life expectancy on human capital (Jayachandran and Lleras-Muney 2009; Fortson 2011; Oster 2012; Hansen 2013). Our findings are consistent with that literature. Since subjective measures of mortality risk were not available, previous studies relied on actual changes in adult mortality to identify the effect. The observed changes in subjective life expectancy allow us to be more confident in the mechanisms driving the results. Lastly, we provide estimates of the effect of eliminating AIDS mortality risk on savings. Standard models of economic growth include savings as a driver of growth, although the impact of life expectancy on this behavior is theoretically ambiguous. Our evidence suggests that higher life expectancy does prompt more savings.

The rest of the paper is organized as follows. Section I describes the theoretical predictions of reducing adult mortality. Section II describes the background of the ART rollout in Malawi, and Section III describes the data and presents the empirical strategy. Section IV discusses the main results, and Section V considers mechanisms that may be responsible for the main findings. Section VI calculates the magnitude of the effect of life expectancy on schooling, and Section VII concludes.

I. Theoretical Predictions

This paper tests the hypothesis that mortality risk at intermediate (working) ages affects savings and human capital investments decisions.[6] Theory predicts that the effect of reducing adult mortality risk on schooling and other long-term

[6] In addition, life expectancy also plays a role in decisions about fertility (Zhang and Zhang 2005; Kalemli-Ozcan 2002; Fortson 2009; Shapira 2013) and lifetime labor supply (Cervellati and Sunde 2013; McLaren 2010). However, we are not able to estimate the effects of life expectancy on lifetime labor supply due to data limitations. The effects of increased life expectancy on fertility are theoretically ambiguous, though including endogenous fertility into a model with life-cycle savings and child investment does not alter the first order result on human capital investment (Ehrlich and Lui, 1991). Since the introduction of ART may impact fertility indirectly through risky sexual behavior and since we only observe respondents two years after the introduction of ART at the longest, we do not focus on fertility in this paper.

investment is unambiguous: by extending the horizon over which an investment pays out, a longer life expectancy increases the rate of return on long-term investments (Ben-Porath, 1967; Becker, 1962). The sudden availability of ART increases the life expectancy for adults as well as children, a double horizon effect. In Section VI, we isolate the horizon effect for the children using the differential life expectancy gains by gender.

The effect of life expectancy gains on savings decisions is more complex and depends on the role of savings. We discuss the effect of life expectancy gains in models of life-cycle savings, precautionary savings, and savings for investment in a credit constrained environment in turn.

In the life-cycle model of savings, increasing longevity implies that individuals are more likely to live into old age, when earnings are low, thereby increasing the motivation to save (Bloom, Canning and Graham 2003; Freire 2004; Lee, Mason and Miller 2000; Zhang and Zhang 2005). However, improvements in longevity are often associated with reductions in morbidity, lengthening the working life and reducing the need to save (Fogel 1994, 1997). Furthermore, the implications on saving also depend on the prevailing life-cycle patterns of production and consumption and may be very different in countries with little old-age dependency (as is the case in low income SSA countries) as compared to countries with extended periods of old-age dependency (Lee and Mason, 2011; Deaton, 1989).

Precautionary savings are another motivation for saving, particularly in developing countries. In general, it is not clear that a non-probabilistic increase in life expectancy should have an effect on precautionary savings. However, when the change in life expectancy is probabilistic, as in our setting, precautionary savings may play a role in insuring individuals across states. For example, individuals may hold savings in anticipation of future illness, funeral costs, or bequests (de Kuilen and Lammers 2007; Freire 2004). If individuals were saving to insure themselves against an AIDS-related shock, then precautionary savings may decrease when ART becomes available. On the other hand, individuals may be more likely to save if those savings were to go toward procuring ART and other incidental costs associated with treatment.

Lastly, individuals may be saving to self-finance investments when credit is not available (Fafchamps and Pender 1997). Since long-term investments become more attractive as longevity rises, credit-constrained individuals may increase savings in order to finance these investments. Individuals may save for any combination of reasons described above, thereby making it difficult to *a priori* predict the effect of a life expectancy increase on savings.

II. Context

Current life expectancy at birth in Malawi is 63 years, a substantial increase from 47 years in 2004 (World Bank Indicators 2015). AIDS has been the main cause of adult mortality in the past decade (WHO 2012). Malawi is one of the countries hit hardest by the AIDS epidemic, with nearly one million people (out of a population of 16 million) currently living with HIV/AIDS. It is one of the world's poorest countries with a GNI per capita of $320 (PPP adjusted $730, World Bank 2012 calculations). Adult HIV prevalence peaked at 15 percent in 1998 and has steadily declined since (UNAIDS 2010). The current HIV prevalence, at 11 percent, is still one of the highest in Africa (2010 Malawi DHS).

Malawi's population is over 80 percent rural and supports itself primarily through subsistence agriculture. The educational attainment is low: the mean years of schooling is 4.2 for adults over 25, and net secondary school enrollment is 24 percent (WDI 2010). Primary education goes up to grade eight and is not compulsory. The official starting age is six years old; but, it is not uncommon for children to start considerably later. While the government established free primary education in 1994, which increased attendance rate by 50 percent (Kadzamira and Rose 2003), families are still responsible for uniforms and school supplies and must consider the opportunity cost of enrollment as children often participate in wage labor or help with household chores.[7] Qualitative interviews as well as quantitative analyses suggests that risk perceptions about HIV/AIDS factor into parental decisions about their children's education (Grant 2008; Castro, Behrman and Kohler 2015).

THE ART ROLLOUT IN MALAWI. — In direct response to the previous governments' refusal to acknowledge the epidemic, in 2003 the Malawian government announced it would provide free antiretroviral therapy to HIV patients. The ART program was paid for largely by the Global Fund, which contributed a total of US$294 million. The HIV Unit in the Ministry of Health (MoH) has been responsible for the dissemination of the medication, the training of nurses and doctors, and other logistics associated with the rollout. The MoH maintains detailed records of the rollout and performs site checks at all ART facilities on a quarterly basis. The systematic and well-monitored expansion contributed to its success as a program. A notable feature of the rollout pertinent to our analysis was the use of existing clinics and hospitals as the primary mode of expansion. Due to limited resources and the need to expand services rapidly, the program did not build new clinics and hire new staff. Instead, the program expanded to existing clinics, which provided brief training to clinicians.[8]

The Ministry of Health (MoH) began providing free ART in June 2004 at nine clinics. By the end of 2010, the number of clinics providing ART had grown to nearly 300 with over 350,000 patients ever initiated on ART.[9] The rollout

[7]In 2006, an estimated 29-37 percent of children aged 5-17 in Malawi were working, more than half on them in agriculture (National Statistics Office Malawi 2008). Children work in the agricultural sector, often alongside their parents on commercial farms and frequently perform domestic work to allow adults to work longer hours in the fields (US Department of Labor 2002).

[8]Generally, clinics provide ART services on a weekly basis, so patients must arrive on the particular day ART services are offered to receive medication. If demand is high such that clinicians cannot see all patients who are waiting or if supplies are low (both common), patients need to return the following week to refill their medication.

[9]The expansion of ART has continued after 2010, which is the last year covered by our data, and in

occurred in two stages: the first, in 2004-05, had the most rigorous requirements for clinics, and 60 sites (mostly hospitals and large clinics) were chosen to begin providing ART. In 2006, the government adopted a plan to expand its ART program with the goal of attaining 100 percent coverage of those in need by 2010. To that end, the MoH aimed to maximize geographical coverage and relaxed the standards for facilities: all clinics with at least one clinician and one data clerk were eligible. Although clinics that provide ART are generally bigger and better equipped than those that do not, the differences are substantially smaller for sites that began providing in later stages of the rollout (see Online Appendix Table A1). The clinics relevant for our analysis are those that began providing ART services around 2008, the latter phase of the rollout.

Enrolling and adhering to ART requires significant *ongoing* effort and resources from patients. ART patients are required to visit the clinic every two weeks to receive medication in the first month after initiation, then every month for the next six months, and every three months thereafter. In rural areas, limited transportation infrastructure, a poor road network, high fuel prices, and nonexistent public transportation make it difficult for individuals with HIV, particularly those who are sick enough to be eligible for ART,[10] to travel to clinics in order to receive treatment. And in this context, relatively small distances—in the range of 5–10km—can imply significant travel costs (effort plus foregone income) and already represent a substantial impediment to ART uptake and adherence.[11]

Adherence to ART in Malawi and other SSA countries is only about 80 percent after 12 months of treatment initiation, and possibly even lower in rural low-income SSA contexts, and therefore not as high as one would a priori expect given that ART is lifesaving for HIV+ persons (Rasschaert et al. 2012). Anecdotal evidence from clinic visits also suggests that a large share of ART patients lost to follow-up are those living far from clinics (Baranov 2012). A number of recent studies in Malawi tracking and interviewing HIV+ patients who were lost to follow-up suggest that transport costs are a major factor in obtaining treatment and were explicitly mentioned by 30 percent of the respondents as the primary reason for failing to obtain treatment.[12] A recent study in Malawi's Karonga

December 2013 there were 689 clinics providing integrated ART services to 472,000 HIV+ persons (more than 100,000 of whom were enrolled during 2013 alone) who have a reported 12-month survival rate of 78%, slightly below the WHO target of 85 percent (Government of Malawi 2014). Although private clinics also receive the ART medication at no cost from the MoH, they are permitted to charge patients a small fee. The private sector accounts for a very small part of the ART rollout, and less than 4 percent of patients were ever initiated on ART through the private sector (MoH 2011 Quarterly Report).

[10]The guidelines for treatment eligibility were determined by the Ministry of Health based on WHO recommendations. As there are only a few CD4 machines in Malawi, eligibility is determined solely by clinical symptoms of Stage 3 (advanced) or 4 (severe) AIDS. The WHO later revised the recommendation to include individuals with higher CD4 counts. The MoH released new guidelines in 2011 that reflected the WHO revisions; however, this change is not pertinent to our analysis.

[11]Transportation infrastructure is generally poor. Only primary roads are paved; secondary and tertiary roads are normally dirt roads and become muddy and difficult to navigate during the rainy season, particularly in rural areas. Few people own cars or motorcycles. The most common modes of transportation are walking, biking, hiring a bike taxi, and hitchhiking (though it is customary to pay the driver).

[12]See, for example, Tabatabai et al. (2014); Rachlis et al. (2013); McGuire et al. (2010); Say and Raine

District has attributed improved treatment adherence in this district to the decentralization of ART provision that importantly reduced distances to the nearest ART clinic (Koole et al. 2014). Distance to the health facility is used by health planners to define access to health services, and a number of recent studies from Sub-Saharan Africa have found that geographic distance to a health facility is an important factor in child mortality and other health outcomes.[13]

III. Estimation

A. Data

This paper uses data from the Malawi Longitudinal Study of Families and Health (MLSFH), which is an ongoing panel survey of up to 4,000 respondents in 120 villages that has been conducted biannually since 1998 (Kohler et al. 2015). The MLSFH cohorts were selected to represent the rural population of Malawi, where the vast majority of Malawians live in conditions that are similar to those in the rural areas of other countries with high HIV prevalence. The survey is conducted in three districts of Malawi: Rumphi in the north, Mchinji in the center, and Balaka in the south. The sample is entirely rural and not necessarily meant to be nationally representative, although key characteristics are similar to those found in the rural sub-sample of the Malawi Demographic and Health Survey (DHS) (Kohler et al. 2015).

The MLSFH collected GPS coordinates for sampled households and performed HIV testing from 2004-2008. In addition to the standard battery of questions in a household survey, beginning 2006 the MLSFH includes a module on subjective expectations, which elicits respondents' beliefs about probabilities using an interactive elicitation technique (Delavande and Kohler, 2009).[14]

ART became available at clinics within the MLSFH study regions shortly before the 2008 MLSFH survey. The clinics used existing staff to distribute ART and did not undertake additional building or hiring to accommodate the new service. Prior to the ART rollout, these clinics already provided HIV testing and counseling services.

Our main analyses use MLSFH survey rounds from 2006, 2008, and 2010. The sample is the set of respondents that are present for all three years of the survey from 2006-2010.[15] The data from the 2004 wave allow us to test for differential

(2007); Zachariah et al. (2006). One qualitative study from Uganda reported that even patients who have not yet been initiated on ART expressed anxiety about getting enough money to cover transport to the clinic (Tuller et al. 2010).

[13]See, for example, McLaren, Ardington and Leibbrandt (2014); Lucas and Wilson (2013); Okwaraji et al. (2012); Okwaraji and Edmond (2012); Guenther et al. (2012); Schoeps et al. (2011).

[14]Individuals were asked to allocate the number of beans (0 to 10) between two plates to reflects the probability of an event occurring versus not occurring.

[15]This was done in order to maximize the number of observations but still maintain a balanced panel. The results are similar using the entire sample of respondents (available from the authors by request). A detailed explanation of the sample selection process is available in Online Appendix A.

pre-ART changes. However, some outcome variables, notably savings and subjective expectations, were not available in the 2004 round. To explore the potential for pre-trends in savings, we incorporate the 1998 and 2001 waves (which still did not measure savings, but did report earnings and other socio-economic characteristics) and impute savings for waves 1998-2004 using available data (see Online Appendix C for details).

Table 1 provides summary statistics of the analytical sample from survey year 2006, before treatment became available ("pre-ART"). Panel A describes the demographic and economic characteristics.[16] Education is low, at a mean of 5 grades completed. Respondents are primarily subsistence farmers, growing and consuming maize as the main source of calories; however, most households rely on additional purchases of maize and other foods. For example, in 2009, 60 percent of farmers were still net buyers of maize despite large harvests (Durevall and Mussa, 2010). The labor market is informal, and individuals often work in informal work, or *ganyu*, on other farms. In a given year, 10 percent of households both supply and demand farm labor (Durevall and Mussa, 2010). Average annual labor income, which is the total amount earned in the past year from working on farms or selling own agricultural output (paid in cash or in kind), is only 81 USD and reflects the very low wages in Malawi.[17] Only 15 percent have a metal roof and 4 percent have a mobile phone in 2006. A wealth index (roughly mean 0, standard deviated 2) is provided to compare households within sample.[18]

Panel B in Table 1 reports summary statistics for the respondents' own 5-year mortality risk (0-10 scale), perceived own-HIV risk,[19] perceived HIV prevalence, and whether respondents report being worried about AIDS. The measured HIV prevalence in our sample is 4%, which is lower than the full MLSFH sample since we restrict the analysis to the balanced panel. Mortality perceptions and other perceptions on risk are greatly overstated by the respondents, a phenomenon that has been documented in a broader literature (Godlonton, Munthali and Thornton, 2015; Kerwin, 2016). Although the life-table mortality risk estimate over five years for people aged 35–40 is 10 percent, respondents perceive a 39 percent risk of death. This overestimation of mortality is likely due to the high

[16]We report all monetary values in "ln" USD using the 2010 exchange rate of 150 MWK = 1 USD. To deal with zeros, we use the inverse-hyperbolic sine transformation ($\log(y + (y^2 + 1)^{\frac{1}{2}})$) instead of logs, which for values that are not too small, can be interpreted as $\log(2y)$.

[17]The precise wording of the question is: "Think about all of the work that you have done in the past year in which you have been paid cash or kind. How much do you estimate that you have earned in the past year?" This does not include the amount households produced for own consumption. We report the log-earnings in Table 1, the level means reported in the text are located in Appendix Table A15, where we replicate our analysis using levels winsorized at the 98th percentile.

[18]The MLSFH wealth index is calculated using Principal Component Analysis on 20 items: all reported household assets (mattress, sofa, table and chairs, gas lamp, TV, radio, mobile phone, mosquito net), vehicles (bicycle, motorbike, oxcart), housing and roofing structure (metal roof, brick house), type of latrine, and animals (number of cows, pigs, goats, and chickens).

[19]Perceived own-HIV risk measured as the likelihood of HIV infection using the Likert scale (0=no likelihood, 1=low, 2=medium, 3=high likelihood). Beginning 2006, we also have measures of HIV risk using the bean method (0-10 scale), which are consistent with the Likert measure. We show the Likert measure here for consistency, as it was available in 2004.

prevalence of AIDS-mortality at the time (MLSFH respondents have a median of two acquaintances who are sick with AIDS and know two others who have died of AIDS in the past year), and the social importance of funerals (MLSFH respondents, for example, attend a median of three funerals per month).[20] Despite this overestimation of the level, the MLSFH subjective mortality expectations adequately reflect gradients in mortality by gender, age, education, and region of residence, and variation in mortality perception among MLSFH respondents are likely to reflect true underlying differences in subjective survival probabilities (Delavande and Kohler 2009).[21]

Table 1 Panel C summarizes pre-ART savings and expenditure outcomes of interest for our analysis, and Panel D shows grade completion for the sample of children of the respondents who are linked over time using data from the household rosters.[22] Respondents were asked to report the total amount of money they have in savings (such as a bank account, savings group, or cash). Fewer than 5 percent of respondents belong to savings groups. Additionally, respondents reported expenditures on their children's education, medical services, and clothing in the past three months. Our measure of savings only captures liquid assets and does not include all possible forms of savings such as land, housing, or large farm animals. While, in theory, we could estimate the value of all durable assets that were reported in the survey, this measure would be highly inaccurate because the values of land and housing, the largest components of wealth, are not easily measurable.[23]

We use distance to the nearest ART facility, a measure of access, as the source of identifying variation. Using precise GPS data on the locations of respondents and clinics, we calculate the distance to the nearest facility providing ART at the time of the survey. To ensure that the most relevant information is captured, we combine rich data on road networks to calculate the distance *by road* to a nearest facility (see Online Appendix A.3 for details on spatial data and calculations).[24] We also calculate the distance to the nearest clinic (regardless of ART status), market, school, major road, and merge in population density at a resolution of

[20]In addition, individuals in Malawi received signals about mortality risk from public information campaigns, many of which discourage risky behavior through stark messages about the danger of HIV/AIDS (e.g., Jato et al. 1999; Gupta, Katende and Bessinger 2003; Geary et al. 2007).

[21]For a broader discussion of the importance of collecting data on subjective expectations in low and middle income contexts, and their usefulness in economic analyses, see Delavande (2014).

[22]See the Online Appendix A for additional details of this linkage process.

[23]The value of land is not easily measurable because the system of land tenure in much of rural Malawi is based on the traditional customs whereby land in a village is considered as belonging to the community although individuals in the community have the right to cultivate and use it (Matchaya, 2009). Furthermore, under customary land tenure, traditional authorities may reallocate land based on community needs, and so household land usage may vary over time. As plots are often not adjacent and vary in sizes, household may have difficulty estimating their land. Land is also very illiquid as roughly 1 percent of landholders obtain land through purchases (USAID, 2010).

[24]As can be seen from Figure 1, the road network is very dense and captures smaller dirt roads in addition to larger and paved roads. The correlation between straight-line and by-road distance was 0.9 and the results are robust to using straight-line distance (not shown). Distance by-road yields more precise estimates, reflecting less measurement error.

100 square meters from the AfriPop database. These variables serve as important controls, as distance to one location is correlated with other spatial features that may pose a threat to identification. Figure 1 shows a map of these features and the survey area of sampled households.

Panel E reports statistics of our spatial characteristics. Before 2007, the nearest ART facility for most respondents was more than 25 kilometers away (the median distance was 27 kilometers), rendering ART virtually inaccessible for the population in the rural MLSFH study region. By 2008, ART arrived to at least one clinic within the survey area of each region, and the median distance to the nearest ART facility became 8.9 kilometers. ART was available at the clinics for an average of 7 months prior to the 2008 interviews. Several clinics also began providing ART after the 2008 survey in the sample regions. These clinics were generally farther away from the respondents than existing ART facilities. In the analysis, we use the 2008 distance to ART facility interacted with year as the identifying variation.[25]

Attrition in the MLSFH is comparable to that of other longitudinal datasets in developing countries (Alderman et al. 2001): approximately 25 percent of the 2006 sample is lost to follow-up by 2010.[26] However, attrition is not correlated with ART proximity. Our attrition analysis, described in detail in Online Appendix B, includes Inverse Probability Weighting to place more sampling weight on individuals with baseline characteristics more similar to attritors as well as including a subsample that was re-located as part of a unique migration follow-up (this approach reduces attrition substantially, from 25 to 14 percent). Our results are robust to these corrections, suggesting attrition is not a threat to our identification strategy.

B. Empirical Strategy

We estimate the effect of ART availability on savings, child expenditures, and schooling outcomes. Using a difference-in-difference strategy, we compare outcomes of respondents living near an ART facility to those living far, before and after ART became available. Distance to the nearest facility proxies for ART availability, incorporating both travel cost and access to information. The main regression analysis is based on the following specification:

$$y_{ijt} = \beta Post_t \times ART\ Proximity_i + \alpha_i + \delta_{rt} + \varepsilon_{ijt} \tag{1}$$

[25] Appendix Figure A1a shows the distribution of distances to respondents' nearest ART facility in 2008. The distance to the nearest ART facility changed for only 30 respondents in 2010. Figure A1d plots the distribution of distances to the nearest facility by year, showing little difference between 2008 and 2010. The results are unchanged if we use time-varying ART proximity instead of the 2008 distances. Using a time-varying measure of exposure to ART (e.g. months ART was available interacted with distance to the facility) yields similar results (not shown). The distribution of distances is not uniform and differs by region (see densities by region in Figure A1c), and at any given distance to ART, the regions are not equally represented. We include region-by-year controls throughout the analysis.

[26] See Kohler et al. (2015) and Anglewicz et al. (2009) for a detailed summary of the data and attrition in the MLSFH.

where y_{ijt} is the outcome for respondent i in village j, and region r, and time period t. For all monetary outcomes, the dependent variables are transformed using the inverse hyperbolic sine transformation (because of frequent zeros), but the results are robust to using levels.[27] $Post_t$ is an indicator for years 2008 and 2010 of the survey, i.e., the years after which ART became available in the MLSFH study regions, though we allow for separate indicators for 2008 and 2010. $ART\ Proximity_i$ is the proximity to the nearest ART facility in 2008 and is time-invariant. The baseline specification also includes individual-level fixed effects, α_i, which absorb the time invariant proximity variable, and region-by-year fixed effects, δ_{rt}, which absorb the indicator for the post period.[28] Standard errors are clustered by village and are robust to heteroskedasticity.

We parametrize ART proximity as the negative log of distance, though the results are robust to other specifications of functional forms such as inverse, linear, piece-wise linear splines, discrete dummies for the distance bins, and so on.[29] This log-of-distance parametrization allows for a convenient interpretation of the coefficient as the effect on the outcome for an individual if the distance to an ART facility were reduced by half.[30] This corresponds to a decrease in distance of 5.8 kilometers from the mean (and median) distance of 9 kilometers. We also show the results nonparametrically (see Appendix Figure A8).

We also estimate specifications controlling for spatial and demographic characteristics. The spatial controls include proximity (interacted with $Post_t \times Region_i$) to a primary road, any clinic (regardless of the availability of ART services at the clinic), major trading center, school, and population density. Proximity is parameterized as the negative log of distance.[31] Demographic controls include pre-period levels of wealth (with additional indicators for metal roof and mobile phone), age, gender, education, household size, number of children, HIV status,

[27]The results are robust to specifications using in nominal values, winsorized at the 98th percentile (all main tables using winsorized values are reproduced in Appendix Tables A15-A20) as well as other thresholds for the winsorization. Our results are also qualitatively similar using quasi maximum likelihood Poisson estimation with fixed effects, though the estimation is frequently not possible due to known convergence issues when adding in controls as maximum likelihood estimates do not exist (Santos Silva and Tenreyro, 2011, 2010).

[28]The results are similar in a specification without individual fixed effects, $y_{ijt} = \beta Post_t \times Proximity_i + \gamma Proximity_i + \delta_{rt} + \varepsilon_{ijt}$. The coefficients on Proximity, γ, are of interest because they show the "effect" of Proximity prior to arrival of ART. These coefficients are, in essence, those presented in Table 1, Columns 3 and 4.

[29]A priori, we would not expect the effect of distance to be linear, since a reduction in distance by 2 km would likely have a much bigger impact at a distance of 5km than at 10km (both because of fixed costs of transport and because of patterns in information spread). The nonparametric results in Appendix Figures A8 suggest that the effect of distance is, indeed, nonlinear. The negative log-distance is our preferred parameterization as it captures the non-linearity in a parsimonious and easily-interpretable way.

[30]This interpretation of the semi-elasticity is only accurate for small changes in distance. The precise interpretation of the coefficient is the impact of reducing distance by a factor of e, that is when $ln(\frac{d_1}{d_2}) = 1$, which means that distance must be reduced by more than half. This corresponds to a decrease in distance from the mean (9.1 km) by 5.8 km.

[31]While the spatial characteristics are all highly correlated, they are not collinear. Regressing ART proximity on the other spatial controls yields an $R^2 = 0.64$, leaving a substantial amount of variation for identification (see Figure A1b).

and marital status interacted with $Post_t$, allowing for differential trends among these demographic groups.

Distance as Access and Knowledge of ART Availability. — Respondents knew about the existence of ART well before it became available in their area. Anecdotal evidence suggests that news spread quickly about the existence of ART, referred to as *mtalikitsa moyo* or "prolonging life" in Chichewa. The country-wide ART rollout was featured prominently in national newspapers, radio, and TV. By 2006, 95 percent of respondents had heard of ART, which was at the time available in urban and peri-urban areas of Malawi. Many MLSFH respondents already had relatively accurate perceptions of the effect of ART on mortality of HIV+ persons: for example, when asked in 2006 about survival probabilities of hypothetical HIV+ individuals, they reported substantially higher 5- and 10-year survival rates for HIV+ persons on ART treatment as compared to HIV+ persons not on treatment (Delavande and Kohler 2016). However, there may still be learning about the longer-term longevity of patients on ART.

Distance facilitates the spread of information about ART availability at a particular clinic. Knowledge of local availability may be more sensitive to distance for individuals who are HIV-negative as they are less likely to actively seek information about treatment options. While the country-wide existence of ART was known broadly, local information about treatment options relied primarily on word-of-mouth. However, because HIV/AIDS is heavily stigmatized, individuals are reluctant to talk about specific information, like innovations in local ART availability, for fear of signaling HIV status to the community.[32]

Conditional upon knowing the locations of nearest ART facilities, distance also serves as a proxy for access to ART as it determines the time and monetary cost of getting treatment. For example, in 2004, as part of an experiment used in Thornton (2008), participants of the MLSFH were offered monetary incentives to obtain their HIV test results at temporary Voluntary Counseling and Testing centers (VCTs), the locations of which were also randomized. The study finds that distance is an important factor in determining whether individuals obtained their results; individuals who lived within one kilometer of the VCT were more than twice as likely to get their results as those who lived between 3 and 4 kilometers away.[33]

While we do not have data on ART uptake over time, we collected data on ART uptake among the subsample of MLSFH participants interviewed in 2012.[34] Of the HIV-positive respondents, 70 percent are on ART, and being 5 kilometers

[32]It is also possible that respondents near ART are more likely to get an HIV test after ART becomes available since ART increases the private benefit of testing, which would also lead to reductions in mortality risk since the large majority are HIV-negative. However, receiving an HIV-negative test result alone, does not appear to have long-lasting effects on mortality risk as respondents continue to worry about future risk (Thornton, 2012).

[33]VCTs were not placed further than 4km away, as they were deemed too far.

[34]The sample of 1,200 respondents included individuals over 45 years old (Kohler et al. 2015).

closer to the ART facility is associated with a 21 percentage point increase in the likelihood that the respondent is on ART ($p = 0.07$, $n = 23$). Although the sample size is small, these results echo the findings from numerous studies tracing ART patients who were lost to follow-up. Yu et al. (2007) found that 35 percent of patients lost to follow-up who were still alive and not on medication cited transport cost as their reason for stopping ART.[35] In another study of ART provision and travel time in rural Malawi, Houben et al. (2012) show that rural clinic openings resulted in large increases in ART takeup as travel time is substantially reduced.

Using the same data and identification strategy as this paper, Baranov, Bennett and Kohler (2015) show that HIV-*negative* respondents near ART reported to be less worried about AIDS. Furthermore, respondents reported lower mortality risk for people living with HIV, after ART became available nearby, while perceived HIV prevalence was unaffected. Thus, respondents near ART became less worried about AIDS specifically due to reductions in mortality risk conditional on being HIV-positive. In Appendix Table A4a, shows that ART proximity significantly reduced the conditional on HIV+ mortality risk, with increasing effects going from the 1-year to the 10-year horizon, even as soon as 2008. We also show that ART proximity did not effect the shorter horizon mortality for conditional on HIV+ and on ART, consistent with our earlier discussion that individuals knew about the existence of the medication. However, we do see effects of ART proximity on the 10-year mortality risk conditional on ART, but only by 2010, which is consistent with distance facilitating learning about the longer-term effectiveness of ART.

In our analysis, we highlight the results for HIV-negative respondents, who are anticipating the need for treatment in case they become infected in the future (and their children, who may need ART even further into the future). Rational respondents might anticipate that ART will be available near them by the time they (or their children) will come to need it, and this should bias our estimates downward. However, our results indicate that distance in our setting is likely to be also a proxy for information and learning rather than just access. Furthermore, while there was indeed a further scale-up of ART that occurred after 2010, there was considerable uncertainty about the program at the MoH as Malawi was rejected for the Round 10 Global Fund grant in 2011, following a widely publicized acute funding crisis (PEPFAR, 2012).[36]

[35] Another study from a different region of rural Malawi finds that, of the traced individuals who survived (an thus able to be interviewed), 30 percent of patients defaulted because of transport and time costs of accessing treatment. In this study, the patients all lived within a 15 kilometer radius of an treatment facility (McGuire et al. 2010).

[36] A report from Doctors Without Borders highlights the difficulties the ART rollout in Malawi faced around this time: "[B]etween February and April 2010, ARV stocks were dangerously low. Although a countrywide shortfall of ARVs was looming, no funding from the Sector Wide Approach (SWAp) was allocated to bridge the gap, nor did any of the individual health donors step in to assist." It is unlikely that our respondents would have known the specifics of the grants, though it would also be extremely optimistic to believe that an internationally funded government program would continue to expand. Interestingly, the report also quoted an HIV patient in Kenya indicating that individuals worried about

Balance. — Our primary identification assumption is that distance to ART is not correlated with unobserved characteristics of respondents that affect trends in outcomes. One way our results arise spuriously is if people near ART are systematically different from those who are far and would exhibit different trends in outcomes regardless of ART becoming available. For example, respondents near health facilities may become more optimistic over time because they have easier access to health care, or respondents near the major roads or trading centers may earn more because they have better economic opportunities. While we cannot test the unobservables directly, our dataset contains a rich set of observed characteristics. Thus, we are able to test if these characteristics are balanced along the distance gradient in the pre-ART period.

Table 1, column 3 reports the coefficient on ART proximity, parameterized as the negative log of distance, when regressing each characteristic on ART proximity (controlling for region dummies). The coefficients, which pertain to the pre-ART period (2006), can be interpreted as the expected change (non-causal) in that characteristic as we move 5.8 kilometers closer to the ART. Panel E shows that ART proximity is correlated strongly with other spatial characteristics. Importantly, respondents near ART do not exhibit more savings and investment behavior, our outcomes of interest, in the pre-ART period.

However, there are some imbalances: areas near ART are more likely to have a metal roof, though other wealth characteristics are not significantly correlated (and the sign is negative for income and land). Additionally, in this pre-ART period, respondents near ART appear to have higher perceived HIV risk and mortality risk, and lower mental health scores. On the other hand, in the pre-ART period, actual infection risk and physical health scores do not vary significantly with ART proximity, and individuals are not significantly more likely to know someone on ART.[37] While there are specific differences, individuals near ART do not appear to be systematically different based on background characteristics before ART became available.

Column 5 of Table 1 shows the coefficients on ART proximity after including for spatial controls (population density and region-specific proximity to clinic, market, major road and school). Most importantly, these spatial controls appear to explain the imbalance in mortality perceptions. The gap in mortality risk is reduced from 0.46 (0.2 of a standard deviation) to 0.2. While individually uncorrelated to ART proximity, the coefficients imply a relationship of the same direction, and we may still worry that the results in subjective expectations and other outcomes are driven by mean reversion. To test for mean reversion, we

future access due to the funding crisis: "In Kenya about 95 percent of HIV programmes are funded by external donors. To us living with HIV this is a very big problem because if the international donors decide to withdraw their funding, the program may not be sustainable according to the present funding levels by the government." p. 22 of the report (Médecins Sans Frontières, 2010).

[37]This is plausible as rural Malawians tend to have fairly large social networks, including generally also family members and friends in peri-urban areas (Myroniuk, Prell and Kohler 2013). And in the pre-ART area in the MLSFH study regions, persons on ART known to MLSFH respondents would most likely be individuals residing in such peri-urban areas that received ART prior to the MLSFH study regions.

include pre-ART mortality risk and perceived likelihood of HIV interacted with year in our analysis.

A few pre-ART characteristics remain unbalanced even after including spatial controls. Households near ART are still 11 percentage points more likely to have a metal roof and 4 percentage points more likely to have a mobile phone. To ensure our results are not driven by these initial demographic differences, we include dummies for roof structure and if the respondent had a mobile phone in the pre-ART period in the demographic controls.

Overall, the sample achieves better balance along the distance gradient with the spatial controls, suggesting that many of the differences found column 3 were attributable to the correlation in spatial characteristics and not inherent to the distance to the ART facility, per se. Without spatial controls, a joint test of all variables in Panels A-C gives an F-statistic with a p=0.07. Controlling for the spatial characteristics, a joint test yields an F-statistic with a p=0.46. All of our subsequent results are robust to including controls for spatial characteristics, where the effect of ART is estimated using a comparison group that is equidistant to (non-ART) medical facilities, schools, major roads and markets, and demographic controls.

Identification Tests. — The identifying assumption behind our difference-in-difference estimation is that the sample is balanced on trends, not levels, along the distance gradient. Table 2 tests for differential pre-ART changes for variables that are available in 2004: Panel A reports pre-trends for the demographic and economic characteristics, Panel B reports trends for HIV and risk perceptions, and Panel C shows pre-trends in child expenditures, the outcome of interest. The table shows little evidence of differential pre-trends in outcomes by distance to ART, with or without additional spatial controls (columns 3 and 5).

There are no significant trends in child expenditures, with the coefficient on ART proximity for education equal to 0.17 (0.2 of a sd) down to 0.11 once spatial controls are introduced, a small change for an elasticity.[38]

The only outcome that has a significant trend (at 5 percent level) after including spatial controls is owning a mobile phone, which is included in the demographic controls.[39] The bottom row of Table 2 shows the p-values on the joint test of

[38]The negative trend in household size near ART is driven by a few large negative outliers. Importantly the trend is not there among the subset of individuals with children (coefficient of -0.05, or 0.02 sd, p =0.88, with spatial controls). Respondents near ART appear to be becoming more worried about AIDS, and controlling for spatial characteristics makes the trend slightly larger. However, spatial controls generally flip the sign for the other measures associate with HIV risk.

[39]This is a potential threat to identification, since mobile phone uptake may be a proxy for forward-looking behavior (or individuals who had mobile phones early were more likely to take up new technology). Alternatively, families with mobile phones may have an advantage in farming or selling goods at the market. We control for if the respondent had a mobile phone in the pre-period in the regressions to ensure the results are not driven by this group. The results are similar if we control for the *change* in mobile phone between 2004 and 2006 interacted with year (since almost no one had mobile phones in 2004 (0.5%), the change between 2004 and 2006 behaves almost identically to the levels in 2006). In 2006, very few respondents had mobile phones–only 3.5 percent. By 2008, that number grew to 24 percent

all variables with (p=0.42) and without (p=0.16) spatial controls, indicating that pre-ART changes are not jointly significantly associated with ART proximity.

A limitation for our data is that savings were not recorded prior to 2006. We are thus are unable to directly test for pre-trends in this outcome.[40] In order to assess the potential that our savings results could be driven by pre-existing trends, we model savings in 2006 in order to impute savings in waves prior to 2006. We incorporate data from the 1998 and 2001 waves in order to obtain a longer time horizon to estimate trends in savings and because earnings were reported in those waves but not in 2004 (see Online Appendix C for exact details of our procedure). This exercise is similar to testing pre-trends across individual variables; however, it combines the available variables in a way that best correlates with the outcome of interest. Using this approach, there is no evidence of pre-trends in savings: the coefficient on a year trend interacted with ART proximity using pre-ART data (1998-2006) is negative and very small.[41]

Other Threats to Identification. — A potential threat to identification is that proximity to ART may be correlated with the provision of other government aid programs such as subsidized maize, agricultural inputs subsidies, or other health initiatives. In particular, we worry about a large agricultural inputs program, which was expanded in 2005-2006, may be correlated with distance to ART facility (Pauw and Thurlow, 2014). The MSLFH asks respondents about whether the household was a recipient of a number of social support programs including food and education subsidies, nutrition programs, agricultural support, and unconditional cash transfers. Overall, 75 percent reported receiving any government aid, and participation in is not correlated with ART proximity in 2006 (and, if anything, negatively correlated with ART proximity in 2010). Agriculture support in particular is not correlated with distance to ART in 2006.[42] Consistent with this, we show the results are robust to including controls for household participation in such programs.[43]

Another concern is that areas near ART facilities may have different unobserved shocks. For this reason, we also include controls for reported economic shocks

and by 2010 to 41 percent. Even by 2008, mobile phone ownership was no longer correlated to ART proximity. Controlling for time-varying mobile phone take-up does not affect our results (not shown).

[40]Since the subjective expectations module was added only starting 2006, we are also unable to test pre-trends for the subjective mortality risk measure. A weaker test, using cross-sectional data from 2006, is to compare trends in subjective mortality risk using cohort-of-birth across distance groups. For example, a regression of subjective mortality risk on year-of-birth interacted with ART proximity, controlling for year-of-birth and ART proximity, yields a small and statistically insignificant coefficient. Online Appendix Figure A3 show the trends in 5-year subjective mortality risk in 2006, for three distance groups. As expected, older respondents have higher mortality risk, and respondents near ART report a higher mortality risk, though the trends run parallel, suggesting that the level difference remained constant prior to ART's arrival.

[41]Column 1 in Appendix Table A9.

[42]See Appendix Figure A2 shows a flat relationship between distance and participation.

[43]These data were only collected in 2006 and 2010. The questions asked if the respondent participated in these social support programs (eleven in total) in the previous two years. For inclusion as controls, we created 11 variables for participation, which only vary between the pre- and post-ART periods.

due to weather and climate conditions, though these are not correlated with ART availability. Economic shock variables include property loss due to natural disaster (e.g. fire or flood), and poor harvest due to crop disease, pests, or theft of animals.[44] [45]

Finally, we may also worry that respondents who are more likely to benefit from ART move closer to the facilities. Rental housing is largely not available in these villages, so individuals would need to move their farm and build a house in order to relocate. Consistent with this, we find that attrition is not correlated with ART proximity (see Appendix Table A10 and the discussion in Online Appendix B). We exclude attritors, individuals who completed the survey in 2006 but not in 2008 or 2010, from the entire analysis to ensure that the results are not biased by the changing demographic composition of the sample over time, and the results remain substantively unchanged when using the full sample.[46]

IV. Results

To illustrate the identifying source of variation, Figures 2 and 3 plot outcomes over time and distance. Figure 2a plots total savings as a nonparametric function of distance to ART for each year data are available (2006-2010). In 2006, prior to ART being available, distance and savings are uncorrelated. By 2008, after ART had become available, respondents living near ART have more in saving relative to those further away, and the pattern persists into 2010. Figure 2b plots the mean savings over time by splitting the sample into three groups: near (within 6 kilometers of ART), middle (between 6 and 12 kilometers), and far (more than 12 kilometers). In this figure, we include the imputed savings in 1998-2004 indicated by the shaded area (the procedure for imputation is described in Online Appendix C). We see again that prior to ART, there is no difference in total savings between areas "Near" and those further away. Importantly, we also see no indication of a pre-trend in savings using the imputed data. The impact of ART is apparent by 2008, though it is much larger by 2010, which is consistent with what we should expect since savings is a stock variable. We also note that there is an strong upward trend in savings, expenditures, and earnings over the period since 2004, which is consistent with national trends.

Figure 3 shows the trends in expenditures per child in the past three months for education, medical, and clothing. We expect that if ART increased the rate

[44]The measures of economic shocks are first available in 2008. Hence, there is not enough data to include these shocks as time-varying controls. Instead, we calculate whether the respondent has ever experienced a particular type of shock and include this set of variables (7 in total) interacted with $Post_t$ as controls. This approach measures the respondent's propensity to experience shocks rather than the actual incidence of shocks.

[45]Because they could be affected by the introduction of ART, we no not include economic shocks due to income loss, death of a breadwinner, divorce, and other shocks. Not including these shocks is conceptually more accurate, although none of these shocks is correlated with ART Proximity; and earlier versions of this paper also showed the results are similar when including them. We explore these mechanisms in more detail in Section V.

[46]See Appendix Tables A2 and A3.

of return to human capital investment, then expenditures for education would increase. Medical expenditures on preventative care are another form of human capital investment, though our measure captures all types of expenditure, and as elsewhere in the developing world preventative care is highly underutilized. Clothing expenditure (which explicitly did not include school uniforms), which contributes least to human capital, should be the least affected by ART. Our results indicated by Figure 3 and echoed in regression analysis are consistent with the above expectations: we see effects of ART primarily on education expenditures, small effects on medical expenditures (though these are not robust), and nothing for clothing. Across all three categories in 2004 and 2006, the respondents are balanced along the distance gradient in trends and levels, indicating little evidence for differential pre-trends by distance to ART.

A. ART Availability and Saving Behavior

Estimates of the effect of ART availability on savings behavior appear in Table 3. Because only 20 percent of respondents had savings in 2006, we show the results using two measures of saving: if the respondent reported any savings (extensive margin) and the (log) total amount reported (intensive margin). We find an immediate response at the extensive margin. The point estimates in column 1 indicate that reducing the respondents' distance to the nearest ART facility by 5.8 km increases the likelihood to save by 7 percentage points in 2008 and 10 percentage points in 2010 over the 2006 period.

In column 2, we include controls for spatial characteristics, and column 3 adds demographic characteristics (including the mean reversion controls of pre-ART mortality and HIV risk). In column 4, we also include economic shocks and participation in government aid programs.[47] The point estimates for respondents' likelihood to save actually increase with the addition of spatial controls, as well as with including demographic controls, while the shocks and government aid controls decrease the estimates. Due to missingness, including the set of demographic controls sharply reduces the number of observations. The changes in the point estimates are not due to the changing sample, but a result of including controls, particularly the spatial controls.[48]

At the intensive margin, column 5 shows that total savings also increase near ART, and the estimated effect is larger and more precise in 2010. The point estimate is an elasticity, and implies that savings would increase by 0.5 percent with a 1 percent increase in proximity. That is, if respondent's distance to ART were reduced by 5.8 km, we should expect to see an increase in total saving by

[47]Due to the large number of controls, time-invariant controls are interacted with $Post_t$. The results are similar if we interact the controls with year dummies (Appendix Table A2).

[48]As a placebo test, we could estimate the effect using the distance to clinics that do not provide ART. However, this is analogous to running a regression with both ART proximity and any clinic proximity as regressors, and testing if the coefficients on clinic proximity are different from zero. Appendix Table A2, reports point estimates on $2010 \times \textit{Clinic Proximity}_i$ and $2008 \times \textit{Clinic Proximity}_i$ and indicates that there is no effect of being near just any medical facility for savings (or human capital investment).

50%. The results are robust to including spatial, demographic, and economic controls, and the pattern is similar to what we observe at the extensive margin. With all controls, the point estimate implies an elasticity of total saving with respect to distance of about 0.7.

Note that because there are frequent zeros (and we use the inverse hyperbolic sine transformation), we must be careful about interpreting the magnitude. As mentioned earlier, our results are robust to other transformations of the dependent variable (for example, Appendix Table A17, shows the results using winsorized levels and estimate that increasing proximity would increase savings by 30 USD). Alternatively, we can construct saving rates (using the panel nature of the data and because we have annual earnings) for 2008 and 2010. This approach reduces our analysis from a double difference to a single difference and requires additional assumptions (see Online Appendix E for more detail), but has the benefit of making the results more easily interpretable. Our estimates imply that reducing distance to ART by 5.8km would increase the saving *rate* by 3-4 percentage points.

B. ART Availability and Investment in Human Capital

Estimates of the effect of ART availability on investment in human capital appear in Table 4. We show the response in spending on education, medical, and clothing for children. We find that education spending on children increases with ART availability, while spending on clothing appears to be unaffected. Column 1 shows results for education spending, where the coefficient on $2010 \times ART\, Proximity$ is large, an elasticity of 0.37, and significant; however, the coefficient on $2008 \times ART\, Proximity$ is much smaller, 0.05, and not statistically significant.[49] The effect of ART on education expenditures only becomes apparent by 2010, which is likely because education decisions were already made by the time ART came online for the 2008 survey rounds.

Columns 2-3 test if the results are robust to including controls, The point estimates on $2010 \times ART\, Proximity$ increases when including spatial controls, but decreases when including the rest of the controls. This is, however, due to the change in sample size. Restricting the sample to be the same across the specifications, the point estimates all yield an elasticity of 0.32, and significant at the 5%, by 2010. In column 4 we also include a leading interaction, $2006 \times ART\, Proximity$, to test for pre-trends under our most stringent specification. The point estimate is 0.14, which is positive but not significantly different from zero. Furthermore, the elasticity is also 0.08 in 2008, which is not consistent with a pre-trend.[50]

[49]In levels, the point estimate implies that reducing the distance by half would result an increase of 2.5 USD in (quarterly) spending on education per child by 2010. This increase is economically large, representing 80 percent of the average reported spending on education per child during 2004–10.

[50]Consistent with the findings in Table 2, the coefficient on ART proximity in 2006 is always small and never statistically different from zero at 5 percent (in all estimates for education, medical, and clothing expenditures).

Column 5 shows results for medical spending, where the coefficient on 2010 × *ART Proximity* is 0.15 and marginally significant. Including controls further decreases the point estimates to an elasticity of 0.03, leading us to conclude that the marginal result in column 5 was not robust.

Finally, since clothing is unlikely to contribute to a child's stock of human capital (respondents were explicitly asked not to include spending on school uniforms), clothing expenditures provides a placebo test. We find no evidence that parents are spending more on children's clothing. If expenditures in general were increasing for reasons not related to ART, for example as a result of an income shock, then we would expect to find evidence of it in clothing expenditures (the largest category of spending on children). Column 9 shows point estimates that are small and statistically insignificant.

V. Mechanisms

This section considers possible mechanisms that may result in changes in investment when ART becomes available. We first investigate other investment and income trends to test if another economic shock is causing our results spuriously. Next, we also explore the whether our results are driven through changing mortality and morbidity patterns. Last, we use the data on perceptions of mortality risk to provide direct evidence of the expectations mechanism.

A. *Economic Spillovers*

The availability of ART may also increase local demand for goods and services that may indirectly affect investment. We explore whether the arrival of ART was associated with higher reported income, more spending across other categories, increased farm inputs, or more assets.[51] While all respondents live at least a kilometer away from ART, which makes it less likely that we are picking up effects from higher foot traffic near the clinics, we worry about boarder income effects. Additionally, our findings could be the result of an income shock unrelated to ART. If respondents near ART facilities are cultivating more maize or earning more on the labor market and becoming wealthier overall then we should expect to see increases in spending in other categories as well.

The MLSFH includes expenditure data (recalled for the past three months) for key categories, including spending on the respondents' clothing and medical needs and household spending on seed purchase, agricultural equipment, fertilizer,

[51] While farm inputs are investments, they are relatively short-term, and the rate of return on short-term investments should be unaffected by longer-term mortality risks. In this setting, farms are unirrigated, and equipment generally consists of small hand tools. Larger, more durable investment items are generally not available for purchase. In our sample, respondents spend 50 percent more on funerals than they do on farm equipment. Generally, we should expect that human capital should respond more to life expectancy than physical capital, since human capital is necessarily embodied whereas physical capital is not (and can thus be bequested). In this way, human and physical capital may be substitutes under certain economic conditions.

hired labor, funeral expenses, and medical spending on others (from 2006 onward). Labor earnings are available from 2006 onward and include wages, earnings from sale of farm output at the market, and other cash or in-kind earnings deriving from labor. 98 percent of respondents farm maize, so reported market earnings do not fully capture all income as households consume a large share of crops they farm. However, nearly all respondents also partake in addition wage-earning activities such as selling items at the market and informal labor (*ganyu*) at some point during the year. While individual expenditure categories have frequent zeros, fewer than 5 percent of the sample report zero total non-child expenditures or earnings. As in the rest of the paper, we transform all nominal values by the inverse hyperbolic sine, allowing us to interpret the coefficient as an elasticity, though the patterns are not different using levels (Appendix Table A19).

Table 5, Columns 1-8, show the effect of ART availability on various expenditures and farm inputs. The point estimates are small, often negative, though generally imprecisely estimated. We also observe reductions in spending on farm inputs, notably on fertilizer and hired labor in 2010, though these estimates are not significantly different from zero. Column 9 summarizes the net effect on (non-child) expenditures: overall non-child expenditures are decreasing nearing ART, the elasticity of expenditures with respect to ART proximity is -0.34.

Column 10 shows that respondents near ART do not report higher annual earnings, the point-estimate for the elasticity is negative in both years. We also consider the effect of ART on the overall wealth index (roughly mean 0, standard deviated 2) calculated using PCA on 20 items incorporating all reported household assets, vehicles, housing and roofing structure, type of latrine, and animals, shown in Column 11. We should not expect the overall wealth of households to improve substantially in the short-run as a result of ART since increased savings and long-term investment should only increase wealth in the long run. We find that the point estimates are slightly negative in all years (around 0.1 standard deviations) and marginally significant.

Given our findings that child expenditures are increasing and respondents report to have more in savings, for budgets to balance, households must be decreasing other non-child expenditures or increasing labor supply on their own farms. While in theory, individuals may also borrow, in our setting households are credit constrained. Our results indicate there is evidence that non-child expenditures are decreasing. Additionally, Baranov, Bennett and Kohler (2015) show that households near ART availability increase the time spent working on the farm. More time on the farm would imply that households need to purchase less food, though food expenditures are unfortunately not measured in the survey.[52] While the null findings on the effect of ART on expenditures, wealth, and earnings are not consistent with an income or productivity shock, we do not fully observe all

[52]These results are consistent with the life-cycle model, since investment and labor supply are jointly determined. As individuals increase savings and investment in long-term assets, they must adjust either by reducing expenditures in non-long-term assets or increasing labor supply, or both.

expenditure categories and cannot rule out that improved farm productivity is increasing consumption and/or reducing purchases of food, leaving more income to be spent on unobserved expenditure categories.

Importantly, Baranov, Bennett and Kohler (2015) also find improvements in mental health associated with reduction in worry about AIDS mortality, suggesting that the increased labor supply may be driven by improvements in mental health. While the patterns of expenditures do support that our findings are driven entirely by mental health improvements (as that would be akin to a productivity or income shock), it is possible that large reductions in mortality risk increase investment through the horizon effect but also reduce anxiety and stress, improving mental health, which translates to increased productivity or work effort. Our results are still a valid estimate of the effect of life expectancy changes on decision-making, though because of the mental health channel, the interpretation would change as it is not longer just due to an increase in the rate of return to long-term investment.

B. *Mortality, Morbidity, and Care-taking*

In this section, we aim to test the degree to which our results may be driven by individuals benefiting from the availability of ART, either directly or indirectly through reduced mortality, morbidity, or caring for sick individuals within the household. To do this, we estimate the baseline specification (which includes spatial controls) but interact $Post \times ART$ with a dummy variable indicating the individual may have benefited directly or indirectly from ART.[53] Table 6, Panel A reports, again, the aggregate effect of ART for all respondents. We first test the possibility that the results are driven by the direct effect of HIV-positive respondents receiving the life-saving medication. We define an indicator, B_i, equal to 1 for individuals who ever tested positive or whose HIV status is unknown.[54] That is, B_i is equal to 0 for individuals who we know for sure were HIV-negative in 2008. Table 6, Panel B reports the effect of ART for the HIV-negative subsample (the coefficients on the triple interactions $B_i \times Post_t \times ART_i$ are not reported to save space). The coefficients on $Post_t \times ART_i$ are actually larger for savings, but 30 percent smaller, and no longer statistically significant, for education expenditures indicating that HIV+ individuals are dis-saving while investing more in their children's human capital. Since the human capital investment result does appear

[53] In other words, we estimate a triple-difference

$$y_{ijt} = \beta_1 Post_t \times ART\ Prox_i + \beta_2 B_i \times Post_t \times ART\ Prox_i + \beta_3 B_i \times Post_t + \alpha_i + \delta_{rt} + \varepsilon_{ijt}$$

where B_i is a dummy for various categories of direct and indirect benefits from the medication, eg HIV, mortality, care-taking, orphans.

[54] Some individuals did not consent to the HIV test, or others were not reached by the HIV testing team during the 2004–08 MLSFH rounds. As a result, 17 percent of our sample did not have HIV testing results by 2008. The survey did not conduct HIV testing in 2010, so we are unable to exclude individuals who seroconvert between 2008 and 2010. These individuals would be unlikely to start treatment since a maximum time from infection of two years is generally too short to develop the clinical symptoms to be eligible to start ART (based on local eligibility criteria).

to be driven somewhat by HIV+, we exclude children of HIV+ respondents in estimating the effect of life expectancy on schooling in Section VI.

There are other important channels by which ART can impact investment without changing expectations. One possible effect of ART availability is that family members other than the respondent who were ill with AIDS began receiving treatment. This would reduce the burden of taking care of a sick household member.[55] Additionally, because AIDS mostly affects individuals during their most productive age, the sickness and death from AIDS reduces the number of productive members in the household.

Another related effect of ART is a reduction of orphaned children. Orphaned children would often be sent to live with neighbors or extended family, increasing the number of dependents in the household. Such a shift in the household structure increases the care-taking burden and may decrease investment in human capital for even the non-orphaned children. While the total number of orphans may not be large enough to fully explain changes in school enrollment due to changes in life expectancy, the effects of orphanhood may be amplified through their effects on households that care for them. Indeed, in Sub-Saharan Africa, about 20 percent of households have an orphan living with them (Evans and Miguel, 2007). Since our results are estimated using the same individuals over time, we do not capture any changes in schooling for orphans themselves. However, households near ART may be less likely to receive AIDS orphans after ART becomes available than those who live far. A prior, we do not anticipate care-taking to drive our results because in the time period of the survey the number of households that have an eligible HIV-positive members is small.[56] However, over longer time periods, the effects of reducing illness, death, and orphans should become evident.

Table 6, Panels C-E explores whether mortality and care-taking mechanisms described above are driving our main results. Panel C reports the effect of ART for respondents that reported no AIDS-related deaths in the household in the previous two years in all waves of the survey. The questionnaire specifically asks if the death is suspected to be AIDS-related. Because the stigmatization of AIDS may lead to an underreporting of AIDS deaths, we also include any deaths that reported the age of the deceased between 15 and 49 as the large majority of these deaths are caused by AIDS. Panel D reports effects for respondents who never reported a seriously ill household member. The results from Panels C and D show that point estimates are extremely similar for all outcomes, when excluding deaths or illnesses in the household.

[55]This channel may be potentially large: In South Africa, where a similar ART rollout occurred over a similar time period, Bor et al. (2011) estimate that 25 percent of the population shared household or compound membership with someone who initiated ART by 2010. However, the HIV prevalence in KwaSulu-Natal was much higher, at 20 percent of adults.

[56]In 2008, 6.4 percent of all survey respondents had HIV, of which only 32 percent qualify based on disease status. Given households comprise of an average of 2.24 adults, the estimated number of respondents either eligible for ART or are living with an ART-eligible adult is approximately 4.6%.

Last, to proxy for the presence of orphans, Panel E reports the coefficient on ART for respondents who never reported non-biological children co-residing with them (approximately 50 percent of the sample). Again, the results are similar for all outcomes, except the coefficient on $2010 \times ART$ for medical expenditures is positive and significantly different from zero.

C. Subjective Expectations

The MLSFH contains rich measures of subjective expectations (Delavande and Kohler, 2009), allowing us to test directly if ART availability affected perceptions of mortality. Baranov, Bennett and Kohler (2015) show that ART availability reduces subjective mortality risk and its components: infection risk and mortality risk conditional on HIV infection, and that these effects are robust to spatial and demographic controls and for the subsample of HIV-negative non-caretakers.[57] Respondents answer questions about their own mortality risk as well as mortality risk for hypothetical individuals similar to them that are healthy, HIV+, or on ART, each over three time-horizons (1, 5, and 10-years). ART availability most directly affects HIV+ mortality. Additionally, while the short-run benefits of ART were apparent, ART proximity may induce learning of the extent to which ART may extend life expectancy. Finally, even healthy mortality risk may be affected by ART because it is a function of future risk of infection and HIV+ mortality risk, especially in our setting where individuals perceive over-inflated risks associated with HIV/AIDS.

In order to avoid the pitfalls of multiple hypothesis testing and to improve power by reducing measurement error in the dependent variable, we use these 12 questions to construct an index of mortality risk using the factor score.[58] Furthermore, by including HIV-related mortality beliefs in the index, we capture changes in mortality beliefs more strongly associated with HIV that are more relevant for long-term longevity (beyond the 10-year horizon) as well as for the respondents' children.[59]

Table 7 reports the estimates for the effect of ART availability on the subjective mortality risk index which is mean 0, standard deviation 1, by construction. To focus on indirect effects, we exclude individuals who ever tested positive for HIV. Column 1 includes the basic set of spatial controls, column 2 adds demographic

[57]The identification strategy is similar, though the parameterization of ART Proximity is slightly different–this paper uses negative log-distance instead of inverse distance because of the ease of interpreting the coefficient.

[58]We use the factor score as a simple way to aggregate the mortality risk measures. Factor analysis is a commonly used statistical method that summarizes the co-variability among observed measures using low dimensional latent variables. The method also accounts for measurement error, which we believe is especially high among our measures of mortality risk (Wansbeek and Meijer, 2000).

[59]Appendix Table A4 shows the results for each of the variables included in the index separately. The results are similar using alternative aggregation methods such as a GLS-weighted index (see Anderson (2008)) or a simple average. We prefer the factor score as it places more weight on correlated variation, which is more likely to reflect underlying mortality beliefs than any single measure, especially if individuals have difficulty calculating exact mortality probabilities for a fixed horizon.

controls plus economic shocks and aid program participation, and finally column 3 adds controls for mean reversion (pre-ART mortality and HIV risk perceptions interacted with year fixed effects). Our results, which are robust to all controls, indicate that ART reduced mortality beliefs by approximately 0.2 of a standard deviation by 2010, and the point estimate in 2008 is generally negative and smaller though not statistically different from zero.[60]

While the mortality index is a helpful summary index, the magnitude of the effect is difficult to interpret. To interpret these results, we use the reduction in the 5-year own mortality probability to calculate the implied subject life expectancy gain: our results suggest that reducing the distance to an ART facility by 5.8 km increases subjective life expectancy by approximately 6 years (see Online Appendix D for details).

Next, we explore heterogeneity by gender as HIV prevalence and age of infection differs between men and women in Malawi.[61] The combination of higher prevalence and earlier infection implies that the life expectancy gains from ART are substantially larger for women.[62] These difference are reflected in the subjective mortality risk response of MLSFH respondents. Table 7, column 4 shows the heterogeneous effect of ART by gender. Women adjust expectations earlier, consistent with the fact that women are generally more likely to visit health facilities than men. But even by 2010, we see that the effect of ART for women is larger by 0.12 standard deviations.

In order for longevity to impact the rate of return for schooling, parents must believe that ART will improve the longevity of their children. It may be the case that adults believe that their children will have access to treatment regardless of location. Unfortunately, we do not directly measure parents' beliefs about their children's mortality risk. As an indirect test, we estimate the differential effect of ART proximity for the cohort aged less than 25 in 2006. If young respondents anticipated that treatment would be available everywhere, distance should not matter for them. On the other hand, if individuals do not expect ART to be available everywhere in the future, the life expectancy gains of eliminating AIDS mortality are also largest for the younger cohort. Column 5 shows the heterogeneity in response to ART by whether the responded was young, and indicates

[60]Since our savings results show that behavioral changes were detectable by 2008, the mortality index results may appear at odds with the savings results. However, HIV+ mortality risk perceptions, the variables most closely capturing the effect of ART, do significantly respond to ART proximity by 2008 (see Table A4). Furthermore, the responses to ART proximity in 2008 were differentially greater among individuals who reported any HIV risk at baseline for both savings and mortality risk (see Table A5).

[61]In our sample, HIV prevalence in 2006 among women was 4.4 percent versus 2.8 percent in men. For the unrestricted sample, the 2006 prevalence was 6.9 percent (women) and 3.9 percent (men). 2010 DHS estimates for rural Malawi are 10.5 percent (women) and 7.1 percent (men) (Malawi DHS, 2011), with the lower prevalence in the MLSFH population due to the fact that the MLSFH does not include peri-urban areas with higher HIV prevalence that are included in the DHS rural sample (Kohler et al., 2015).

[62]UN life tables suggest that the estimated life expectancy gains from eliminating AIDS mortality are 11.1 years for men, compared to 14.4 years for women. Indeed, since the start of the rollout in 2003, measured life expectancy at age 5 has increase by 12.5 year for women and 9.1 years for men (see Appendix Figure A6).

that, consistent with the larger life expectancy gains, the effect of ART proximity is more than twice as large for the younger cohort.

VI. Life Expectancy and Schooling

Our results thus far suggest that ART availability resulted in increased spending on children's human capital by way of changing perceptions about longevity. To further strengthen this conclusion, we also estimate the effect of ART availability on children's grade attainment as reported by their parents.[63] Finally, to understand the magnitude of our results, we calculate the implied elasticity of schooling with respect to life expectancy (the horizon effect).

Table 8 provides results using the sample of respondents' children who are of school age (5–19) and are reported in the 2006, 2008, and 2010 years of the survey. We also restrict the analysis excluding any children of HIV+ parents, to avoid capturing the direct effect of the treatment. We use grade completion (and control for age interacted with year in all regressions) rather than grade-for-age for ease of interpretation, although using grade-for-age yields similar results. The effect of ART on grade completion seems to be quite large. The point estimate in column 1 implies that decreasing the distance to ART by half would increase years of schooling by 0.33. The effect is only large and significant by 2010, which is consistent with the lagged response of educational spending. The results are robust to including spatial and demographic controls, including them increases the point estimates but also reduces precision.

Since ART increases life expectancy for adults and children, the results presented in Table 8, columns 1 and 2, include the effect of life expectancy gains for parents and children. However, we wish to calculate the implied effect of an additional year of children's life expectancy on schooling to estimate the horizon effect outlined in human capital theory.[64] To estimate this effect of children's life expectancy on years of schooling without capturing the effect of parental longevity, we exploit differential life expectancy gains by gender, which is perceived by respondents as shown in Section V.C. We use a triple-difference approach, similar to Jayachandran and Lleras-Muney (2009), to estimate the additional increase in grade attainment girls received relative to boys as a result of ART. We estimate

[63] Given frequent school interruptions and grade repetition in context such as rural Malawi, highest attained schooling grade is generally a better indicator of a child's human capital than years of schooling.

[64] If ART only increases life expectancy for the respondents but not their children, the rate of return to education from the perspective of the child is unaffected. However, the parents are more likely to live into old age and receive benefits from investments in child human capital through upward intergenerational transfers (Banerjee 2004). Holding fixed the life expectancy of the parents, when children are expected to live longer, the rate of return to education from the perspective of the child has increased. Therefore, since ART increases life expectancy for adults as well as children, there are two relevant margins that push toward higher investment in human capital.

the specification

$$y_{ijt} = \beta Girl_i \times Post_t \times Proximity_i + \gamma Girl_i \times Post_t + \\ \eta Post_t \times Proximity_i + \alpha_i + \delta_{rt} + \varepsilon_{ijt},$$

where y_{ijt} is the child's grade attainment. We include age-by-year effects, individual fixed effects and region-year effects and allow individual indicators for 2010 and 2008 instead of $Post$. As in the rest of the paper, the standard errors are clustered at the village level, j. The individual fixed effect absorbs the control for gender and ART proximity, and their interaction, as they are time invariant, and the region-by-year effects absorb the control for $Post$. This model assumes that parents are not more likely to invest in girls versus boys for reasons other than their different life expectancy gains, which is a limitation. Prior to ART, older boys and adolescent males from the main survey have slightly higher grade attainment, suggesting that the rate of return relative to costs are not substantially higher for girls.

Columns 3 and 4 show the differential impact of ART availability by girls and boys in a triple difference regression. The point estimates on the triple difference are not precise. We also include results for a restricted sample of only older children, since the younger children may not have yet had a chance to drop out. These results give slightly higher estimates and are significant at the 10 percent level. Although the standard errors are large (potentially because of the limited sample size), they are robust to including various controls. The estimates suggest that girls' schooling attainment increases by 0.38 years more than for boys. Given that the life expectancy gains for girls are 3.3 years greater than for boys, we can divide these numbers to get a "back-of-the-envelope" estimate of the horizon effect: the marginal effect of an extra year of life expectancy on years of schooling is 0.12.[65] The magnitude of the effect is similar to that estimated in different contexts by Jayachandran and Lleras-Muney (2009), who estimate 0.11 years of schooling per year of life expectancy, and more recently by Hansen (2013), who find an estimate of 0.17.

VII. Conclusion

While economic theory predicts that a longer life expectancy increases the value of long-term investments such as education, it has ambiguous predictions for saving behavior. Recent studies provide compelling evidence suggesting that education responds to life expectancy; however, few studies have considered the effects on savings. This paper uses spatial and temporal variation in the availability of life-extending AIDS medication to evaluate its impact on savings and human capital investment in Malawi. Our study has several advantages: it allows us

[65]This calculation is biased downward as we attribute the change in grade attainment, which is estimated using the distance gradient, to the full difference in life expectancy gains.

to estimate the effects of ART on the savings behavior and human-capital investments of HIV-*negative* individuals, that is, individuals who currently do not directly benefit from receiving ART. In addition, we use data on self-reported mortality risk to provide direct evidence that individuals actively change investment decisions based on their subjective longevity.

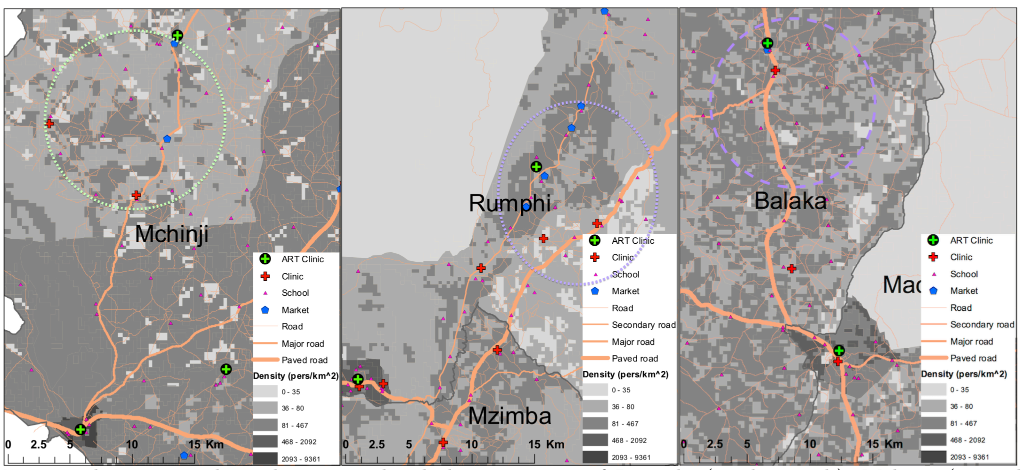
We employ a difference-in-difference strategy to estimate the impact of ART availability on cash savings, education expenditures, and children's schooling. The identification strategy compares the investment outcomes of people who live near and far from ART, before and after it became available.

We find large effects of ART availability on reported savings and investment in children's human capital. Consistent with these findings, we also show that ART availability improves educational attainment for children of the respondents. For example, halving the distance to ART (a decrease of approximately 5 kilometers for the average respondent) would imply an increase in schooling by 0.3 years. The results are similar for the HIV-negative respondents, indicating that the results are not driven by the direct effect of HIV-positive individuals receiving life-saving medication. Other potentially important channels not related to changing expectations, such as the household care-taking burden from AIDS-related illness, death, and orphanhood, cannot explain our findings. However, ART availability does have a measurable decrease in self-reported mortality risk.

Our findings about the effects of ART availability on savings and investment in children's human capital are consistent with the standard theory of human capital whereby expectations about longevity affect long-term investment. The savings results also provide evidence that higher life expectancy does prompt more savings in a low-income setting such as Malawi. However, alternative channels related to improvements in disease environment, such as mental health, may also contribute to our findings.

Our findings also have important policy implications. We show that antiretroviral therapy leads to large and economically important increases in savings and investment behavior both for HIV-positive and HIV-negative individuals. This spillover benefit should be incorporated into cost-benefit analyses of such programs by governments and donor organizations. Our results also suggest that the impact of ART may have large implications for economic growth in sub-Saharan Africa.

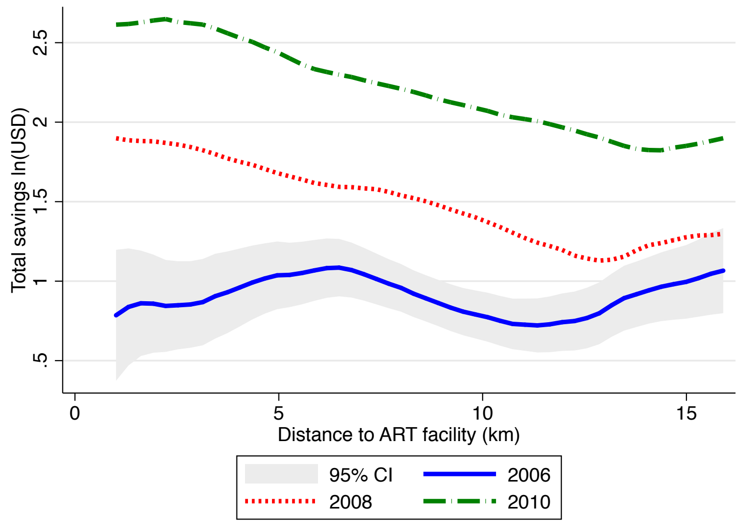
Figure 1. : Geography of All Regions



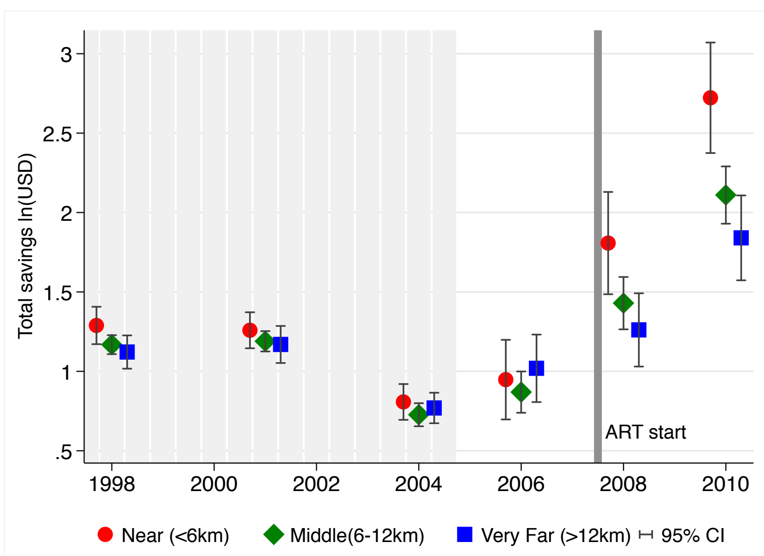
Notes: These maps show the geographical characteristics of Rumphi (in the north), Mchinji (central district), and Balaka (in the south) districts from which the survey samples are drawn. To ensure confidentiality of respondents, we do not plot individual household locations but note the general area where the households reside with the dotted circle. The data on locations of clinics (ART and non-ART) are from the Malawi Ministry of Health, HIV Unit. Data on locations of schools, major markets, and roads were obtained from the Malawi National Statistics Office. Population density is from the Afripop dataset (now a part of the WorldPop project), and is estimated using census data along with satellite imagery for mapping settlements.

Figure 2. : Trends in saving by distance to ART facility

(a) Total cash savings and distance to ART



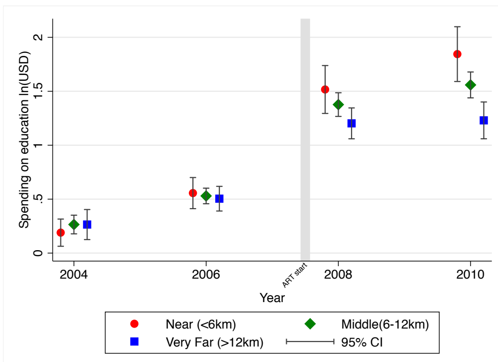
(b) Total cash savings trends by distance group



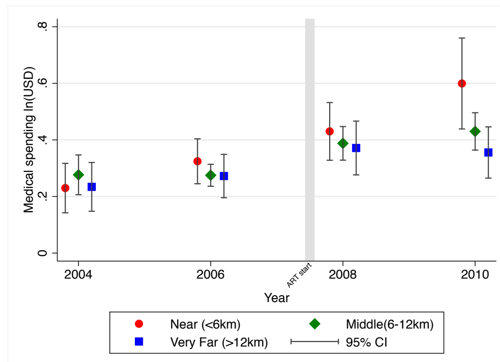
Notes: Figures show the variation in total cash savings (transformed using the inverse hyperbolic sine transformation) both as functions of ART proximity and time. Figure 1a shows the total savings as a function 2008 distance to ART using local linear regression for the three years that savings data were actually reported (2006, 2008 and 2010). For simplicity, a 95 percent confidence band was plotted only for year 2006. Figure 1b shows average total savings over time by splitting the sample into three groups: those near the ART facility (less than 6km away, by road), those in the middle group (6-12km away), and those far (more than 12km away). Note the groups are time invariant, but ART only became available on average 7 months before the 2008 survey wave. Thus, respondents in the near group are near the facility prior to 2008 but that facility does not provide ART. Figure 1b includes additionally "predicted" or imputed savings for years 1998, 2001, and 2004 (in shaded region) based on data on demographics, earnings, and assets available in those years. Due to slight differences in the distribution of respondents with respect to distance to ART by region, these averages have had region-by-year effects partialled out for both figures.

Figure 3. : Trends in human capital investment by distance to ART facility

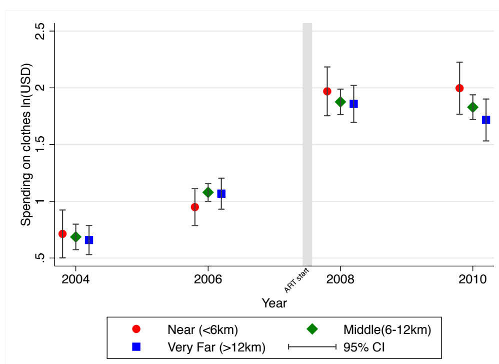
(a) Education expenditures for children



(b) Medical expenditures for children



(c) Clothing expenditures for children



Notes: Figures plot the average child expenditures (transformed by the inverse hyperbolic sine) over time using all 4 years of available data by splitting the sample into three groups: those near the ART facility (less than 6km away, by road), those in the middle group (6-12km away), and those far (more than 12km away). Note the groups are time invariant, but ART only became available on average 7 months before the 2008 survey wave. Thus, respondents in the near group are near the facility prior to 2008 but that facility does not provide ART. Due to slight differences in the distribution of respondents with respect to distance to ART by region, these averages have had region-by-year effects partialled out.

Table 1—: Pre-ART (2006) characteristics of the MLSFH study population

			Coefficient on ART Proximity: (w/o spatial controls)		(w/ spatial controls)	
	(1) Mean	(2) St.dev.	(3) β	(4) p-val	(5) β	(6) p-val
Panel A: Socioeconomic Characteristics (2006)						
Age	36.85	13.1	−0.46	0.46	0.04	0.97
Household size	5.46	2.3	−0.17	0.19	−0.12	0.61
Education (grades completed)	5.10	3.5	0.24	0.16	0.25	0.36
Labor income ln(USD)	4.00	1.6	−0.07	0.58	−0.10	0.62
Land (hectares)	1.59	1.5	−0.05	0.62	0.01	0.97
High discount rate	0.67	0.5	−0.02	0.56	−0.04	0.35
Wealth index (20 item)	0.11	2.0	0.20	0.13	0.15	0.57
Has metal roof	0.15	0.4	0.07	0.02**	0.11	0.04**
Has bicycle	0.58	0.5	0.04	0.27	0.00	0.99
Has radio	0.76	0.4	0.02	0.55	−0.01	0.76
Has mobile phone	0.04	0.2	0.02	0.25	0.04	0.02**
Panel B: HIV, Health, & Risk Perceptions (2006)						
HIV Positive	0.04	0.2	−0.01	0.30	0.01	0.75
Physical health score (PCS12)	52.50	7.2	−0.50	0.18	−0.84	0.29
Mental health score (MCS12)	55.57	8.0	−1.03	0.02**	−0.95	0.16
Know someone on ART	0.50	0.5	0.04	0.34	0.02	0.79
Worried about AIDS	0.27	0.4	0.03	0.12	0.02	0.54
Mortality risk (5 year; own)	3.87	2.3	0.46	0.01***	0.20	0.28
Perceived likelihood of HIV (Likert)	0.36	0.7	0.11	0.00***	0.04	0.44
Perceived HIV prevalence	0.28	0.2	0.01	0.18	0.02	0.17
Panel C: Savings & Expenditures on children (2006)						
Has savings	0.22	0.4	−0.03	0.27	−0.04	0.32
Total savings ln(USD)	0.92	1.9	0.01	0.91	−0.19	0.28
Education ln(USD/child)	0.54	0.9	−0.01	0.90	−0.03	0.75
Clothing ln(USD/child)	1.06	1.0	−0.00	1.00	0.02	0.83
Medical ln(USD/child)	0.28	0.5	0.02	0.39	0.04	0.43
Panel D: Child outcomes & characteristics (2006)						
Child age	10.0	2.8	0.34	0.15	0.38	0.48
Grades completed	2.7	2.0	0.27	0.21	0.08	0.88
Panel E: Spatial Characteristics						
Distance to ART in 2006 (km)	26.4	4.9	4.02	0.00***		
Distance to ART in 2008 (km)	9.1	3.6	−6.84	0.00***		
Distance to clinic (km)	6.1	3.1	−3.48	0.00***		
Distance to major market (km)	5.3	3.8	−3.72	0.00***		
Distance to major road (km)	5.0	3.5	−1.78	0.00***		
Distance to school (km)	1.7	1.0	−0.09	0.58		
Population Density (pers/km^2)	101	56	−16.0	0.04**		
Joint test Panels A-C (p-value)	–	–	0.07		0.46	

$N = 1379$. For child sample (Panel D), $N = 525$. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Note: This table describes characteristics of respondents and their children in 2006, before ART became available. Columns (3) and (5) report the coefficient on ART proximity (parameterized as the negative log distance) from regressing each variable in 2006 on ART proximity, with respective p-values in columns (4) and (6). Column (3) only controls for region dummies, while column (5) controls for region-specific spatial characteristics listed in Panel E below distance to ART in 2008 (described in detail in the text). The sample of survey respondents is restricted to those who were interviewed in all three years for the main analysis (2006, 2008, and 2010). Panel D describes characteristics of the respondents' children and is restricted to children who were reported in the household roster for all three years.

Table 2—: Pre-ART Trends: Changes between 2004–2006

			Coefficient on ART Proximity: (w/o spatial controls)		(w/ spatial controls)	
	(1) Mean	(2) St.dev.	(3) β	(4) p-val	(5) β	(6) p-val
Panel A: Demographic and Economic Characteristics						
Household size	−0.42	2.4	−0.34	0.01**	−0.46	0.09*
Land (hectares)	0.41	1.6	0.09	0.58	0.20	0.33
High discount rate	0.20	0.6	−0.02	0.66	0.05	0.36
Wealth index (20 item)	0.04	1.2	−0.07	0.31	−0.09	0.50
Has metal roof	0.01	0.3	0.01	0.54	0.03	0.14
Has bicycle	0.04	0.5	−0.02	0.43	−0.03	0.47
Has radio	0.02	0.5	−0.03	0.29	−0.05	0.35
Has mobile phone	0.03	0.2	0.02	0.14	0.04	0.03**
Panel B: HIV, Health, and Risk Perceptions						
HIV Positive	0.01	0.1	0.00	0.59	−0.01	0.05*
Know someone on ART	−0.18	0.4	0.02	0.58	−0.02	0.75
Worried about AIDS	−0.27	0.5	0.06	0.04**	0.07	0.27
Perceived likelihood of HIV (Likert)	−0.25	1.1	0.10	0.16	−0.04	0.72
Perceived HIV prevalence	−0.12	0.3	0.01	0.61	−0.04	0.24
Panel C: Expenditures on Children						
Education ln(USD/child)	0.13	0.8	0.17	0.11	0.11	0.52
Clothing ln(USD/child)	0.23	1.2	−0.04	0.78	0.15	0.41
Medical ln(USD/child)	−0.01	0.6	0.06	0.31	0.14	0.14
Joint test Panels A-C (p-value)	–	–	0.16		0.42	

$N = 1354$ * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Note: This table shows the mean changes between 2004 and 2006 (i.e., the period before ART came online in the MLSFH study regions) in available outcomes and characteristics of the sample. Columns (3) and (5) report the coefficient on ART proximity (parameterized as the negative log distance) from regressing each variable in 2006 on ART proximity, with respective p-values in columns (4) and (6). Column (3) only controls for region dummies, while column (5) controls for region-specific spatial characteristics (as described in the text).

Table 3—: ART Availability and Saving Behavior

	Any Savings				ln(Savings)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2010 × ART Proximity	0.10***	0.14***	0.13***	0.12**	0.53***	0.91***	0.84***	0.72***
	(0.04)	(0.04)	(0.05)	(0.05)	(0.14)	(0.21)	(0.22)	(0.23)
2008 × ART Proximity	0.07*	0.11**	0.14***	0.13***	0.32*	0.69***	0.78***	0.73***
	(0.04)	(0.05)	(0.05)	(0.05)	(0.19)	(0.25)	(0.24)	(0.24)
Mean dep. var	0.32	0.32	0.32	0.32	1.55	1.55	1.54	1.54
Observations	3989	3989	3575	3473	3984	3984	3570	3470
Within R^2	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.15
Spatial controls	–	Y	Y	Y	–	Y	Y	Y
Demo. controls	–	–	Y	Y	–	–	Y	Y
Shocks & aid programs	–	–	–	Y	–	–	–	Y
Individual FEs	Y	Y	Y	Y	Y	Y	Y	Y
Region × Year FEs	Y	Y	Y	Y	Y	Y	Y	Y

* $p < .10$, ** $p < .05$, *** $p < .01$

Note: Standard errors (in parentheses) are clustered by village (113 clusters) and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects and region-by-year dummies. The sample is restricted to individuals who were interviewed in all three years of the survey (2006, 2008, and 2010). Spatial controls include population density and proximity to clinic, market, major road and school (all interacted with region and $Post_t$). Demographic controls include pre-period wealth, roof material, if the respondent has a mobile phone, age, household size, gender, education, HIV status, and marital status (all interacted with $Post_t$). Mean reversion controls, included in the demographic controls, include 2006 levels of self-reported 10-year mortality risk and HIV risk interacted with time. Controls for economic shocks and other aid programs are described in detail in the text.

Table 4—: ART Availability and Expenditures on Children

	Education				Medical				Clothing			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
2010 × ART Proximity	0.37***	0.40***	0.32**	0.43**	0.15*	0.14	0.03	0.13	0.08	0.07	0.10	0.24
	(0.12)	(0.16)	(0.15)	(0.19)	(0.08)	(0.10)	(0.10)	(0.11)	(0.13)	(0.14)	(0.14)	(0.20)
2008 × ART Proximity	0.05	0.10	−0.03	0.08	0.09	0.08	0.02	0.13	−0.00	−0.03	−0.11	0.03
	(0.11)	(0.16)	(0.17)	(0.21)	(0.07)	(0.10)	(0.10)	(0.10)	(0.14)	(0.19)	(0.18)	(0.18)
2006 × ART Proximity				0.14				0.14*				0.18
				(0.14)				(0.08)				(0.18)
Mean dep. var	1.01	1.01	1.01	1.01	0.35	0.35	0.36	0.36	1.45	1.45	1.46	1.46
Observations	2833	2833	2543	2543	2890	2890	2596	2596	2889	2889	2595	2595
Within R^2	0.27	0.28	0.29	0.30	0.04	0.05	0.08	0.08	0.22	0.24	0.26	0.26
Spatial controls	–	Y	Y	Y	–	Y	Y	Y	–	Y	Y	Y
Demo. controls	–	–	Y	Y	–	–	Y	Y	–	–	Y	Y
Shocks & aid programs	–	–	Y	Y	–	–	Y	Y	–	–	Y	Y
Individual FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Region × Year FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

* $p < .10$, ** $p < .05$, *** $p < .01$

Note: Standard errors (in parentheses) are clustered by village (109 clusters) and robust to heteroskedasticity. All expenditures variables are transformed using the inverse hyperbolic sine. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects, region-by-year dummies, and month of interview controls. The sample is restricted to respondents with school-age children and regressions are weighted by inverse of number of household respondents. All regressions use data from 2004. Spatial controls include population density and proximity to clinic, market, major road and school (all interacted with region and $Post_t$). Demographic controls include pre-period wealth, roof material, if the respondent has a mobile phone, age, household size, gender, education, HIV status, and marital status (all interacted with $Post_t$). Mean reversion controls, included in the demographic controls, include 2006 levels of self-reported 10-year mortality risk and HIV risk interacted with time. Controls for economic shocks and other aid programs are described in detail in the text.

Table 5—: ART Availability, Income, and Other Expenditures

	Expenditures				Farm Inputs				Income and Wealth		
	(1) Clothing (Own)	(2) Medical (Own)	(3) Medical (Others)	(4) Funeral	(5) Seed	(6) Farm Equipt	(7) Fertilizer	(8) Hired Labor	(9) Total Expend.	(10) Labor Earnings	(11) Wealth Index
2010 × ART Proximity	−0.06	0.02	−0.00	−0.01	−0.05	−0.07	−0.29*	−0.13	−0.34**	−0.05	−0.21
	(0.17)	(0.13)	(0.08)	(0.08)	(0.09)	(0.10)	(0.17)	(0.13)	(0.15)	(0.18)	(0.14)
2008 × ART Proximity	−0.22	−0.08	−0.10	0.01	−0.01	−0.01	0.13	0.09	−0.20	−0.31	−0.23*
	(0.19)	(0.11)	(0.09)	(0.10)	(0.07)	(0.09)	(0.19)	(0.15)	(0.17)	(0.20)	(0.13)
2006 × ART Proximity	−0.02	0.04		0.01	0.07	0.07	0.31***	0.14			−0.16**
	(0.13)	(0.09)		(0.05)	(0.05)	(0.05)	(0.09)	(0.10)			(0.08)
Mean dep. var	1.93	0.66	0.29	0.58	0.30	0.34	0.61	0.78	3.29	4.92	0.13
Observations	5310	5307	3971	5267	5270	5268	5263	5272	3932	3994	4907
Within R^2	0.17	0.09	0.01	0.09	0.07	0.05	0.08	0.09	0.13	0.35	0.03
Individual FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Region × Year FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Spatial controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

* $p < .10$, ** $p < .05$, *** $p < .01$

Note: Standard errors (in parentheses) are clustered by village (113 clusters) and robust to heteroskedasticity. Household level regressions (3-11) are inverse weighted by the number of respondents from that household. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects, region-by-year dummies, and month of interview controls. Spatial controls include population density and proximity to clinic, market, major road and school (all interacted with region and $Post_t$). The sample is restricted to individuals who were interviewed in all three years of the survey (2006, 2008, and 2010). Estimates for columns 1,2, 4-8, and 11 also use data from 2004. Total expenditures, Column 9, is the sum of expenditures in columns 1-8. All expenditures and earnings variables, columns 1-10, are transformed using the inverse hyperbolic sine. The dependent variable in column 11 is a total wealth index (roughly mean 0, standard deviated 2) calculated using PCA incorporating all assets, housing and roofing structure, and animals.

Table 6—: ART Availability and Investment – HIV Mortality, Caretaking, and Orphans

	Saving Behavior		Expenditures on Children		
	(1) Any Savings	(2) ln(Savings)	(3) Education	(4) Medical	(5) Clothing
Panel A: Aggregate Effect of ART					
2010 × ART Proximity	0.14***	0.91***	0.40***	0.14	0.07
	(0.04)	(0.21)	(0.16)	(0.10)	(0.14)
2008 × ART Proximity	0.11**	0.69***	0.10	0.08	−0.03
	(0.05)	(0.25)	(0.16)	(0.10)	(0.19)
Panel B: HIV-negative					
2010 × ART Proximity	0.18***	1.09***	0.28	0.08	0.08
	(0.04)	(0.20)	(0.17)	(0.10)	(0.14)
2008 × ART Proximity	0.13***	0.81***	0.03	−0.00	−0.11
	(0.05)	(0.27)	(0.18)	(0.09)	(0.19)
Panel C: No family illness					
2010 × ART Proximity	0.14***	0.89***	0.37**	0.11	0.07
	(0.04)	(0.21)	(0.17)	(0.11)	(0.15)
2008 × ART Proximity	0.10**	0.66***	0.10	0.03	−0.03
	(0.05)	(0.25)	(0.17)	(0.09)	(0.19)
Panel D: No recent death					
2010 × ART Proximity	0.17***	0.97***	0.37**	0.19	0.04
	(0.05)	(0.23)	(0.17)	(0.13)	(0.17)
2008 × ART Proximity	0.12**	0.70**	0.05	−0.02	−0.11
	(0.05)	(0.28)	(0.14)	(0.09)	(0.19)
Panel E: No orphans					
2010 × ART Proximity	0.16***	0.98***	0.37**	0.25**	0.06
	(0.05)	(0.26)	(0.18)	(0.12)	(0.20)
2008 × ART Proximity	0.12**	0.68***	0.18	0.22	0.12
	(0.06)	(0.26)	(0.18)	(0.15)	(0.25)
Observations	3989	3984	2833	2890	2889
Individual FEs	Y	Y	Y	Y	Y
Region × Year FEs	Y	Y	Y	Y	Y
Spatial controls	Y	Y	Y	Y	Y

* $p < .10$, ** $p < .05$, *** $p < .01$

Note: Standard errors (in parentheses) are clustered by village (columns 1 and 2 have 113 clusters, columns 3-5 have 109 clusters) and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects, region-by-year dummies, and month of interview controls. Spatial controls include population density and proximity to clinic, market, major road and school (all interacted with region and $Post_t$). The sample is restricted to individuals who were interviewed in all three years of the survey (2006, 2008, and 2010). Regressions reported in columns 3-5 are restricted to respondents with school-age children and weighted by inverse of number of household respondents. Columns 3-5 also use data from 2004. Outcomes in columns 2-5 are transformed using the inverse hyperbolic sine. Panel A reproduces the aggregate effects of ART from Tables 3 and 4. Panels B-F each represent separate estimations of heterogeneous treatment effects, estimated by interacting the group variable with $Year_t \times ARTProx_i$, while controlling for group-specific trends. In Panel B, the group dummy is equal to 1 if the respondent is ever HIV+ or status is unknown, and thus the reported coefficients are interpreted as the effect of ART proximity for HIV– respondents (while the coefficients on HIV+×Year×ART are suppressed to save space).

Table 7—: ART Availability and Subjective Mortality Expectations

	Mortality Risk Index				
	(1)	(2)	(3)	(4)	(5)
2010 × ART Proximity	−0.16*	−0.24**	−0.24***	−0.18	−0.19*
	(0.09)	(0.11)	(0.09)	(0.11)	(0.10)
2008 × ART Proximity	0.01	−0.06	−0.04	0.19*	−0.01
	(0.11)	(0.12)	(0.09)	(0.11)	(0.11)
Female × 2010 × ART Prox				−0.12	
				(0.12)	
Female × 2008 × ART Prox				−0.38***	
				(0.10)	
Age<25 × 2010 × ART Prox.					−0.19*
					(0.11)
Age<25 × 2008 × ART Prox.					−0.07
					(0.15)
HIV+ × 2010 × ART Prox.					
HIV+ × 2008 × ART Prox.					
High Risk × 2010 × ART Prox					
High Risk × 2008 × ART Prox					
Mean dep. var	−0.00	0.01	0.01	0.01	0.01
Observations	3699	3475	3258	3258	3258
Within R^2	0.07	0.10	0.23	0.23	0.23
Individual FEs	Y	Y	Y	Y	Y
Region × Year FEs	Y	Y	Y	Y	Y
Spatial controls	Y	Y	Y	Y	Y
Demo., shocks & aid	–	Y	Y	Y	Y
Mean reversion	–	–	Y	Y	Y

* $p < .10$, ** $p < .05$, *** $p < .01$

Note: Standard errors (in parentheses) are clustered by village (113 clusters) and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects, region-by-year dummies, and month of interview controls. The sample is restricted to individuals who were interviewed in all three years of the survey (2006, 2008, and 2010), and excludes individuals who ever tested positive for HIV . Spatial controls include population density and proximity to clinic, market, major road and school (all interacted with region and $Post_t$). Demographic controls include pre-period wealth, roof material, if the respondent has a mobile phone, age, household size, gender, education, HIV status, and marital status (all interacted with $Post_t$). Controls for economic shocks and other aid programs are described in detail in the text. Mean reversion controls include 2006 levels of self-reported 10-year mortality risk and HIV risk interacted with time. The mortality index is constructed as a factor score of 12 variables: mortality risk for hypothetical individuals (healthy, HIV+, on ART) and self, all across 3 time horizons (1,5, and 10-years), and is mean 0 standard deviation 1.

Table 8—: ART Availability and Children's Grade Attainment

	All children				Older cohort	
	(1)	(2)	(3)	(4)	(5)	(6)
2010 × ART Proximity	0.33***	0.36*	0.24*	0.28	0.25*	0.18
	(0.12)	(0.22)	(0.13)	(0.22)	(0.14)	(0.22)
2008 × ART Proximity	0.09	0.15	0.09	0.17	0.10	0.08
	(0.09)	(0.20)	(0.11)	(0.21)	(0.11)	(0.21)
Girl × 2010 × ART Proximity			0.27	0.28	0.38*	0.41*
			(0.21)	(0.20)	(0.22)	(0.21)
Girl × 2008 × ART Proximity			−0.03	−0.04	0.00	0.01
			(0.15)	(0.14)	(0.16)	(0.15)
Mean dep. var	3.70	3.72	3.70	3.72	3.94	3.96
Observations	1521	1512	1521	1512	1368	1359
Within R^2	0.69	0.71	0.69	0.71	0.69	0.72
Child FEs	Y	Y	Y	Y	Y	Y
Region × Year FEs	Y	Y	Y	Y	Y	Y
Spatial & Demo. controls	–	Y	–	Y	–	Y

* $p < .10$, ** $p < .05$, *** $p < .01$

Note: Standard errors (in parentheses) are clustered by village (96 clusters, except column 5-6 with 95) and robust to heteroskedasticity. The sample is restricted to children who were reported in all three years of the survey (2006, 2008, and 2010), and excludes children of HIV+ parents (18 children). Regressions are weighted by inverse of number of children per household. Columns 1-4 use the full sample of children aged 5-19, and columns 5-6 only includes children who were older than 12 years old by 2010. ART proximity is parameterized as the negative of log distance by road. All regressions include child fixed effects, region-by-year dummies, and month of interview controls. Spatial controls include population density and proximity to clinic, market, major road and school (all interacted with region and $Post_t$). Demographic controls include pre-period wealth, roof material, if the respondent has a mobile phone, age, household size, gender, education, and marital status (all interacted with $Post_t$).

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