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

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Abstract

Antiretroviral therapy (ART), a treatment that significantly delays the onset of AIDS, has recently become available throughout many African countries, rapidly reversing the downward trend in life expectancy due to AIDS. Economic theory predicts that a longer life expectancy increases the value of human capital investment. The effect of life expectancy on savings, however, is theoretically ambiguous and ultimately an empirical question. This paper uses spatial and temporal variation in ART availability in Malawi to evaluate the impact of ART provision on savings and human capital investment. We find that ART has large and significant impacts on savings behavior and child expenditures, particularly for schooling and medical expenses. Additionally, grade attainment and health improve for the sample of the respondents' children near ART. We show that the results are not driven by the direct effect of HIV-positive respondents receiving treatment or by caretaking effects from reducing morbidity and mortality of household members. Rather, the effects seem to be a consequence of broadly improving perceptions of life expectancy, as measured by self-reported mortality risk.

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1 Introduction

The relationship between life expectancy and investment has important implications for economic growth (Soares 2005; Weil 2007; Lorentzen, McMillan, and Wacziarg 2008). One way in which life expectancy may impact growth is through its effect on human capital investment. A longer life expectancy encourages human capital investment by increasing the time horizon over which the investment pays out (Ben-Porath 1967; Becker and Tomes 1979).[1] Additionally, changes in life expectancy are likely to affect savings decisions, which also play an important role in growth models (Solow 1956; Koopmans 1965; Romer 1986). Individuals may save more if they expect a longer retirement, but may, in fact, save less if they expect a longer and healthier working life (Bloom, Canning, and Graham 2003; Fogel 1994, 1997). Since the relationship between life expectancy and savings is theoretically ambiguous, it is ultimately an empirical question and one that few studies have explored.[2]

This paper uses the expansion of AIDS treatment in Malawi to study the impact of life expectancy on savings and investment in human capital. The AIDS epidemic has dramatically decreased life expectancy in sub-Saharan Africa. In southern Africa, the region hardest-hit by the epidemic, life expectancy has fallen by nearly 25 percent in the past 15 years (UN Population Division 2010). The recent widespread availability of antiretroviral therapy (ART), a drug treatment that drastically slows the progression of AIDS, is reversing the trend. 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 announced that ART would become available for free. The rapid scale-up of the ART program, widely regarded as a public health success, has already resulted in observable reductions in adult mortality (Jahn et al. 2008). In addition to the direct benefits for HIV-positive individuals, the availability of ART also increases life expectancy for those who are not currently infected.

The ART rollout in Malawi provides a good setting to study the effect of life expectancy on investment for a number of reasons. First, the life expectancy gains are large: UN-based estimates of life expectancy gains from eliminating AIDS mortality in Malawi are 12.7 years. Second, the shock to life expectancy

[1] We specifically focus on life expectancy gains from reducing adult mortality as distinct from infant mortality, since infant mortality does not impact investment decisions through this mechanism.

[2] A notable exception is Thornton (2012), which finds that learning one's HIV status had only short term effects on subjective beliefs about ones HIV status, and no apparent effects on savings, expenditures, and employment. However, because individuals who learn they are HIV-negative may still be worried about catching HIV in the future, the effects on life expectancy may be too small to detect changes in the economic outcomes. 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). Some studies have looked at the effect of HIV on savings in cross-country regressions, but no consensus has yet emerged (Bonnel 2000, Lammers, Meijdam, and Verbon 2007).

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.[3] Third, the data allow us to estimate these effects among the HIV-negative respondents and over a short time horizon, thereby minimizing concerns of estimating the direct effects of treatment, population shifts, and other general equilibrium effects unrelated to expectations. Last, the data contain information on self-reported mortality risk, allowing for 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 will provide a direct test of the theory (Manski 2004).

Using survey data on a panel of respondents, we estimate the impact of ART availability on savings, expenditures on children's human capital, and children's schooling and health. Our identification relies on spatial variation in ART availability as measured by the respondents' distance to the ART facility. Comparing outcomes before and after ART became available at the facility, we employ a difference-in-difference strategy with individual fixed effects. This identification strategy compares changes in investment outcomes of individuals near the ART facility to those living far.

We find a strong response in savings behavior: halving the distance between a respondent and the ART facility–a reduction of approximately 5 kilometers for the average respondent–results in an increase in the fraction of respondents with savings by 10 percentage points and an increase in total savings of US$20. The response in total savings is large, a nearly 100% increase over the pre-period average, but not infeasible since the change in savings represents 4% of the increase in earnings over this time period. Additionally, we find that ART availability increases investment in human capital. Reducing the distance by half increases expenditures on children's education by US$2.40 and children's medical spending by US$0.50. 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. Similarly, children's reported health improves near ART. The results are robust to including controls for spatial and demographic characteristics, reported economic shocks, and participation in other government aid programs.

The magnitudes are similar and remain significant among the HIV-negative respondents, indicating

[3] Oster, Shoulson, and Dorsey (2012) estimate the causal impact of limited life expectancy on human capital investment using genetic variation in the population of Huntington disease patients. The study provides a well identified estimate of the elasticity of demand for education with respect to years of life expectancy in the context of Huntington patients; however, the results may not extend easily to developing countries. Huntington disease patients may exhibit a larger elasticity because of the emphasis on the difference between their life expectancy and that of the population. Additionally, we may generally expect to find larger elasticities for sudden decreases in life expectancy due to the effects of stress, shock, and depression, whereas gradual improvement from the status quo may be less easily detected.

that the results are not driven by the direct effect of respondents receiving life-saving medication. We also consider some of the specific pathways through which ART availability affects investment outcomes. Mechanisms such as household caretaking burdens from AIDS related illness, death, and orphanhood, cannot explain our findings. However, we do find that ART availability measurably decreases self-reported mortality risk.[4] 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 half (a 5 kilometer reduction) increases subjective life expectancy by 4.2-6.8 years. Taken together, these findings suggest that individuals actively adjust their investment decisions in response to a subjective lengthening of their investment horizon.

Last, we calculate the marginal effect of life expectancy on schooling. The increases in educational attainment reported above reflect changes in life expectancy for both parents and children. Therefore, in order to isolate the effect of an additional year of a child's life expectancy, we exploit the differential change in life expectancy by gender. Higher HIV prevalence rates and younger ages of infection imply that women gain 3.3 more years in life expectancy from eliminating AIDS mortality than men (UN-based estimates). In a triple-difference approach, we estimate the additional gain in schooling by gender. The results imply that an additional year of life expectancy increases schooling by 0.1 years.

Our human capital results add to a growing literature on the impacts of life expectancy on human capital (Jayachandran and Lleras-Muney 2009; Fortson 2011; Oster 2012). Our findings are consistent with that literature. Furthermore, the observed changes in subjective life expectancy allow us to be more confident in the mechanisms driving the results.[5]

Our savings results provide another channel through which life expectancy may impact growth. 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, in fact, higher life expectancy does prompt more savings. The impact of life expectancy on growth is therefore greater,

[4] Baranov, Bennett, and Kohler (2012) explore the effect of ART on perceived risk in detail.

[5] Economists rarely measure subjective expectations and must rely on actual population shifts in adult mortality to identify the effect. For example, Jayachandran and Lleras-Muney (2009) find that the reduction in maternal mortality in Sri Lanka during the mid-20th century substantially improved female education outcomes. Fortson (2011) exploits geographic and time variation in HIV prevalence in Sub-Saharan Africa to estimate the effect of the HIV/AIDS epidemic on human capital investment. While these studies provide evidence in support of the standard model of human capital accumulation, neither provide direct evidence of the mechanism. Moreover, empirical strategies in macro-based studies over long time horizons must rely on changes in life expectancy that affect population dynamics and are likely to influence decisions in ways that are not related to changes in expectations (Santaeulalia-Llopis 2008). For example, one important consequence of changes in mortality is the immediate effect on family structure. After a death of an adult, the dependency ratio in that household increases.

even, than would be suggested by the human capital channel alone.

Our approach is unable to entirely rule out other general equilibrium effects of ART that may impact investment. The effects of changes in risky sexual behavior, fertility, wages, and demand are likely to take time to become apparent in this setting. The very short time frame during which we observe the response to ART mitigates concern over some of the long-run effects of ART. For example, we find that the fraction of respondents with positive savings increases in a matter of months after ART becomes available. Another limitation to our approach is that ART availability may improve mental health and productivity (Baranov, Bennett, and Kohler 2012). We show that other expenditures do not increase as a result of ART, implying that our findings are not a result of an income shock. However, we cannot rule out that some of the investment response may be due, in part, to improvements in mental health.

The rest of the paper is organized as follows. Section 2 provides a brief summary of the theoretical predictions relevant for our analysis. Section 3 describes the background of the ART rollout in Malawi, and Section 4 describes the data and presents the empirical strategy. Section 5 discusses the main results, and Section 6 considers alternative mechanisms that may be responsible for the main findings. Section 7 discusses the magnitudes of the responses and calculates the implied effect of life expectancy on schooling. Finally, Section 8 concludes.

2 Theoretical Predictions

This section briefly describes the theoretical predictions of increasing life expectancy on investment.[6] First, we consider the effect on savings. We discuss three possible motivations for savings: retirement savings, precautionary savings, and savings for investment in a credit constrained environment. In the life-cycle model of consumption, savings increase in response to a positive life expectancy shock if the agent faces a declining income trajectory (a simple model showing these results is presented in Appendix A.1). Reducing AIDS mortality means individuals are more likely to live into old age, increasing motivation to save (Bloom, Canning, and Graham 2003; Freire 2004; Lee, Mason, and Miller 2000; Zhang and Zhang 2005). On the other hand, reducing AIDS mortality may lengthen the working life, reducing the need to save (Fogel 1994, 1997).

Few studies have looked at the effect of life expectancy on savings. However, the effect of reducing AIDS mortality on saving behavior is theoretically ambiguous. On one hand, reducing AIDS mortality

[6] In addition to investment, life expectancy may also play a role in decisions about fertility (Fortson 2009; Shapira 2010), risky sexual behavior (Lakdawalla, Sood, and Goldman 2006; Wilson, Xiong, and Mattson 2011; De Walque, Kazianga, and Over 2010; Oster 2012; Friedman 2012), and labor supply (McLaren 2010).

means individuals are more likely to live into old age, increasing motivation to save (Bloom, Canning, and Graham 2003; Freire 2004; Lee, Mason, and Miller 2000; Zhang and Zhang 2005). Additionally, gains in life expectancy raise the rate of return for other long-term investments and, in a credit constrained environment, increase demand for savings. Since the net effect on savings is theoretically ambiguous, the question is ultimately an empirical one.

While the life-cycle model is of great theoretical interest, it may not the most relevant one in the context of rural Malawi.[7] A more likely motivation for savings, particularly in developing countries, is precautionary savings.[8] One possibility is that if individuals were saving to insure themselves against an AIDS-related shock, then precautionary savings may decrease when ART becomes available. For example, individuals may hold savings in anticipation of future illness, funeral costs, or bequests (Van de Kuilen and Lammers 2007; Freire 2004). On the other hand, individuals may be more likely to save if those savings were to go toward procuring ART. While the medication itself is free, there are additional costs of food and care during the time the patient recovers once they start treatment.[9] It is possible that the marginal dollar saved would have a higher rate of return in the case when ART is available than when it is not.[10]

A third consideration for savings is that in a credit constrained environment individuals need to build up savings for investment purposes. This motivation is particularly relevant in light of the impact of life expectancy on long-term investment. Since long-term investments become more attractive when longevity rises, individuals with credit constraints 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. However, the theoretical predictions for the effect of life expectancy on human capital investment are more straightforward and have been developed elsewhere (Ben-Porath 1967; Jayachandran and Lleras-Muney 2009). Since ART increases life expectancy for adults and children, we must consider an additional margin. A simple model outlining the results is presented in Appendix A.2, but the predications and intuition are as follows. 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 not affected. However, the parents are now more likely to live into old age and reap the benefits of their investment, namely the children's resources. In a sense, investment in children

[7] We should note that we only consider cash savings in the empirical analysis, which, given what we know about saving in developing countries, may not be the relevant saving method for old age.

[8] In general, it is not clear that an increase in life expectancy should have an effect on precautionary savings.

[9] This is especially true in Malawi, since ART is initiated only once the patient presents with clinical symptoms.

[10] Certainly this seems like a plausible motivation to save if the individual is not saving to begin with, which is the case for 80 percent of the respondents.

is a form of saving for retirement.[11] If, in addition, children are also expected to live longer, the rate of return to education from the perspective of the child has also increased. This channel is the central motivation in Jayachandran and Lleras-Muney (2009), Fortson (2011), and Oster (2012). 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. We will first consider the combined effect of ART on investment in human capital, then try to isolate the effect of increasing life expectancy for children on years of schooling using differential life expectancy gains by gender.

3 Context

A small, landlocked nation in Southeastern Africa, Malawi is one of the countries hit hardest by the AIDS epidemic, with nearly one million people currently living with HIV/AIDS. HIV prevalence peaked at 14.7 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). Although Malawi has had a relatively peaceful transition since gaining its independence from Britain in 1964, it has remained one of the world's poorest countries with a GDP per capita of $340 (PPP adjusted $918). Malawi's population, 15.4 million, is over 80 percent rural and supports itself primarily through subsistence agriculture. 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. Few people own cars or motorcycles, and fuel prices are very high.[12]

Life expectancy at birth in Malawi is 54 years. HIV/AIDS is a leading public health issue, and AIDS is the main cause of adult mortality (AVERT 2012). 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 in part by the Global Fund to Fight AIDS, Tuberculosis, and Malaria, 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. Other notable features of the rollout include its systematic and well-monitored expansion, the use of existing

[11] One might argue that children are not particularly good investments for retirement and that this effect is small. We consider this possibility, nevertheless.

[12] The most common modes of transportation are walking, biking, hiring a bike taxi, and hitchhiking. Hitchhiking, however, is still costly and can take a very long time as passing cars are scarce.

clinics and hospitals as the primary mode of expansion, and a short time frame between when clinics were selected to provide ART and when they actually began providing the medication.

The Ministry of Health began providing free ART in June of 2004. At this time, only nine clinics in Malawi were providing ART. 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.[13] The rollout occurred in two stages: Round 1 (2004-2005) 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 outlined a 5-year plan to continue expanding its ART program with the goal of attaining 100% coverage of those in need by 2010. To that end, the MOH aimed to maximize geographical coverage and relaxed the standards for facilities, considering all clinics with at least one clinician and one data clerk. 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. (Appendix Table A.1 summarizes characteristics of clinics by ART status and Table A.2 summarizes characteristics by when ART became available in the clinic.)

The guidelines for 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.[14] 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. 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, to travel long distances to receive treatment.

The educational attainment in Malawi is low, even by developing country standards. The mean years of schooling is 4.2 for adults over 25; and net secondary school enrollment, at 24%, is very low (WDI 2010). Primary education goes up to grade eight and is not compulsory. The official starting age is six years old; however, it is not uncommon for children to start considerably later. The government established free primary education in 1994, which increased attendance rate by approximately 50% (Kadzamira and Rose 2003). However, families are still responsible for uniforms and school supplies[15] and must consider the

[13]By June 30, 2010, there were 396 clinics (290 static and 106 outreach) in the public and private sector that had registered a total of 359,771 patients on ART. 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–less than 4% of patients were ever initiated on ART through the private sector (MOH 2011 Quarterly Report).

[14]Recently, the WHO revised the recommendation to include individuals with higher CD4 counts, substantially expanding the set of eligible patients. The MOH released new guidelines in 2011 that reflected the WHO revisions; however, this change is not pertinent to our analysis.

[15]While requiring uniforms is against the law, many schools turn students away without them.

opportunity cost of enrollment as children often participate in wage labor or help with household chores. In 1999, the ILO estimated that 32.2 percent of children between the ages of 10 and 14 in Malawi were working. 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).

4 Estimation

4.1 Data

This paper uses data from the Malawi Longitudinal Study of Families and Health (MLSFH), which is an ongoing panel survey that has been conducted since 1998.[16] The MLSFH collected GPS coordinates for sampled households and performed HIV testing in 2004, 2006, and 2008.[17] The survey is conducted in three distinctive districts of Malawi: Rumphi in the north, Mchinji in the center, and Balaka in the south.[18] The three districts are different along many characteristics and are not equally represented in the survey. The sample is entirely rural and not necessarily meant to be nationally representative, although key characteristics are similar to those found in the Demographic and Health Survey (DHS). Attrition in the MLSFH is high: approximately 25 percent of the 2006 sample is lost to follow-up by the 2010 survey. However, attrition is not correlated with ART proximity (see Anglewicz, Adams, Obare, Kohler, and Watkins, 2009, for a summary of the data and attrition).

We use distance to the nearest ART facility as the source of identifying variation. Using 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 calculate the distance to a nearest facility by road (Figure 2 shows the distribution of distances).[19] We also calculate the distance to the nearest clinic (regardless of ART status), market, school, and major road. These variables serve as important controls, as distance to one location is correlated with other spatial features that may

[16]This survey has also been referred to as the Malawi Diffusional and Ideational Change Project (MDICP) in the past.

[17]A subsample of the respondents was also tested in 2012.

[18]Ethnic groups within Malawi vary widely. The Rumphi district is inhabited primarily by Tumbuka and is predominantly Protestant. The region generally follows the patrilineal system of kinship and lineage, where residence is ideally patrilocal, inheritance is traced through sons, and parents of the groom pay a brideprice to the parents of his bride. In contrast, the Balaka region is primarily Muslim, inhabited by Yao, and follows a matrilineal system of kinship. Residence is ideally matrilocal, though it is not uncommon for wives to live at least some period of time in their husband's village. The Mchinji region, inhabited by Chewa, is roughly an equal mix of Protestants and Catholics. It follows a less rigid matrilineal system whereby residence may be matrilocal or patrilocal depending on the fulfillment of certain payments.

[19]Data on road networks were provided by the National Statistics Office of Malawi. The results are robust to using straight-line distance (not shown).

pose a threat to identification. Figure 1 shows a map of these features and the spatial distribution of sampled households in the Mchinji district. The ART facilities are generally located just outside the surveyed regions, which mitigates some concerns that the placement of the clinics was related to the characteristics of the respondents. The distribution of respondents from the facilities is not uniform and differs by region. Thus, when dividing the sample by a fixed cutoff distance to ART, the regions are not equally represented within the cutoff. To ensure we capture the relevant variation over time, we include region-by-year controls throughout the analysis.

ART became available at clinics within the sampled regions shortly before the 2008 survey (respondents were exposed to ART for an average of 7 months in the 2008 round). Before 2007, the nearest ART facility for most respondents was more than 25 kilometers away (the median distance was 27 kilometers).[20] After 2008, the median distance to the nearest ART facility was 8.9 kilometers. The main analysis uses the rounds from 2004, 2006, 2008, and 2010; however, some of the outcome variables were not available in the 2004 round. The data from the 2004 round allow us to look for differential pre-treatment trends for variables that are available in all four rounds.

Table 1 provides summary statistics of the data being used from the pre-treatment year 2006. The sample is divided according to the median distance to the ART facility in 2008. Panel A describes the basic characteristics of the sample. Panel B summarizes the outcomes of interest for our analysis. Respondents were asked to report the total amount of money they have in savings (such as a bank account, savings group, or cash). Additionally, they were asked about the total household expenditures in the past three months on their children's education, medical services, and clothing. Panel C of Table 1 shows summary statistics for the sample of children of the respondents who are linked over time using the data from the household rosters. The outcomes for children used in our analysis are grade completion and health score (based on a subjective health score reported by the parent). Panel D reports means of spatial characteristics.

In addition to the standard battery of questions in a household survey, the MLSFH includes a module on subjective expectations, which elicits respondents' beliefs about probabilities using the bean method (Delavande and Kohler 2009). Individuals are asked to choose the number of beans (0 to 10) that reflects the probability of an event occurring. Among other things, respondents were asked to assess their own mortality risk over a 1, 5, and 10-year horizon, their perceived HIV status, and their perceived HIV

[20]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 (the distance to the nearest ART facility changed for only 30 respondents 2010). Figure B.2 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.

prevalence (Table 1, Panel A contains the means for the respondents' own 5-year mortality risk). The effect of ART availability on subjective perceptions of risk is demonstrated in Baranov, Bennett, and Kohler (2012). These results allow us to explicitly link changes in investment behavior to measured changes in subjective expectations. We use the 5-year subjective mortality risk to calculate the implied effect of ART on subjective life expectancy.

4.2 Empirical Strategy

We estimate the effect of ART availability on savings, child expenditures, and child health 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 information. The main regression analysis is based on the following specification:

$$y_{ijrt} = \beta Post_t \times Proximity_{ijr} + \alpha_{ijr} + \delta_{rt} + \varepsilon_{ijrt} \tag{4.1}$$

where y_{ijrt} is the outcome for respondent i in village j, and region r, and time period t. $Post_t$ is an indicator for years 2008 and 2010 of the survey, after ART became available.[21] $Proximity_{ijr}$ is the proximity to the nearest ART facility in 2008 and is time-invariant. We parametrize ART proximity as the negative of log-distance. This 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. The results are robust to other specifications of functional forms on distance, and we also explore nonparametric regressions (see Figure B.4). The baseline specification also includes individual level fixed effects, α_{ijr}, which absorb the time invariant proximity variable, and district-year fixed effects, δ_{rt}, which absorb the indicator for the post period.[22] Standard errors are clustered by village and are robust to heteroskedasticity.

In the above specification, the effect of ART is estimated through the differential change in outcomes along the distance gradient. Distance serves a proxy for access to ART. It determines the time and monetary cost of getting treatment.[23] While we do not have ART uptake over time, we collected data on

[21] In the specifications that follow, we allow for separate indicators for 2008 and 2010, that is, for each "post" year.

[22] As mentioned earlier, district-year fixed effects are important in our setting because the distributions of ART proximity vary substantially by district (see Appendix Figure B.1). These effects are particularly important when we categorize respondents by distance group (as in Figures 3-6), as the district share is not constant across the three distance groups. For this reason, we report these figures after de-trending by district-year (and adding back the year effects) so as to not attribute district trends to the distance group trends. The sample generally reflects only a fraction of the ART facility's catchment population, so there is little reason to believe that there is a relationship between the choice of the facility and the specific characteristics of the distribution of our sample.

[23] For example, in 2004, as part of an experiment used in Thornton (2008), participants of the MLSFH were offered

ART uptake among the subsample of respondents interviewed in 2012.[24] Of the HIV-positive respondents, we find that individuals on ART are 3.5 kilometers closer to an ART facility than those not on ART ($p = 0.07$, $n = 23$). This finding is a small validation in using distance as a proxy of access to ART. Additionally, distance is important in that it facilitates the spread of information about ART availability at a particular clinic.[25] This second aspect may be more important for individuals who are HIV-negative as they are less likely to actively seek information about treatment options.

The primary threat to identification is that distance to ART is 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. We first seek evidence of such differences by looking for differences in observable characteristics in the pre-treatment period. Table 1, Panel A shows that individuals near ART do not appear to be systematically different based on characteristics, such as education and wealth, from people who live far in levels before ART comes online.[26] Other small differences between groups are observed: respondents near ART are more likely to have a metal roof and slightly more in savings, but less land (although some of these differences are driven by regional composition). In order to control for initial differences, we include demographic characteristics interacted with $Post_t$ to account for compositional differences by ART proximity, and allow for differential trends among these demographic groups.[27]

We then look for differential trends by checking for pre-treatment trends by distance to ART. Table 2 examines the pre-treatment trends for variables that are available in 2004: Panel A reports pre-trends for the outcomes on expenditures on children and Panel B reports these trends for other characteristics. The table shows no evidence of differential pre-trends by near and far groups.[28]

monetary incentives to obtain their HIV test results at temporary Voluntary Counseling and Testing centers (VCTs). The location of the VCTs was randomized based on the straight-line distance from respondents' households. Voucher amounts, randomized by letting each respondent draw a token out of a bag indicating the monetary amount, were redeemable two to four months after sample collection. Thornton (2008) 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.

[24]This sample included individuals over 45 years old, approximately 1000 respondents.

[25]Using data from India, Oster and Millet (2011) demonstrate that distance to a call center is an important factor in the spread of information about requirements to obtain employment. Notably, they find that the spread of information is highly localized: their findings suggest the information did not spread to individuals living more than 5-6 kilometers away from the centers.

[26]Although the table reports that HIV prevalence is lower by 2 percentage points near ART, this is entirely due to regional composition differences.

[27]Demographic controls included in the regressions are pre-period wealth, age, gender, education, and marital status. Additionally, we control for population density (interacted with $Post_t$) and visit month.

[28]We also calculated correlations between ART proximity (parametrized as in the main regression analysis) and the pre-treatment levels and pre-treatment trends (see Tables B.3 and B.4). In addition to using the full variation in ART proximity, we remove region-specific effects (so as not to pick up regional differences). These correlations also indicate no differential

Another potential threat to identification is that areas near ART facilities may have different unobserved shocks due to their spatial proximity to landmarks that may also impact individual outcomes. That is, respondents near health facilities may become more optimistic over time because they have easier access to healthcare, or respondents near the major roads or trading centers may earn more because they have better economic opportunities. For this reason, we control for spatial characteristics such as proximity to a primary road, any clinic (regardless of ART status), and major trading center (interacted with $Post_t$).[29] We also include controls for reported economic shocks by household, though these are not correlated with ART availability. In addition, we may be concerned that proximity to ART is also correlated with the provision of other government aid programs such as subsidized maize or other health initiatives. Respondents report their participation for a number of programs, and we find that participation in other aid programs is not correlated with ART proximity. Nevertheless, we include the household participation in such programs in the controls.

We rule out the possibility that the results are driven by the direct effect of HIV-positive respondents receiving the life-saving medication by excluding the HIV-positive sample.[30] We also exclude attritors from the entire analysis to ensure that the results are not biased by the changing demographic composition of the sample over time, although the results are similar using the full sample (not shown). We may also worry that respondents who are more likely to benefit from ART move closer to the facilities. However, we find that attrition is not correlated with ART proximity. Moreover, the difficulties in moving due to lack of rental housing makes this argument less plausible.

5 Results

We will first present the overall effect of ART availability on savings and human capital investment. To illustrate the identifying source of variation, Figures 3-6 plot the main outcomes variables 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). The outcomes are de-trended by district-year, with the year effects added back. This is done to ensure that the trends we observe are not driven by district-specific

trends on observables. The correlations using the 2006 levels of all variables in Table 1 indicate that wealth score and income are weakly correlated with ART proximity and houses with a metal roof are strongly correlated. Since there is some evidence of demographic differences by distance to ART, it will be important to allow for trends by demographic characteristics in the robustness checks.

[29]For the estimation using the children's sample, we also include proximity to a school.

[30]The results are also robust to restricting the sample to only HIV-negative respondents (see Tables B.6 and B.7). The survey did not conduct HIV testing in 2010, so we are unable to exclude individuals who stereoconvert 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.

trends that may arise because of the unequal representation of districts.

Figures 3 and 4 show the fraction of respondents with savings and average total savings, respectively. Data for savings behavior is only available beginning 2006. The fraction of respondents with savings in 2006 is not statistically different by distance group; if anything the "Far" group is more likely to have savings (Figure 3). By 2008, the impact of ART is already detectable as the fraction of respondents "Near" group who report positive savings increases by 15 percentage points, whereas the "Far" group has a slight decrease. Figure 4 shows the trends in total amount in savings, which again show little difference in the pre-period (although in this case, the "Near" group does have slightly more in total savings). 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.

Figure 5 shows the trends in expenditures on education per child in the past three months. For this outcome, we are able to go back to 2004, and we see no difference by distance group. The effect of ART only becomes apparent by 2010, which is consistent with what we may expect given that education decisions were likely already made by the time ART came online for the 2008 survey rounds. Moreover, liquidity constrained households may need time to accumulate savings before adjusting their response. Figure 6 shows very similar trends in medical spending per child in the past three months by distance group. In both figures, we see education and medical spending are similar across groups in 2004 and continue to be similar in 2006, indicating little concern for differential pre-trends by distance to ART.

We also explore the effects of ART proximity nonparametrically. Figure B.4 reports nonparametric estimates for the main dependent variables, with linear estimates graphed for comparison. The regressions include region-year fixed effects. The figure displays 95 percent confidence intervals, computed using 1,000 bootstrap replications (clustered by village). In each bootstrap step, an undersmoothed local linear bandwidth is chosen following Hall (1992).

Below we describe the results from the regression analysis. Using the negative log of distance as the parametrization of ART proximity means that we can interpret the coefficient, roughly, as the effect on the outcome variable if distance to ART was reduced by half.[31] This corresponds to a decrease in distance of 5 kilometers from the mean (and median) distance of 9 kilometers. The reader should note, however, that the results for expenditures on children and their schooling outcomes represent the combined effects of increasing life expectancy for parents and children. Section 7 will address this confound and attempt

[31] 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. Precisely, this corresponds to a decrease in distance from the mean (9 km) by 5.68 km. For ease of exposition, we will to refer to the coefficient as the effect of decreasing distance by half.

to isolate the effects of children's life expectancy on schooling.

5.1 ART Availability and Saving Behavior

Estimates of the effect of ART availability on savings behavior appear in Table 3. Panel A shows the results for the full sample of respondents, while Panel B excludes HIV-positive respondents. Column (1) shows the response in the proportion of respondents with positive savings, and column (2) shows the response in total savings. Due to the fact that many individuals report zero savings, and very few individuals report positive savings over all three survey years, we use levels in our analysis. As the distribution is heavily skewed to the right, we capped the total savings to the 99th percentile.[32]

We find a strong and immediate response in respondents' likelihood to save. The point estimates in Table 3, column (1), indicate that reducing the respondents' distance to the nearest ART facility increases the likelihood to save by 9.2 percentage points in 2008 and 10 percentage points in 2010 over the 2006 period. The point estimates are slightly larger when excluding HIV-positive respondents (Panel B). In both cases, the point estimates are statistically significant at the 5% level. Total savings also improve, and the estimated effect is larger and more significant in 2010 (though the difference in the two coefficients is not statistically significant). The point estimate implies that total savings would increase by 19.8 USD between 2006 and 2010 if the respondent's distance to ART were reduced by half.

Table 4 presents a series of robustness checks for the results described in Section 5.1. We specifically consider two sets of controls: a set of spatial controls that consist of distances to any clinic, major market, major road, and school; and a set of other controls which consist of demographic characteristics, economic shocks, and participation in government aid programs. The demographic characteristics include pre-period wealth score, age, gender, household size, population density, and education. The economic shocks controls consist of a set of reported shocks that have impacted the household's economic situation. We include these as a test of whether households near ART faced different shocks than households that live far. Finally, the survey asks respondents about their participation in a number government aid programs ranging from free maize to subsidized agricultural inputs to nutrition and health programs. These controls allow us to test whether our measure of ART availability is picking up the effect of other aid programs.[33]

Table 4 shows robustness in savings behavior; columns (1) and (2) show results for the outcome of whether the respondent has positive savings, and columns (3) and (4) use total savings as the dependent

[32]This corresponds to a cap at US$600, though the results are not sensitive to the threshold used. Many of the responses in this upper range are likely due to reporting error as they are frequently widely inconsistent with previous years' responses and other wealth variables.

[33]As mentioned earlier, ART proximity is not correlated with economic shocks or other aid programs.

variable. We first include spatial controls in columns (1) and (3). We then add demographic controls, reported economic shocks, and participation in government aid programs (columns 2 and 4). The results for respondents' likelihood to save remain large and significant as we include controls. If anything, the point estimates become slightly larger when including the controls. The point estimates on total savings in column (3) are similar to the main results and remain significant, implying that spatial factors are not likely to give rise to our results. Including all other controls (column 4) results in a point estimate that is similar in magnitude, though less precisely estimated (significant only at the 10% level).

5.2 ART Availability and Investment in Human Capital

Estimates of the effect of ART availability on investment in human capital appear in Table 5. Panel A shows the results for the full sample of respondents, while Panel B excludes HIV-positive respondents. Columns (1)-(3) show the response in expenditures on education, medical, and clothing for children in the past three months. As with total savings, we use levels for the expenditure outcomes and similarly treat the extreme upper tail of the distributions, but the results are not sensitive to the threshold used.[34]

We find that education and medical related spending on children increases with ART availability, though the response is lagged. Column (1) shows results for education spending, where the coefficient on $2010 \times \textit{ART Proximity}$ is large, 2.40 and significant; however, the coefficient on $2008 \times \textit{ART Proximity}$ is much smaller, 0.36, though imprecisely estimated. The point estimate implies that reducing the distance by half would result an increase of 2.40 USD in spending on education per child by 2010. The point estimate is 14% smaller for the subsample excluding HIV-positive respondents, but is still significant at the 5% level. Column (2) shows results for medical spending, where the coefficient on $2010 \times \textit{ART Proximity}$ is large, 0.54 and significant; however, the coefficient on $2008 \times \textit{ART Proximity}$ is smaller, 0.22, though imprecisely estimated. Results are also similar for the subsample excluding HIV-positive respondents, though the point estimates are smaller. Last, we find no evidence that parents are spending more on children's clothing. Column (3) shows point estimates that are slightly negative for 2010, and positive but small in 2008, but both imprecisely estimated. Restricting the sample in Panel B, we see that both estimates for 2008 and 2010 are slightly negative and imprecisely estimated. The lack of response in clothing expenditures is not surprising since the question explicitly asks respondents not to include school uniforms.

Table 6 shows robustness in expenditures on children using the same set of controls described above.

[34]The total number of observations that are affected by the cap is approximately 20 for each of the expenditure categories.

Columns (1)-(3) are robustness checks for education spending. Column (1) includes the variable 2006 × *ART Proximity*; column (2) includes spatial controls; and column (3) includes demographic controls, reported economic shocks, and participation in government aid programs. Similarly, columns (4)-(6) show these robustness checks for medical spending, and columns (7)-(9) for expenditures on clothing. Including these controls does not change the null results found for clothing expenditures, so we will not discuss these further. Column (1) shows that the coefficient on 2006 × *ART Proximity* is small, just one tenth that of the estimated effect in 2010, though imprecisely estimated, implying that ART proximity did not have an impact on spending before it became available. The results are similar across the specifications, and the point estimate stays within the range of 3.07 and 2.28 for education spending and 0.86 and 0.65 for medical spending. Including the full set of controls does reduce the magnitude, though not the precision, of the point estimate for the education spending. This is driven by the demographic controls and not by the reduction in sample, economic shocks, or other government aid.

5.3 ART Availability and Children's Human Capital

The section above provided evidence that ART is associated with increased educational and medical spending on children. The next step is to look for improvements in schooling and health for the children of the respondents. We provide evidence on the effect of ART availability on children's grade attainment and their general health as reported by their parents. We should, once again, emphasize that these results are the combined effect of increasing life expectancy for parents and children. Table 7 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. Panel A shows the effect of ART on grades completed (columns 1-3) and reported health (columns 4-6), and Panel B shows the effects for the sample of children whose parents are not HIV-positive. We chose to use grade completion (and control for age times year in all regressions) rather than grade-for-age for ease of interpretation, although using grade-for-age yields similar results.[35] Including spatial and demographic controls slightly increase the point estimates on grades completed. The effect of ART on grade completion seems to be quite large. The point estimates in column 1 imply that decreasing the distance to ART by half would increase years of schooling by 0.26 in the full sample (and 0.34 in the sample excluding HIV-positive parents). The effect is only large and significant by 2010, which is consistent with the lagged response of educational spending.

[35] Additionally, children's age is often estimated by the parent so including it in the dependent variable adds noise that is difficult to interpret. In the regressions, we use the mean reported age over the three surveys, which ideally corresponds to the age in 2008.

We find that there is some evidence of improvements in child health. Theory predicts that parents expecting to live longer should invest in their children's health, because it will enable them to earn higher wages as adults. Columns (4)-(6) show that by halving the distance to ART, parents are 12 percentage points more likely to report their child to be in excellent health by 2008 and 14 percentage points by 2010 (those percentages are 14 and 15, respectively, for the sample excluding HIV-positive parents). Including spatial and demographic controls reduces the point estimates slightly, but substantially decreases the precision.

6 Mechanisms

This section considers other possible mechanisms that may result in changes in investment when ART becomes available. The baseline results were not sensitive to excluding HIV-positive individuals from the sample, which rules out the possibility that the results are driven by the HIV-positive sample that may be benefitting directly from the medication.[36] 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.[37] 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 caretaking burden on families that care for orphaned children 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% 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 (unlike Jayachandran and Lleras-Muney

[36]Many individuals did not consent to the HIV test (17% of our sample did not have HIV testing results by 2008). The results above are similar if we exclude the sample from whom the HIV results are missing (see Appendix Table B.7).

[37]This channel may be potentially large: In South Africa, where a similar ART rollout occurred over a similar time period, Bor, Barnighausen, Newell, Tanser, and Newell (2011) estimate that 25% 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% of adults.

2009). However, households near ART may be less likely to receive AIDS orphans after ART becomes available than those who live far.

Table 8 addresses the concern that our results are driven by the alternative mechanisms mentioned above. Panel A repeats the main results from Tables 3 and 5 excluding the HIV-positive sample for easy reference. Panel B of Table 8 restricts the sample to 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. Since AIDS is still largely stigmatized in Malawi, we may expect underreporting of AIDS deaths. We, therefore, 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 C excludes respondents who ever reported a seriously ill household member. Last, Panel D excludes respondents who ever reported non-biological children co-residing with them. We use this approach because we do not have specific data on whether the non-biological children are orphans. The results are similar across specifications. While the estimates are only slightly smaller, the precision is reduced in some cases.[38]

The availability of ART may also influence other decisions, notably labor supply, that may indirectly affect investment. Baranov, Bennett, and Kohler (2012) find that ART availability is associated with improvements in maize production and that the increased productivity may be driven by improvements in mental health. While our approach cannot rule out the possibility that our results are driven by improvements in mental health, we can consider whether our findings are the result of an income shock. If respondents near ART facilities are cultivating more maize and becoming, effectively, wealthier then we should expect to see increases in spending in other categories as well.

Table 9 shows the effect of ART availability on other spending and investment. The variables on expenditures are the respondents' reported spending in the past three months. The point estimates are small and imprecisely estimated, indicating that our main results are not driven by an income effect. If anything, spending decreases on farm investment, columns (5)-(8). The reported reduction in medical spending for people other than the respondent or the respondent's children and the reduction in hired labor are consistent with ART reducing the caretaking burden and dependency ratio.

7 Interpreting magnitudes

In this section, we evaluate the magnitudes of the estimates reported in Section 5. First, we report estimates of the impact of ART availability on subjective mortality risk (these are a repeat of the results

[38]The results are also robust to excluding all groups at the same time (not shown).

from Baranov, Bennett, and Kohler 2012).[39] We then calculate the implied subjective life expectancy by adjusting the age-specific mortality rates from life tables.[40] Based on that calculation, we are able to report the effect of ART availability on subjective life expectancy. We then compare the effect on subjective life expectancy to estimates of actual life expectancy gains from eliminating AIDS mortality.

Table 10 reports the estimates for the effect of ART availability on 5-year subjective mortality risk. These results are repeated from Baranov, Bennett, and Kohler (2012) using the parametrization of ART proximity used in this paper. Column (1) shows the results using the full sample (of non-attritors) and column (2) excludes respondents who ever tested positive for HIV. The point estimates imply that reducing distance to ART by half would reduce respondents' 5-year mortality risk by 0.058 (0.057 for the HIV-negative sample) by 2010. The results are also displayed graphically in Appendix Figures B.3 and B.4. We use these point estimates to then calculate the implied life expectancy gain using mortality tables.

To estimate the implied life expectancy gain, we made the additional assumption that ART only changed mortality risk for respondents between the ages of 15 and 49 (this is generally the age range for which HIV prevalence is reported), although the calculate is not particularly sensitive to extending the mortality decreases beyond 49 (to, say, 69). We also take two approaches: in the first, we assume that the level change in subjective mortality risk reported using beans is an accurate reflection of the respondents' risk assessment. In this case, we apply the 5.8 percentage point decrease to the relevant age categories.[41] The second approach assumes that the level of mortality risk that individuals report does not reflect their true beliefs, but that the percentage change over the level is meaningful. Then 5.8 percentage points more accurately reflects a 15 *percent* decrease in mortality risk (since the average perceived mortality risk before ART was 0.39). We do this second approach because we may be concerned with interpreting the response in levels, given the levels of perceived mortality risk seem implausibly high. We then apply a 15 percent decrease to the 5-year death probabilities to the relevant age categories in the life tables. These two approaches yield different results: the first approach using levels implies a life expectancy (at age 5) gain of 6.8 years, whereas the second approach implies a life expectancy gain of 4.2 years.

Figure 8 shows the implied gains in life expectancy by age using the two approaches outlined above. It also includes two estimates by the UN Population Division of life expectancy gains of eliminating AIDS

[39] These results are effectively the first stage results.

[40] We use life tables from the UN Population Division for Malawi in 2009 since these are calculated based on mortality data over the previous 5 years, which corresponds best to the years of the survey.

[41] Except for the 15-24 age groups, which we treat separately, since that would result in negative mortality probabilities. Here we smooth the values by interpolating the decrease in mortality risk linearly.

(UN World Population Prospects, 2010 Revision). These estimates provide a reasonable upper bound for the effect of ART on subjective life expectancy, since ART medication does not entirely eliminate AIDS mortality.[42] In light of these calculations, the strong response in subjective mortality risk and other behavior changes.

7.1 Marginal Effect of Life Expectancy on Schooling

We calculate the implied effect of an additional year of children's life expectancy on schooling. As we discussed above, the results presented in Table 7 include the effect of life expectancy gains for parents and children. Thus, in order to estimate the effect of children's life expectancy on years of schooling, we exploit differential life expectancy gains by gender and compare the education response for boys and girls.[43]

Large differences in HIV prevalence exist between men and women in Malawi. In our sample, HIV prevalence among women was 8 percent versus 4 percent in men. Moreover, AIDS mortality for women occurs earlier in life than for men because women are infected by the virus at younger ages.[44] The combination of these realities implies that the life expectancy gains from ART for women are substantially larger than the life expectancy gains for men. Figure 7 shows the estimated gains in life expectancy by age for men and women. The life expectancy gains at age 5 for men are 11.1 years, whereas for women they are 14.4 years. We also see a corresponding difference in the subjective mortality risk response. Table 10, columns (3) and (4) show the results for subjective mortality risk for women and men, respectively. The point estimate on the 2010 coefficient shows that ART availability decreases mortality risk for women by 0.064, and for men by 0.045. These point estimates correspond to implied life expectancy gain of 8.5 and 6.2, respectively (using the levels approach).

Another limitation we have is that we observe subjective mortality for respondents but not 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 measure, we estimate the change in subjective mortality risk for the youth sub-sample in column (5) of Table 10. The results are large and significant, despite the small sample size, indicating

[42] These estimates for life expectancy gains may seem high given the prevalence of HIV. It is useful to realize that the lifetime risk of getting HIV is also much higher than the prevalence, and in a country with 10 percent prevalence the lifetime risk of HIV is approximately 45 percent (Blacker and Zaba 1997).

[43] This approach is similar to that of Jayachandran and Lleras-Muney (2009).

[44] This is likely a result of young women dating older men because the older men have more money, a common practice throughout Sub-Saharan Africa. Additionally, the difference in prevalence can partly be explained by transmission probabilities.

that there does not seem to be a generational gap in the effect of ART availability. Additionally, the differential response by gender is evident in the youth sample (not shown).

Given these large gender differences, we look to see whether there is a differential response in schooling for girls than for boys. Implicit in this exercise is the assumption that parents are not more likely to invest in girls versus boys for reasons other than their different life expectancy gains.[45] We look for evidence of a gender bias in educational attainment before ART is introduced in the children's sample and the youth respondents. If anything, boys have slightly higher grade attainment. This analysis is a difference-in-difference-in-difference estimation, where the estimating equation is

$$y_{ijrt} = \beta Girl_i \times Post_t \times Proximity_{ijr} + Girl_i \times Post_t + \alpha_{ijr} + \delta_{rt} + \varepsilon_{ijrt}. \quad (7.1)$$

Of course, as in all of our regression analysis, we allow individual indicators for 2010 and 2008 instead of *Post*. We also include age-by-year effects, individual fixed effects and region-year effects.

Table 11 shows 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% level. Although the results are not very precise (which is not surprising given the sample size), they are fairly robust to including various controls. Although not precise, the estimates suggest that girls' schooling attainment increases by 0.3 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 effect: These results imply that the marginal effect of an extra year of life expectancy on years of schooling is 0.09. The magnitude of the effect is very similar to that estimated by Jayachandran and Lleras-Muney (2009).

8 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

[45] This assumption is also implicit in Jayachandran and Lleras-Muney (2009).

AIDS medication to evaluate its impact on savings and human capital investment in Malawi. Our study has several advantages: it allows us to estimate the effects of ART on the HIV-*negative* sample, that is, individuals who do not directly benefit from receiving the medication. 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 savings, education expenditures, and children's schooling and health. 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 caretaking 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.

Taken together, these results suggest that our findings are due to changes in expectations about longevity, and provide compelling evidence in favor of the mechanism in human capital theory. The savings results also provide evidence that higher life expectancy does prompt more savings.

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 for healthy 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.

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Table 1 – Pre-characteristics

	Before ART (2006)		
ART Proximity:	Near	Far	P-value
	(1)	(2)	(3)
Panel A: Characteristics			
Education	4.99	5.21	0.25
Mortality risk (5 year)	0.39	0.38	0.31
HIV positive	0.03	0.05	0.06
Household size	5.38	5.54	0.19
Wealth index	0.16	0.06	0.37
Metal roof	0.17	0.13	0.03
Land (hectares)	1.43	1.74	0.00
Has bicycle	0.60	0.56	0.27
Labor income (USD)	89.32	71.58	0.14
High discount rate	0.55	0.58	0.23
Panel B: Outcomes			
Has savings	0.22	0.22	0.99
Savings (USD)	20.71	13.46	0.05
Education (USD per child in past 3 months)	1.78	1.33	0.19
Medical (USD per child in past 3 months)	0.36	0.46	0.17
Clothing (USD per child in past 3 months)	2.44	2.28	0.54
Panel C: Children's Characteristics			
Child sample size	236	290	–
Age	10.15	9.94	0.39
Grades completed	2.94	2.58	0.04
Subjective health score (1-5)	4.00	4.26	0.00
Distance to school (km)	1.47	1.85	0.00
Panel D: Spatial Characteristics			
Distance to nearest ART facility in 2006 (km)	28.49	23.75	0.00
Distance to nearest ART facility in 2008 (km)	6.20	11.92	0.00
Distance to nearest clinic (km)	4.86	7.33	0.00
Distance to nearest market (km)	4.33	6.22	0.00
Population density (pers./100 m^2)	0.94	1.07	0.00
Balaka district	0.42	0.23	0.00
Mchinji district	0.14	0.40	0.00
Number of respondents	680	699	–

Note: This table describes characteristics of respondents and their children in 2006, before ART became available. The sample is divided according to the median distance to an ART facility, 8.9 kilometers. P-value of the difference between near and far groups is given in column (3). 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 C describes characteristics of the respondents' children and is restricted to children who were reported in the household roster for all three years.

Table 2 – Comparison of Pre-treatment Trends

	Change from 2004-2006		
ART Proximity:	Near	Far	P-value
	(1)	(2)	(3)
Panel A: Pre-trends in available outcomes			
Education (USD per child)	0.29	0.07	0.50
Medical (USD per child)	-0.00	-0.15	0.28
Clothing (USD per child)	0.37	0.34	0.95
Panel B: Pre-trends in other characeteristics			
Education	0.10	0.10	0.99
HIV positive	0.00	0.01	0.49
Wealth index	0.02	0.07	0.56
Metal roof	0.02	0.02	0.97
Land (hectares)	0.06	0.26	0.11
Number of cows	-0.20	0.27	0.07
Number of pigs	-0.22	0.14	0.04
Number of goats	0.04	0.15	0.58
Has cell phone	0.03	0.02	0.41
Has bicycle	0.04	0.05	0.59
Has radio	-0.01	0.04	0.05
Sample size	670	688	–

Note: This table shows the mean changes between 2004 and 2006 (before ART came online) in available outcomes and characteristics of the sample by near and far groups. Sample is divided according to the median distance to an ART facility in 2008, which is 8.9 kilometers. P-value of the difference between near and far groups in given in Column (3).

Table 3 – Effect of ART Availability on Savings

	Saving Behavior	
Dependent variable:	Has savings	Savings (USD)
	(1)	(2)
Panel A: Full sample		
2010 × ART Proximity	0.10***	19.8***
	(0.035)	(5.71)
2008 × ART Proximity	0.092**	13.3*
	(0.041)	(6.98)
Sample size	3989	3984
Adjusted R^2	0.079	0.11
Panel B: Excluding HIV-positive		
2010 × ART Proximity	0.11***	19.2***
	(0.032)	(5.91)
2008 × ART Proximity	0.099**	15.0**
	(0.042)	(7.60)
Sample size	3809	3803
Adjusted R^2	0.083	0.12

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects and region-year dummies. The sample is restricted to individuals who were interviewed in all three years of the survey (2006, 2008, and 2010). Regressions in Panel B exclude respondents who ever tested positive for HIV.

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

Table 4 – Effect of ART Availability on Saving Behavior - Robustness

Dependent variable:	Has savings		Savings (USD)	
	(1)	(2)	(3)	(4)
2010 × ART Proximity	0.13***	0.15***	21.4**	20.8*
	(0.046)	(0.057)	(10.0)	(11.9)
2008 × ART Proximity	0.12**	0.15***	14.9	14.4
	(0.049)	(0.056)	(9.80)	(10.7)
Spatial controls	Yes	Yes	Yes	Yes
All other controls	No	Yes	No	Yes
Sample size	3989	3125	3984	3123
Adjusted R^2	0.080	0.096	0.11	0.13

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects, and region-year dummies. Spatial controls include population density and proximity to clinic, market, major road and school (interacted with post). All other controls include demographic characteristics, economic shocks, and participation in other aid programs. Demographic controls include pre-period wealth, age, household size, gender, education, and marital status. Controls for economic shocks and other aid programs are described in detail in the text.

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

Table 5 – Effect of ART Availability on Investment in Human Capital

	Expenditures on Children (USD)		
Dependent variable:	Education	Medical	Clothing
	(1)	(2)	(3)
Panel A: Full sample			
2010 × ART Proximity	2.40**	0.54**	-0.066
	(0.94)	(0.23)	(0.73)
2008 × ART Proximity	0.36	0.22	0.32
	(0.65)	(0.23)	(0.68)
Sample size	2780	2837	2832
Adjusted R^2	0.11	0.022	0.13
Panel B: Excluding HIV-positive			
2010 × ART Proximity	2.06**	0.45*	-0.31
	(0.98)	(0.24)	(0.75)
2008 × ART Proximity	-0.12	-0.0080	-0.19
	(0.74)	(0.14)	(0.65)
Sample size	2660	2715	2710
Adjusted R^2	0.11	0.022	0.13

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects and region-year dummies. The sample is restricted to individuals who were interviewed in all three years of the main survey (2006, 2008, and 2010) and use data from 2004 when available. Regressions reported are restricted to respondents with school-age children and weighted by inverse of number of household respondents. Regressions in Panel B exclude respondents who ever tested positive for HIV.

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

Table 6 – Effect of ART Availability on Expenditures on Children - Robustness

Dependent variable:	Education (USD)			Medical (USD)			Clothing (USD)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
2010 × ART Proximity	3.07***	3.15***	2.28***	0.86***	0.69***	0.65***	0.11	0.21	-0.076
	(1.01)	(1.10)	(0.87)	(0.27)	(0.26)	(0.24)	(0.82)	(0.76)	(0.72)
2008 × ART Proximity	1.03	1.12	0.21	0.54**	0.37	0.32	0.75	0.86	0.44
	(0.76)	(0.78)	(0.81)	(0.26)	(0.25)	(0.21)	(0.70)	(0.73)	(0.70)
2006 × ART Proximity	0.32			0.23			0.18		
	(0.66)			(0.16)			(0.62)		
Spatial controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
All other controls	No	No	Yes	No	No	Yes	No	No	Yes
Sample size	2671	2671	2480	2727	2727	2535	2724	2724	2533
Adjusted R^2	0.11	0.11	0.15	0.027	0.031	0.051	0.13	0.13	0.15

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects, region-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 regression use data from 2004. Spatial controls include population density and proximity to clinic, market, major road and school (interacted with post). Demographic controls include pre-period wealth, age, household size, gender, education, and marital status. Controls for economic shocks and other aid programs are described in detail in the text.

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

Table 7 – Effect of ART Availability on Schooling and Kids Health

Dependent variable:	Grades completed			In excellent health		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Full sample						
2010 × ART Proximity	0.26*	0.32*	0.34*	0.14**	0.13	0.11
	(0.13)	(0.18)	(0.18)	(0.06)	(0.08)	(0.08)
2008 × ART Proximity	0.06	0.13	0.12	0.12*	0.11	0.09
	(0.09)	(0.14)	(0.14)	(0.07)	(0.08)	(0.08)
Sample size	1578	1578	1524	1578	1578	1524
Adjusted R^2	0.68	0.68	0.69	0.06	0.07	0.07
Panel B: Excluding HIV-positive						
2010 × ART Proximity	0.34***	0.39**	0.40**	0.15**	0.13	0.11
	(0.12)	(0.17)	(0.17)	(0.06)	(0.08)	(0.08)
2008 × ART Proximity	0.09	0.14	0.13	0.14**	0.11	0.09
	(0.09)	(0.14)	(0.14)	(0.06)	(0.08)	(0.08)
Sample size	1521	1521	1476	1521	1521	1476
Adjusted R^2	0.69	0.69	0.69	0.07	0.08	0.08
Spatial controls	No	Yes	Yes	No	Yes	Yes
Demographic controls	No	No	Yes	No	No	Yes

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include child fixed effects, and region-year dummies. The sample is restricted to children who were reported in all three years of the survey (2006, 2008, and 2010). Regressions are weighted by inverse of number of children per household. Regressions in Panel B exclude children whose parents ever tested positive for HIV.

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

Table 8 – ART Availability and Investment – Other Mechanisms

	Saving Behavior		Expenditures on Children (USD)		
Dependent variable:	Has savings	Savings (USD)	Education	Medical	Clothing
	(1)	(2)	(3)	(4)	(5)
Panel A: Excluding HIV-positive respondents					
2010 × ART Proximity	0.11***	19.2***	2.06**	0.45*	-0.31
	(0.032)	(5.91)	(0.98)	(0.24)	(0.75)
2008 × ART Proximity	0.099**	15.0**	-0.12	-0.0080	-0.19
	(0.042)	(7.60)	(0.74)	(0.14)	(0.65)
Sample size	3809	3803	2660	2715	2710
Panel B: Respondents who never reported an AIDS-related death in previous 2 years					
2010 × ART Proximity	0.14***	12.9	2.18*	0.61*	-0.79
	(0.046)	(8.51)	(1.31)	(0.37)	(1.07)
2008 × ART Proximity	0.10**	10.0	-0.46	-0.23	-0.65
	(0.047)	(8.88)	(0.65)	(0.17)	(0.86)
Sample size	2674	2669	1845	1883	1881
Panel C: Respondents who never reported a seriously ill household member					
2010 × ART Proximity	0.11***	17.4**	1.93*	0.47*	-0.14
	(0.036)	(7.49)	(1.04)	(0.26)	(0.74)
2008 × ART Proximity	0.082*	12.1*	0.034	-0.017	-0.21
	(0.044)	(6.45)	(0.75)	(0.15)	(0.67)
Sample size	3404	3398	2376	2426	2421
Panel D: Respondents who never reported non-biological children living with them					
2010 × ART Proximity	0.12**	26.0***	1.66	0.63**	-0.33
	(0.049)	(9.23)	(1.64)	(0.27)	(1.33)
2008 × ART Proximity	0.076	2.78	-0.75	0.21	-0.23
	(0.047)	(8.75)	(0.86)	(0.15)	(0.91)
Sample size	2074	2071	1244	1276	1276

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects and region-year dummies. 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. All regressions exclude HIV-positive respondents.

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

Table 9 – ART Availability and Other Expenditures

Dependent variable:	Clothing (Own) (1)	Medical (Own) (2)	Medical (Others) (3)	Funeral (4)	Seed (5)	Farm Equipt (6)	Fertilizer (7)	Hired Labor (8)	Total Exp ln(USD) (9)	Earnings ln(USD) (10)
2010 × ART Proximity	-0.17	0.34	-1.16*	0.15	-0.22	-0.45	-5.32***	-2.88**	-0.36*	-0.10
	(1.35)	(0.47)	(0.68)	(0.35)	(0.29)	(0.39)	(1.63)	(1.26)	(0.20)	(0.14)
2008 × ART Proximity	1.92	0.25	-1.08	0.20	0.023	0.0029	-0.71	-0.50	-0.098	-0.20*
	(1.28)	(0.34)	(0.68)	(0.42)	(0.15)	(0.16)	(1.48)	(1.32)	(0.20)	(0.12)
Sample size	3450	3450	1006	3450	3450	3450	3450	3450	2646	2820
Adjusted R^2	0.13	0.081	0.025	0.030	0.048	0.038	0.070	0.047	0.13	0.42

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects, region-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 (interacted with post). Demographic controls include pre-period wealth, age, household size, gender, education, and marital status. Controls for economic shocks and other aid programs are described in detail in the text.

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

Table 10 – ART Availability and Subjective Expecations

Sample:	Full sample (1)	Excluding HIV-pos. (2)	Women (3)	Men (4)	Youth (age 16-20) (5)
2010 × ART Proximity	-0.058**	-0.057**	-0.064***	-0.045	-0.10**
	(0.023)	(0.024)	(0.025)	(0.032)	(0.051)
2008 × ART Proximity	-0.038*	-0.037	-0.073***	0.022	-0.064
	(0.022)	(0.025)	(0.027)	(0.029)	(0.047)
Sample size	3943	3766	2300	1626	420
Adjusted R^2	0.042	0.041	0.053	0.037	0.092

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects and region-year dummies. The sample is restricted to individuals who were interviewed in all three years of the survey (2006, 2008, and 2010).

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

Table 11 – Effect of ART Availability on Schooling – DDD

Sample:	All Children			Exluding Children Age<12 by 2010		
	(1)	(2)	(3)	(4)	(5)	(6)
Girl × 2010 × ART Proximity	0.30	0.22	0.25	0.39*	0.32	0.35*
	(0.21)	(0.21)	(0.20)	(0.23)	(0.22)	(0.21)
Girl × 2008 × ART Proximity	-0.02	-0.10	-0.09	0.00	-0.07	-0.08
	(0.15)	(0.16)	(0.15)	(0.15)	(0.17)	(0.16)
2010 × ART Proximity	0.24*	0.31*	0.32*	0.24*	0.28	0.28
	(0.14)	(0.18)	(0.18)	(0.14)	(0.19)	(0.19)
2008 × ART Proximity	0.09	0.15	0.16	0.09	0.13	0.13
	(0.11)	(0.15)	(0.15)	(0.11)	(0.16)	(0.16)
Spatial controls	No	Yes	Yes	No	Yes	Yes
Demographic controls	No	No	Yes	No	No	Yes
Sample size	1521	1521	1476	1368	1368	1323
Adjusted R2	0.69	0.69	0.69	0.69	0.69	0.70

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include child fixed effects, and region-year dummies. The sample is restricted to children who were reported in all three years of the survey (2006, 2008, and 2010). Regressions are weighted by inverse of number of children per household. Regressions exclude children whose parents ever tested positive for HIV. Columns (1)-(3) use the full sample of children aged 5-19, and Columns (4)-(6) only include children who were older than 12 years old by 2010.

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

Figure 1 – Geography

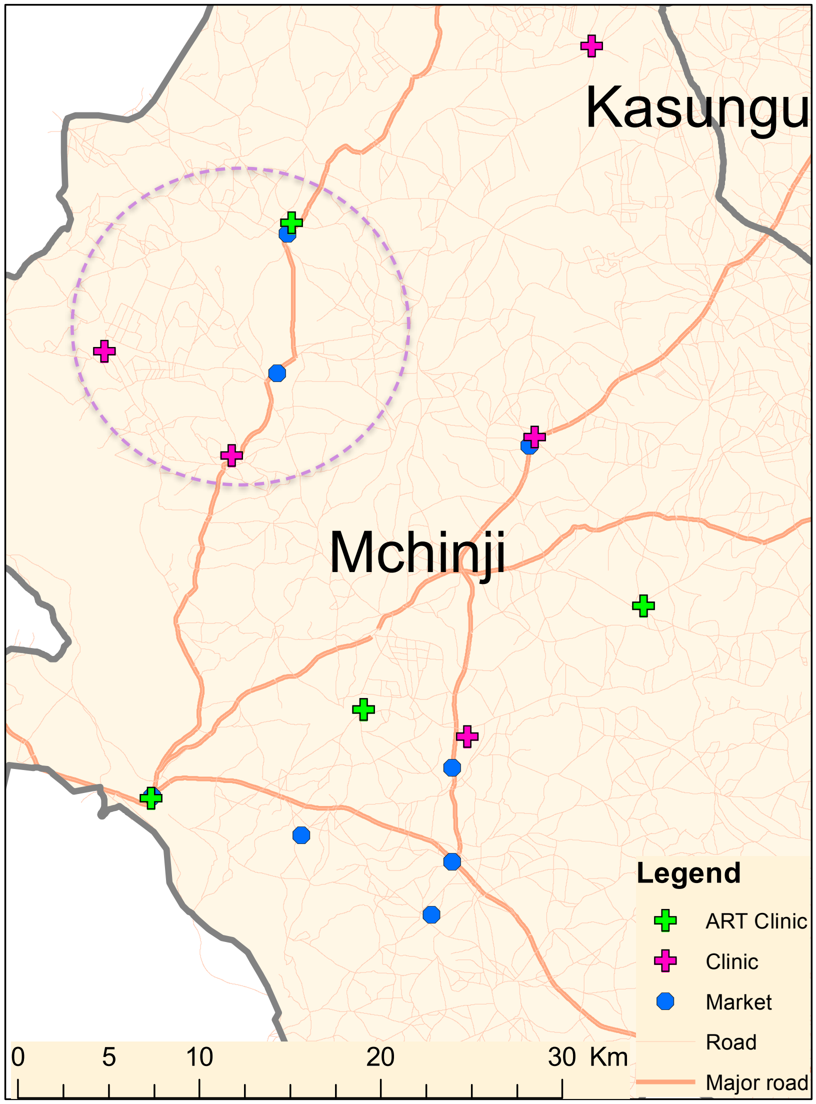


Figure 2 – Variation in ART Proximity in 2008

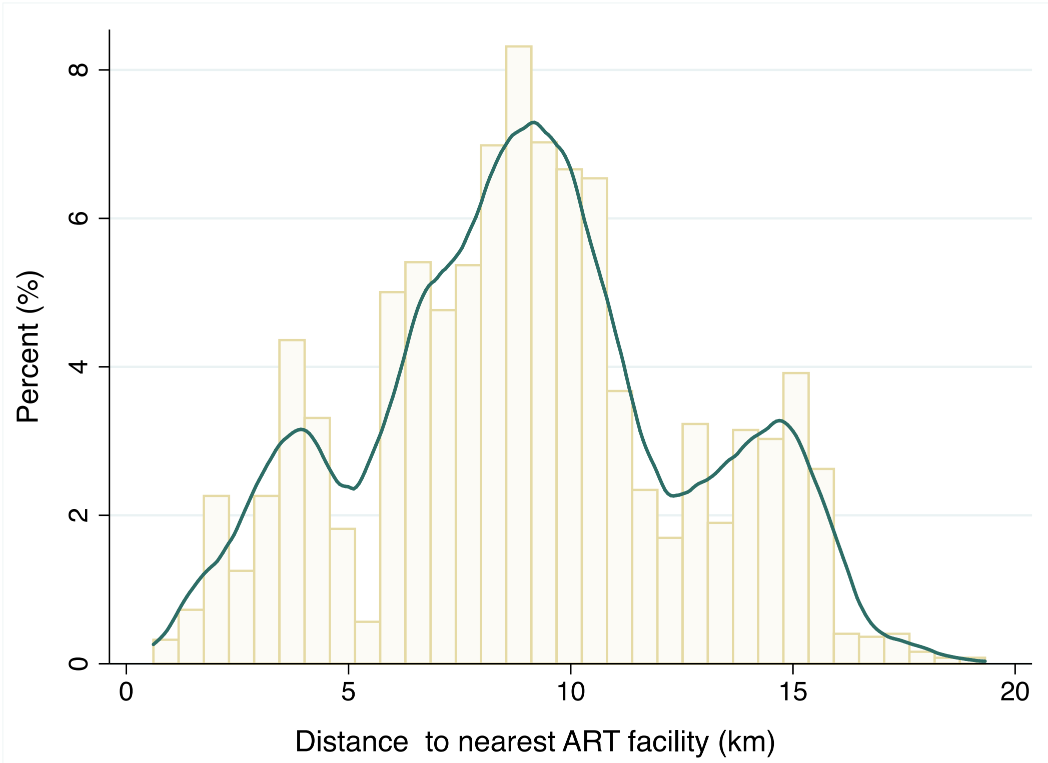


Figure 3 – Trends in propensity to save by distance to ART

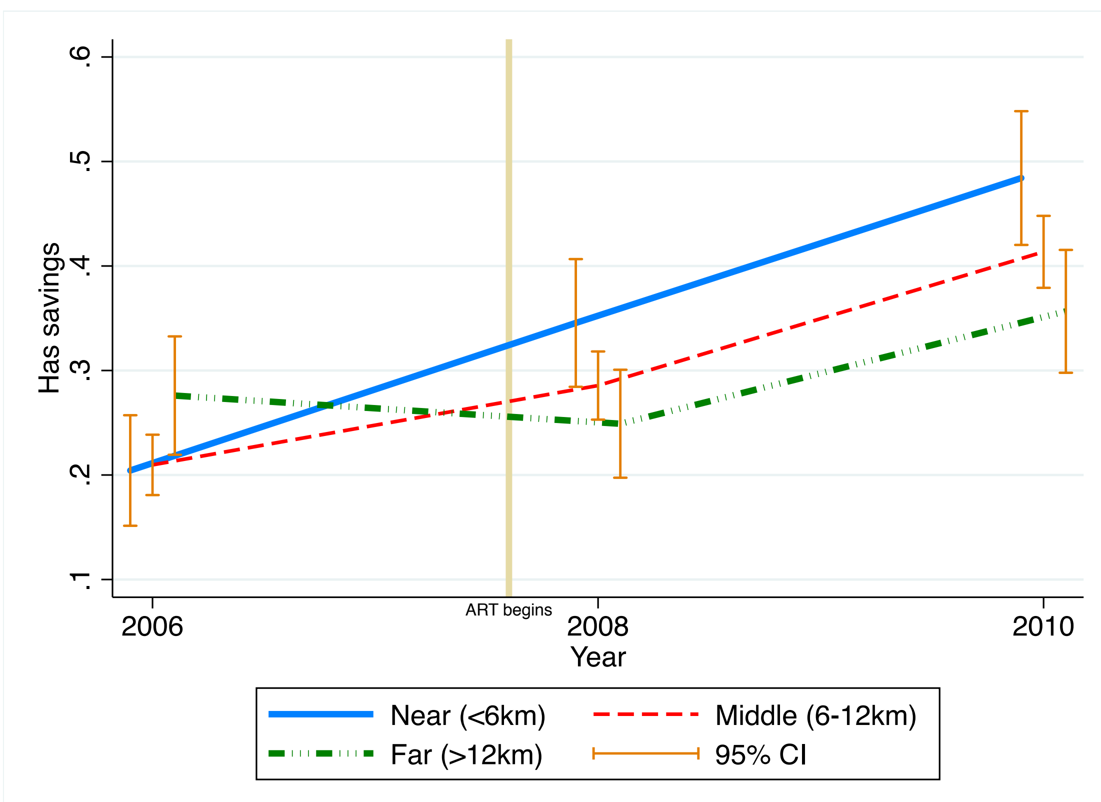


Figure 4 – Trends in total savings by distance to ART

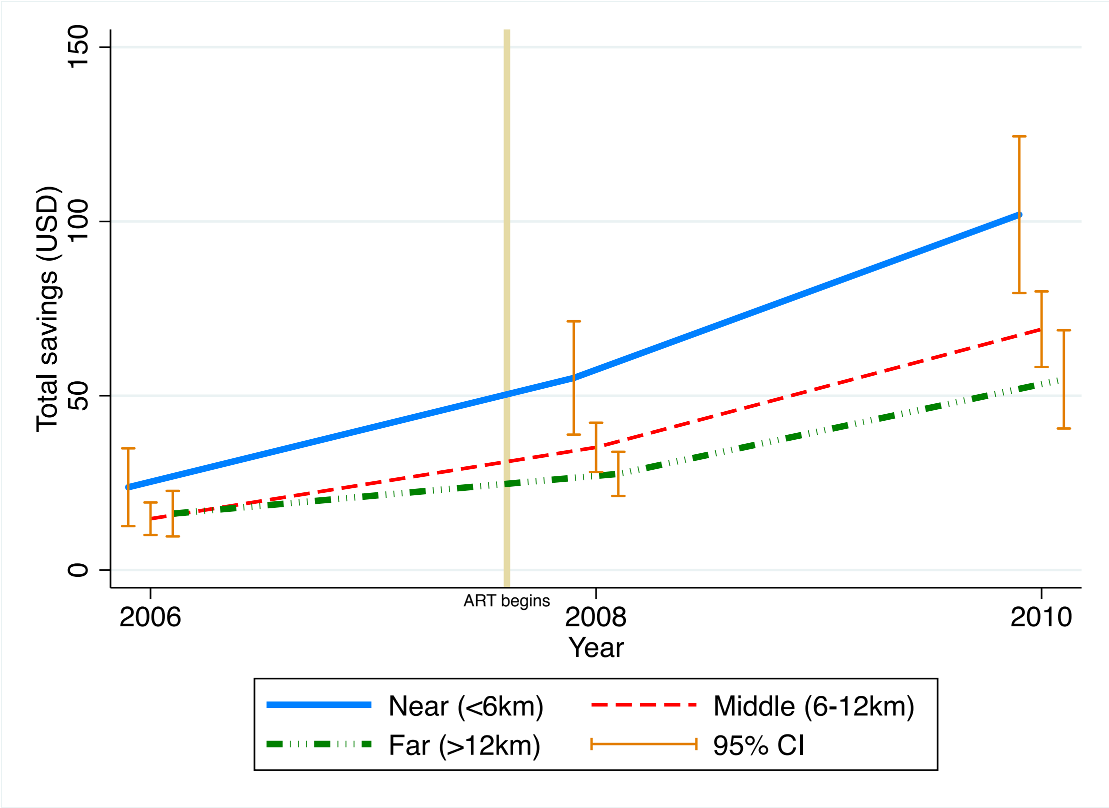


Figure 5 – Trends in spending on education by distance to ART

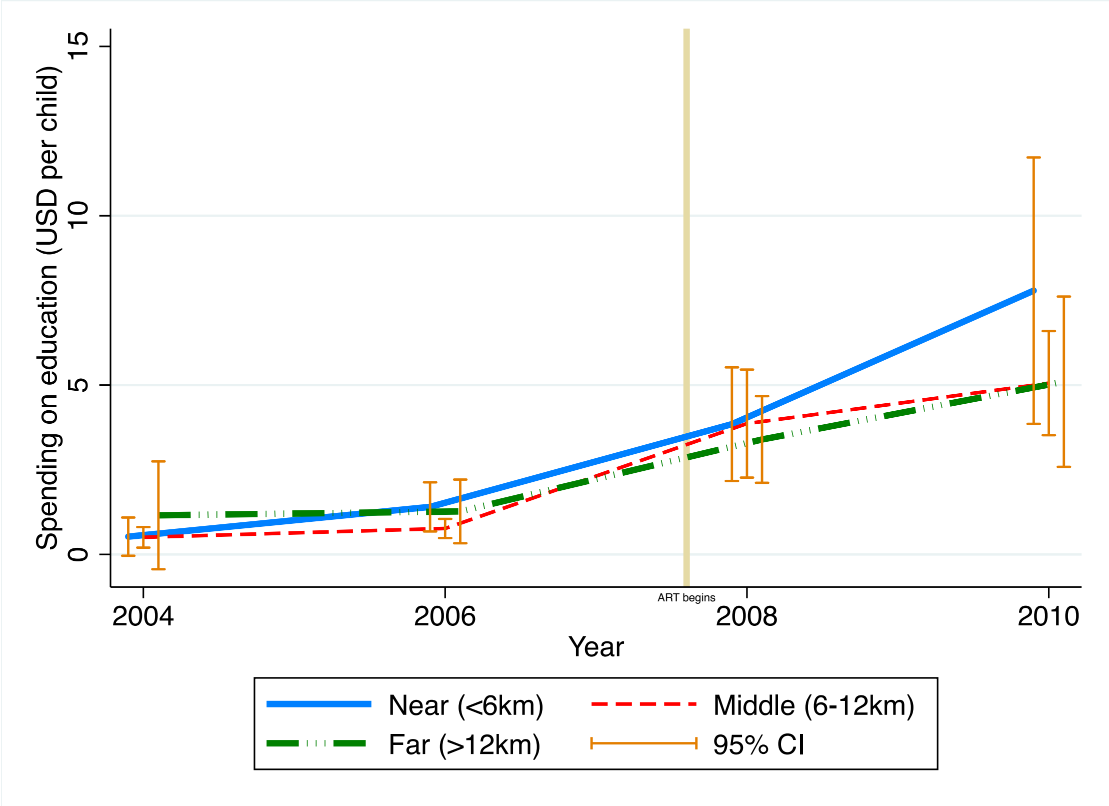


Figure 6 – Trends in spending on medical by distance to ART

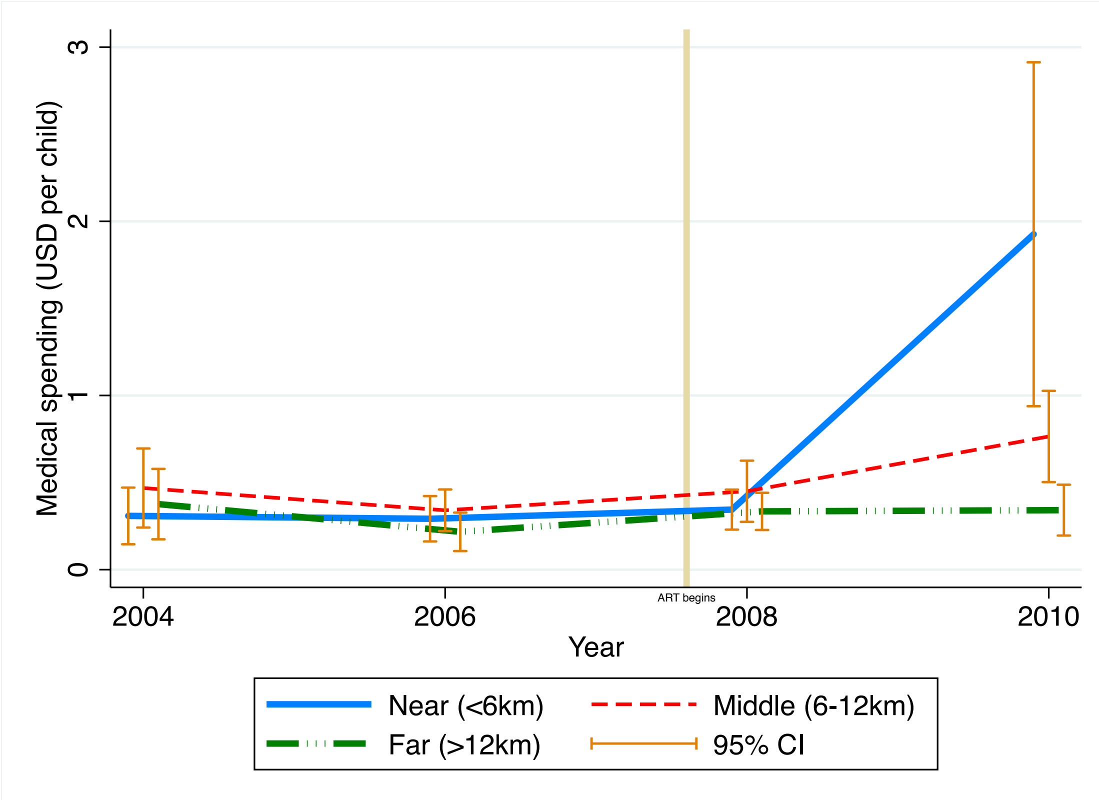


Figure 7 – Life expectancy gains of eliminating AIDS

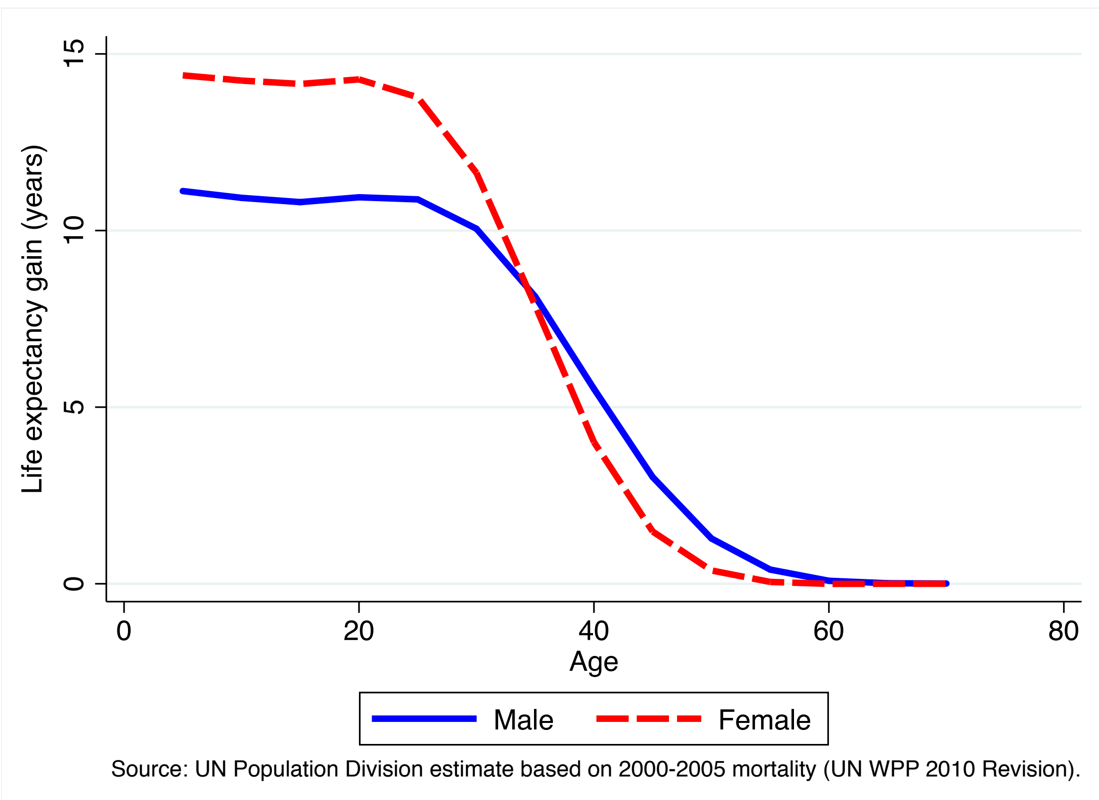
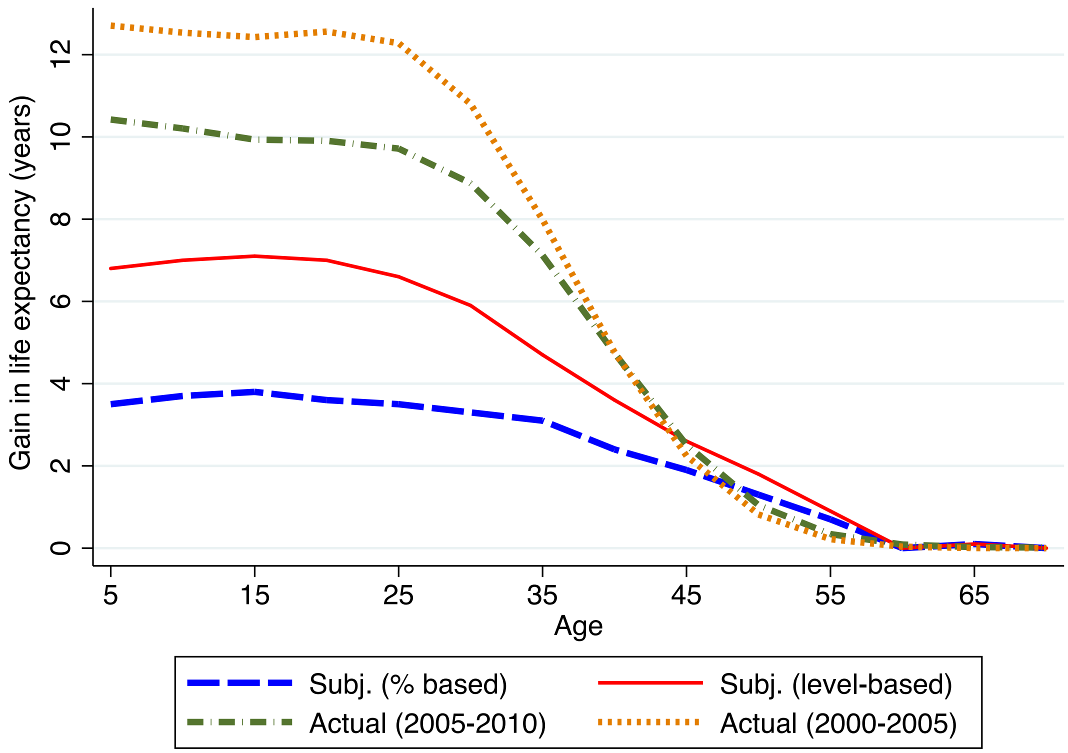


Figure 8 – Life expectancy gains: subjective and estimated



A Appendix

A.1 Model of Life-cycle Savings with Life Expectancy Shock

This section presents a basic model of life-cycles savings. For ease of exposition, we use a two-period model, where the utility in the second period is discounted by the standard discount factor, β, and the probability of surviving into the second period, δ. This survival probability parameter is is directly proportional to life expectancy.[46] The agent chooses the amount to save between the two periods of life to maximize the present discounted value of the utility stream:

$$\max_{s} \quad u(y_t - s) + \beta\delta u\left(y_{t+1} + (1+r)s\right).$$

This problem yields the necessary condition

$$u'(y_t - s) = \beta\delta(1+r)u'\left(y_{t+1} + (1+r)s\right). \tag{A.1}$$

To solve for savings, assume log utility, and that individuals are credit constrained in that they cannot borrow at all. Further, let $y_{t+1} = \alpha y_t = \alpha y$, so that α captures the gross growth rate in income.

$$s(\delta) = \begin{cases} y\left(\frac{\beta\delta - \frac{\alpha}{1+r}}{\beta\delta+1}\right) & \text{if } \frac{\alpha}{1+r} < \beta\delta \\ 0 & \text{if } \frac{\alpha}{1+r} \geq \beta\delta \end{cases} \tag{A.2}$$

Equation A.2 tells us that individuals will have positive savings if their income in the second period is sufficiently smaller than their income in the first, i.e., as long as $\alpha < \beta\delta(1+r)$.[47] Because, in our setting, individuals do not have access to bank accounts, it is likely the case that $r = 0$. This would imply that individuals would save only in the event that $\alpha < \beta\delta < 1$, that is when income next period is smaller than the current period. If savings are positive in the first period, then an increase in the probability of survival, δ, has a positive effect on savings:

$$\frac{\partial s}{\partial \delta} = y\frac{\beta(1+\frac{\alpha}{1+r})}{(\beta\delta+1)^2} > 0. \tag{A.3}$$

[46] The two-period case provides the same predictions as the infinite-time problem where δ is the survival probability every period. Instead of "next period income", the solution depends on the annuitized present discounted value of all future income, which itself depends on δ.

[47] More generally (i.e., without assuming a functional form for utility) $s(\delta) = \frac{y\left[1-\alpha u'^{-1}(\beta\delta(1+r))\right]}{(1+r)u'^{-1}(\beta\delta(1+r))+1}$ and savings are positive when $1 > \alpha u'^{-1}\left(\beta\delta(1+r)\right)$.

However, if the income growth is too high, that is, $\alpha > \beta\delta(1+r)$ and that remains true under the new probability of survival, then $\frac{\partial s}{\partial \delta} = 0$.[48] If the agent will have income growth in the future but are borrowing constrained such that they are unable to borrow, an increase in the survival probability into the next period will have no effect on their savings. Meanwhile, individuals who face a decreasing income trajectory will increase savings when survival probability increases. These are the predictions of the basic life-cycle consumption model. As in many other examples, in our data we find that earnings are inverse-U shaped as a function of age. Moreover, savings and propensity to save are also inverse-U shaped as would be predicted by the life cycle model with borrowing constraints.

A.2 Model of Human Capital Investment with Life Expectancy Shock

We will present a very simple model of human capital investment in which both adults and children may have life expectancy shocks. Imagine a two-period model, "young" when parents invest in schooling, and "old" when parents receive help from their children. Let h represent investment in the human capital of the child. Let δ^A represent the survival probability of the parent into the second period (old age), and δ^C represent the survival probability of the child into adulthood (when the parent is old). The rate of return to the child's human capital for the parent is ρ. The parent's problem is therefore

$$\max_{h>0} \quad u(y_1 - h) + \beta\delta^A u\left(y_2 + \delta^C h(1+\rho)\right).$$

The child's survival probability is the probability that the parent received the payout in old age. We assume that y_2, the income in old age, is low enough such that the parents always invests a positive amount into their children (i.e., in the case of log utility, $\beta\delta^A\delta^C(1+\rho)y_1 > y_2$). Assume, for exposition, that we can parametrize utility using the log function. Then the solution is

$$h(\delta^A, \delta^C) = \frac{\beta\delta^A\delta^C(1+\rho)y_1 - y_2}{\delta^C(1+\rho)\left[\beta\delta^A + 1\right]}, \tag{A.4}$$

which is positive because we have assumed the parents' old age income relative to adulthood income was much lower. Thus holding fixed the survival probability of the child, an increase in the parents' survival probability would increase investment in human capital, $\frac{\partial h}{\partial \delta^A} > 0$. Similarly, holding fixed the parents' survival probability, an increase in the child's survival probability would also increase investment in human

[48] There are individuals who, under the old survival probability do not save, but under the new survival probability switch to saving.

capital: $\frac{\partial h}{\partial \delta^C} > 0$. Lastly, if both parent and child survival probabilities increase at the same time, then human capital should also increase. For example, assume that $\delta^A = \delta^B = \delta$, then

$$\frac{\partial h}{\partial \delta} = \frac{\beta\delta^2(1+\rho)y_1 + (2\beta\delta + 1)y_2}{\delta^2(1+\rho)[\beta\delta + 1]^2} > 0. \tag{A.5}$$

B Appendix of Graphs and Tables

Figure B.1 – Distribution of distances to ART (in 2008) by region

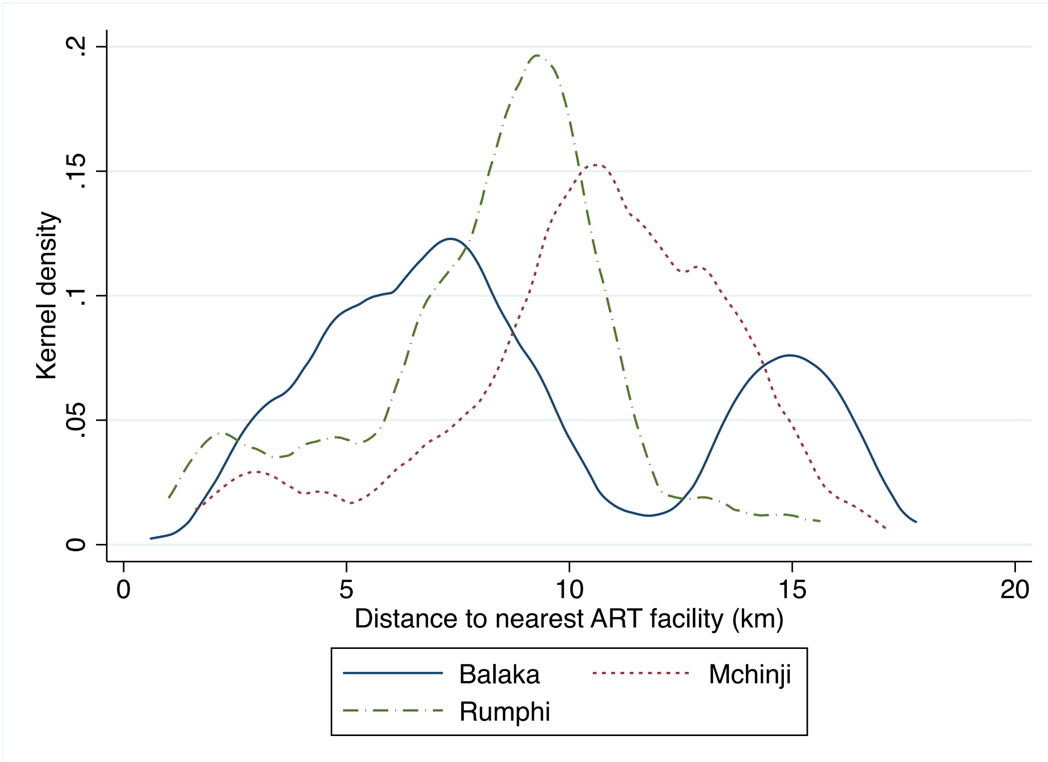


Figure B.2 – Distribution of distances to ART by year

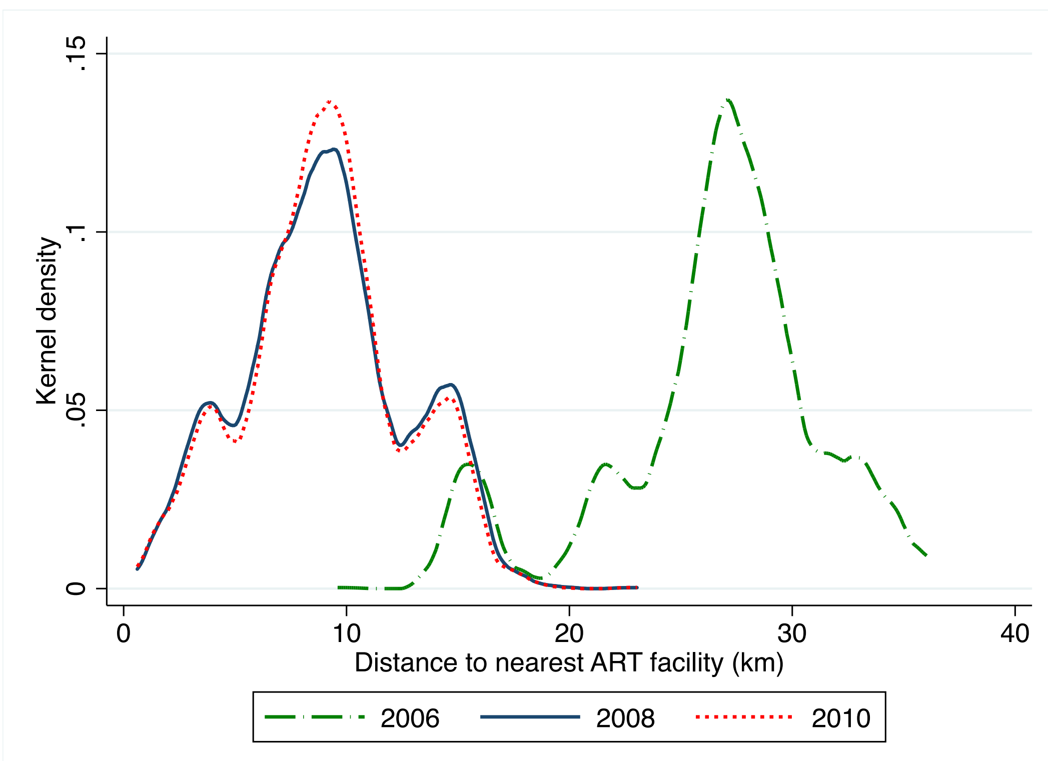


Figure B.3 – Effect of ART on 5-year subjective mortality risk by distance to ART

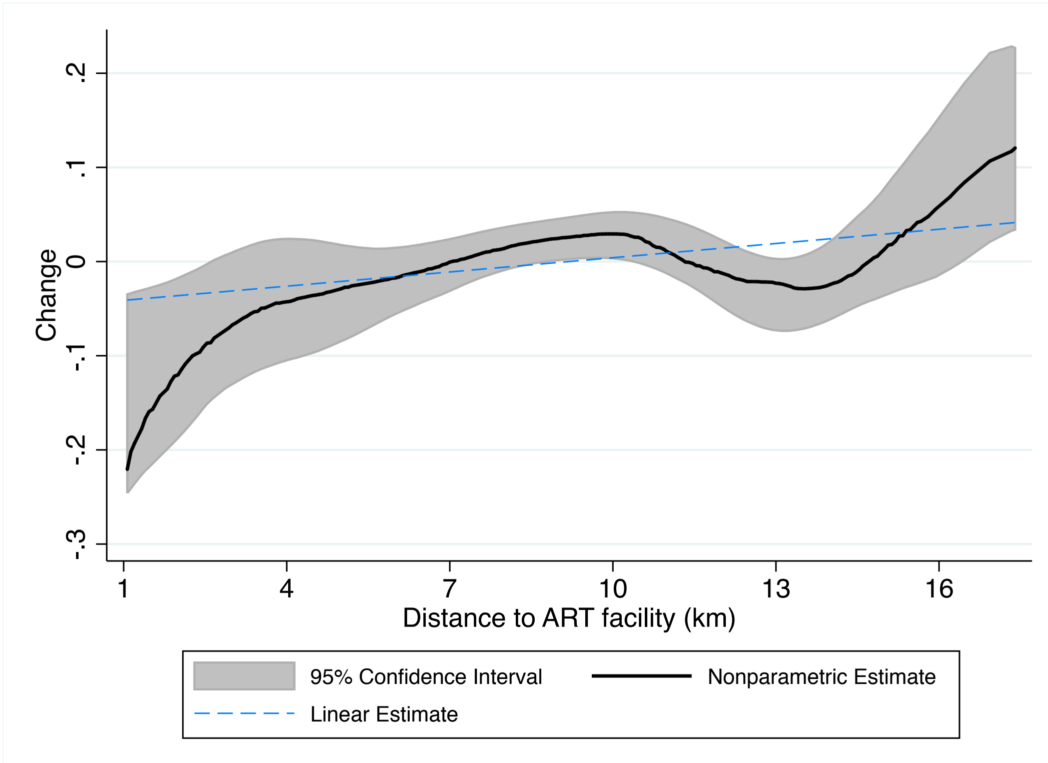
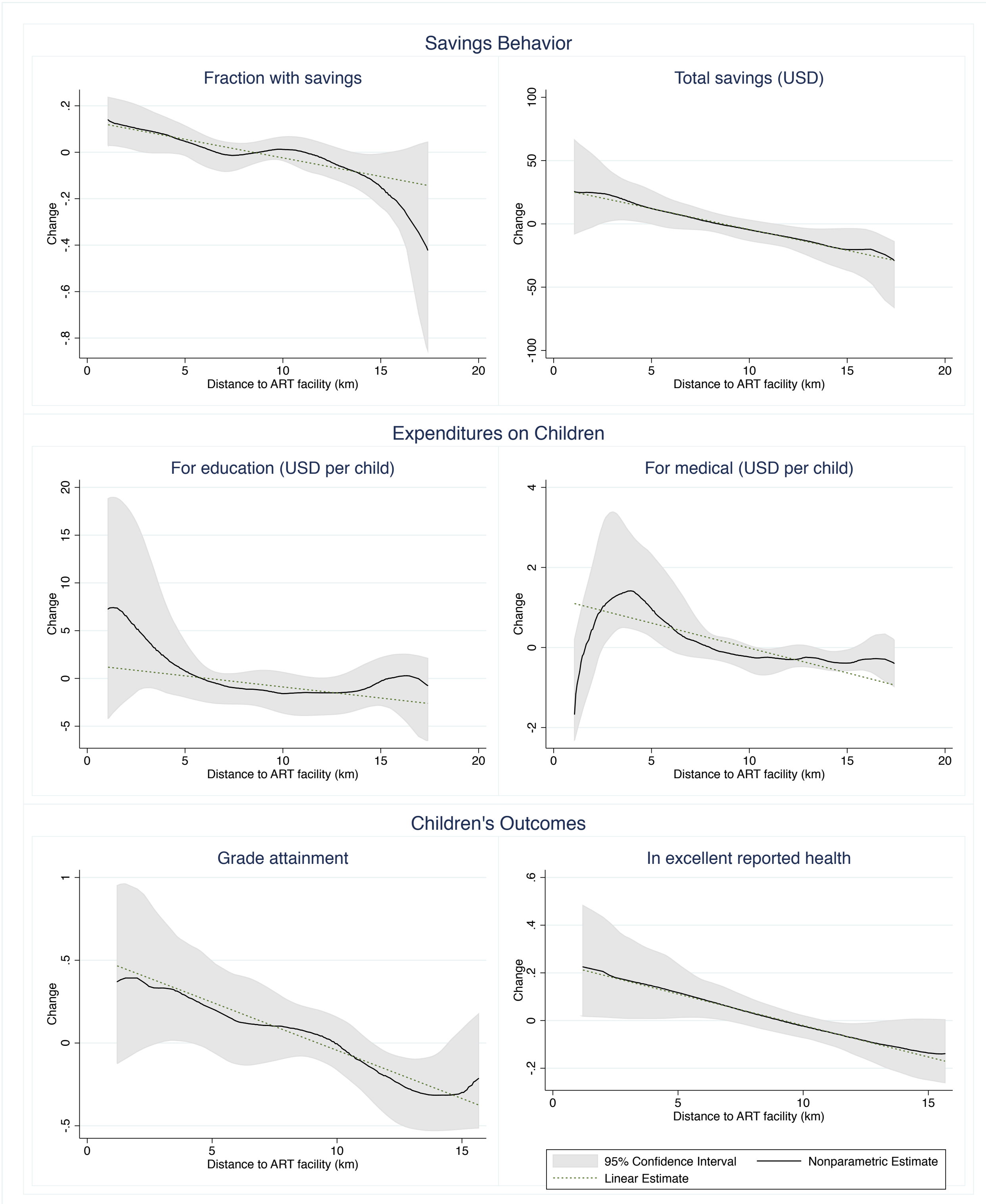


Figure B.4 – Effect of ART by distance



This figure shows nonparametric estimates of changes in the outcome variables by distance to ART. Changes are computed using 2010 as the "post" year, and 2006 and 2004 as the "pre" years (except savings and mortality risk, which do not have 2004 values). This corresponds to the coefficient on 2010 × *ART Proximity* in the parametric results presented in the tables. All graphs are nonparametric local linear regressions and include region-year fixed effects. Confidence bands at the 95% are computed using 1,000 bootstrap replications, clustered by village. In each bootstrap step, and undersmoothed local linear bandwidth is chosen following Hall (1992).

Table B.1 – Comparison of Clinics With and Without ART Services

	All Clinics in Malawi			MLSFH Sample		
	No ART	ART	Diff/SE	No ART	ART	Diff/SE
	(1)	(2)	(3)	(4)	(5)	(6)
Catchment Population	19575	43386	-23811***	12493	34422	-21929*
			(2188)			(7165)
Number of Beds	11.9	109.4	-97.5***	6.29	75.8	-69.5
			(7.75)			(45.1)
Electricity	0.43	0.76	-0.33***	0.43	0.75	-0.32
			(0.050)			(0.33)
Flush Toilet	0.31	0.74	-0.42***	0.29	0.75	-0.46
			(0.047)			(0.31)
HIV Testing	0.82	0.95	-0.13***	1	1	0
			(0.037)			(0)
Outpatient	0.96	0.99	-0.033	1	1	0
			(0.019)			(0)
Inpatient Maternity	0.74	0.97	-0.23***	0.43	1	-0.57
			(0.041)			(0.27)
Inpatient General	0.15	0.59	-0.45***	0.14	0.50	-0.36
			(0.040)			(0.28)
Antenatal Clinic	0.82	0.99	-0.18***	0.86	1	-0.14
			(0.036)			(0.19)
STI Clinic	0.34	0.65	-0.31***	0.29	0.50	-0.21
			(0.049)			(0.33)
TB Clinic	0.70	0.89	-0.19***	0.86	1	-0.14
			(0.045)			(0.19)
Laboratory	0.17	0.70	-0.53***	0	0.50	-0.50*
			(0.040)			(0.21)
Number of clinics	487	118	605	7	4	11

Note: This table shows a comparison of clinic characteristics by their status as ART providers. Columns (1) and (2) show the summary statistics for the full sample of clinics in Malawi, and Column (3) shows the difference with standard errors. Columns (4) and (5) show these summary statistics for the subset of clinics that serve the MLSFH survey region.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.2 – Characteristics of Clinics by ART Start Date

ART Start Date:	Before 2005 (1)	2005-2006 (2)	2007-2008 (3)	2009-2010 (4)	No ART (5)
Catchment Population	43709	54092	30453	22605	18972
	(25872)	(46095)	(14320)	(13901)	(14131)
Number of Beds	312.5	120.4	14.9	13.1	11.7
	(286.5)	(102.3)	(13.0)	(14.3)	(27.2)
Electricity	1.0	0.9	0.5	0.5	0.4
	(0.0)	(0.2)	(0.5)	(0.5)	(0.5)
Flush Toilet	1.0	0.9	0.4	0.4	0.3
	(0.0)	(0.3)	(0.5)	(0.5)	(0.5)
HIV Testing	1.0	0.9	0.9	0.9	0.8
	(0.0)	(0.2)	(0.2)	(0.2)	(0.4)
Outpatient	1.0	1.0	1.0	1.0	1.0
	(0.0)	(0.1)	(0.0)	(0.0)	(0.2)
Inpatient Maternity	1.0	0.9	1.0	0.9	0.7
	(0.0)	(0.2)	(0.0)	(0.3)	(0.5)
Inpatient General	1.0	0.8	0.2	0.2	0.1
	(0.0)	(0.4)	(0.4)	(0.4)	(0.3)
Antenatal Clinic	1.0	1.0	1.0	1.0	0.8
	(0.0)	(0.1)	(0.0)	(0.2)	(0.4)
STI Clinic	0.9	0.8	0.5	0.5	0.3
	(0.3)	(0.4)	(0.5)	(0.5)	(0.5)
TB Clinic	0.9	0.9	0.8	0.7	0.7
	(0.2)	(0.3)	(0.4)	(0.4)	(0.5)
Laboratory	0.9	0.9	0.4	0.4	0.1
	(0.3)	(0.3)	(0.5)	(0.5)	(0.3)
Number of clinics	18	55	51	60	421

Note: This table shows a comparison of clinic characteristics according to the year they began providing ART. Column (1) shows the clinics that began providing ART before 2005, and most of these facilities had ART before the national rollout. Column (5) shows the characteristics for clinics that have not begun providing ART as of the beginning of 2011. Standard deviations of the means are in parentheses.

Table B.3 – Correlations of Pre-treatment (2006) Levels with ART Proximity

Panel A: Outcomes	
Has savings	-0.045
Savings (USD)	0.018
Education (USD per child)	-0.011
Medical (USD per child)	0.006
Clothing (USD per child)	0.019
Panel B: Characteristics	
Education	0.038
Mortality risk (5 year)	0.095***
HIV positive	-0.027
Household size	-0.038
Wealth Index	0.050*
Metal roof	0.097***
Land (hectares)	-0.006
Has bicycle	0.036
Labor income (USD)	0.047*
High discount rate	-0.011
Panel C: Children's Characteristics	
Age	0.040
Grades Completed	0.054
Subjective Health (1-5)	-0.086**

Note: These values represent the correlation coefficient between the pre-treatment (2006) levels of outcomes and characteristics and ART proximity, where ART proximity is parameterized as the negative log of distance. The significance level of the correlation is marked as noted below.

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

Table B.4 – Correlations of Pre-treatment Trends with ART Proximity

Panel A: Outcomes	
Education (USD per child)	-0.011
Clothing (USD per child)	-0.046
Medical (USD per child)	0.052
Panel B: Other characteristics	
Education	-0.005
HIV positive	0.033
Wealth Index	-0.038
Metal roof	0.001
Land (hectares)	0.008
Number of cattle	-0.042
Number of pigs	-0.043
Number of goats	-0.038
Cell phone	0.052**
Bicycle	-0.036
Radio	-0.033

Note: These values represent the correlation coefficient between the pre-treatment trends (change in the variables from 2004 to 2006) and ART proximity, where ART proximity is parameterized as the negative log of distance. The significance level of the correlation is marked as noted below.

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

Table B.5 – Effect of ART Availability on Savings and Investment in Human Capital - Distance Dummies

	Saving Behavior		Expenditures on Children (USD)		
Dependent variable:	Has savings	Savings (USD)	Education	Medical	Clothing
	(1)	(2)	(3)	(4)	(5)
Panel A: Full sample					
2010 × Near(<6km)	0.21***	33.7***	3.91***	1.07***	0.50
	(0.058)	(10.3)	(1.18)	(0.29)	(1.06)
2008 × Near(<6km)	0.15**	22.7***	1.47	0.32	1.36
	(0.070)	(8.53)	(0.92)	(0.26)	(1.01)
2010 × Middle(6-12km)	0.12**	9.30	1.48*	0.35*	0.22
	(0.053)	(9.56)	(0.86)	(0.20)	(0.67)
2008 × Middle(6-12km)	0.096**	10.4*	1.55**	0.081	0.76
	(0.048)	(5.44)	(0.76)	(0.15)	(0.78)
Sample size	3989	3984	2780	2837	2832
R^2	0.081	0.11	0.11	0.027	0.13
Panel B: Excluding HIV-positive					
2010 × Near(<6km)	0.22***	32.4***	3.66***	0.99***	0.27
	(0.051)	(10.8)	(1.23)	(0.30)	(1.10)
2008 × Near(<6km)	0.15**	24.7***	1.05	0.082	0.85
	(0.071)	(9.17)	(1.00)	(0.17)	(1.03)
2010 × Middle(6-12km)	0.12**	9.91	1.23	0.34	0.13
	(0.048)	(10.0)	(0.90)	(0.22)	(0.69)
2008 × Middle(6-12km)	0.096*	11.6**	1.48*	0.054	0.54
	(0.050)	(5.90)	(0.81)	(0.15)	(0.81)
Sample size	3809	3803	2660	2715	2710
R^2	0.085	0.12	0.11	0.028	0.14

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. The omitted distance catagory is individuals living further than 12 km from the nearest ART facility. All regressions include individual fixed effects and region-year dummies. 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. Regressions in Panel B exclude respondents who ever tested positive for HIV.

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

Table B.6 – Effect of ART Availability on Savings Behavior - Robustness using HIV-neg. and Balanced Panel

Dependent variable:	Has savings			Savings (USD)		
	(1)	(2)	(3)	(4)	(5)	(6)
2010 × ART Proximity	0.23***	0.20***	0.19***	29.3**	26.0*	21.6
	(0.045)	(0.050)	(0.052)	(12.5)	(13.3)	(13.7)
2008 × ART Proximity	0.22***	0.20***	0.19***	23.2**	21.4*	17.0
	(0.058)	(0.061)	(0.064)	(11.4)	(11.9)	(11.6)
Spatial controls	Yes	Yes	Yes	Yes	Yes	Yes
Demographic controls	No	Yes	Yes	No	Yes	Yes
Econ shocks and aid program controls	No	No	Yes	No	No	Yes
Sample size	2257	2257	2257	2259	2259	2259
R^2	0.098	0.11	0.13	0.14	0.16	0.17

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects, and region-year dummies. Spatial controls include population density and proximity to clinic, market, major road and school (interacted with post). Demographic controls include pre-period wealth, age, household size, gender, education, and marital status. Controls for economic shocks and other aid programs are described in detail in the text. The sample is restricted to individuals who are HIV-negative and excludes respondents who did not consent to testing. Additionally, the regressions are restricted to the fully balanced panel.

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

Table B.7 – Effect of ART Availability on Expenditures on Children - Robustness using HIV-neg. and Balanced Panel

Dependent variable:	Education (USD)				Medical (USD)				Clothing (USD)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
2010 × ART Proximity	4.44*	3.52	4.25**	4.20**	0.93*	0.95*	1.13**	1.19**	0.99	0.51	0.16	0.38
	(2.39)	(2.11)	(2.01)	(1.94)	(0.55)	(0.54)	(0.55)	(0.54)	(1.01)	(1.11)	(0.96)	(1.04)
2008 × ART Proximity	-0.33	-1.55	-0.84	-0.90	-0.014	0.011	0.19	0.26*	-1.33	-1.90*	-2.24**	-2.03**
	(0.72)	(0.93)	(1.19)	(1.26)	(0.14)	(0.15)	(0.15)	(0.14)	(0.86)	(0.96)	(0.99)	(1.01)
2006 × ART Proximity				-0.28				0.24				0.81
				(0.99)				(0.19)				(0.80)
Spatial controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic controls	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Econ shocks and aid program controls	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Sample size	744	744	744	744	880	880	880	880	876	876	876	876
Adjusted R^2	0.13	0.15	0.16	0.15	0.058	0.062	0.064	0.063	0.15	0.16	0.19	0.19

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions include individual fixed effects, region-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 regression use data from 2004. Regressions in columns (1), (5), and (9) are restricted to the balanced panel. Spatial controls include population density and proximity to clinic, market, major road and school (interacted with post). Demographic controls include pre-period wealth, age, household size, gender, education, and marital status. Controls for economic shocks and other aid programs are described in detail in the text. The sample is restricted to individuals who tested negative for HIV in 2008, and excludes individuals who did not consent to the test. The regressions are also done on a perfectly balanced panel, so that respondents have data for all relavent variables in all 4 years of the survey.

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

Table B.8 – Effect of ART Availability on Schooling and Kids Health - Distance Dummies

Dependent variable:	Grades completed			In excellent health		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel B: Full sample						
2010 × Near(<6km)	0.55**	0.67**	0.63**	0.23**	0.19	0.18
	(0.24)	(0.32)	(0.31)	(0.10)	(0.13)	(0.13)
2008 × Near(<6km)	0.26	0.40	0.33	0.14	0.10	0.06
	(0.16)	(0.24)	(0.24)	(0.10)	(0.11)	(0.12)
2010 × Middle(6-12km)	0.20	0.15	0.15	0.16**	0.13	0.15
	(0.19)	(0.20)	(0.20)	(0.08)	(0.09)	(0.10)
2008 × Middle(6-12km)	0.05	0.01	-0.04	-0.02	-0.05	-0.05
	(0.10)	(0.13)	(0.13)	(0.09)	(0.10)	(0.10)
Sample size	1578	1578	1524	1578	1578	1524
Adjusted R^2	0.68	0.68	0.69	0.06	0.07	0.08
Panel B: Excluding HIV-positive						
2010 × Near(<6km)	0.66***	0.74**	0.70**	0.26**	0.20	0.19
	(0.23)	(0.31)	(0.31)	(0.10)	(0.13)	(0.13)
2008 × Near(<6km)	0.30*	0.39	0.33	0.17*	0.11	0.09
	(0.16)	(0.24)	(0.24)	(0.10)	(0.11)	(0.12)
2010 × Middle(6-12km)	0.26	0.21	0.19	0.18**	0.15	0.17*
	(0.18)	(0.19)	(0.19)	(0.08)	(0.09)	(0.10)
2008 × Middle(6-12km)	0.06	0.01	-0.04	-0.01	-0.05	-0.05
	(0.09)	(0.13)	(0.13)	(0.09)	(0.10)	(0.10)
Sample size	1521	1521	1476	1521	1521	1476
Adjusted R^2	0.69	0.69	0.69	0.07	0.08	0.09
Spatial controls	No	Yes	Yes	No	Yes	Yes
Demographic controls	No	No	Yes	No	No	Yes

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. The omitted distance catagory is individuals living further than 12 km from the nearest ART facility. All regressions include child fixed effects and region-year dummies. The sample is restricted to children who were reported in all three years of the survey (2006, 2008, and 2010). Regressions are weighted by inverse of number of children per household. Regressions in Panel B exclude children whose parents ever tested positive for HIV.

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

Table B.9 – Effect of ART on Savings and Investment (Without Individual Fixed Effects)

	Saving Behavior		Expenditures on Children (USD)		
Dependent variable:	Has savings	Savings (USD)	Education	Medical	Clothing
	(1)	(2)	(3)	(4)	(5)
Panel A: Full sample					
2010 × ART Proximity	0.081**	18.6**	3.81**	1.00**	1.04
	(0.037)	(7.10)	(1.90)	(0.43)	(0.87)
2008 × ART Proximity	0.096**	12.6*	-0.33	-0.072	-1.24*
	(0.045)	(7.26)	(0.79)	(0.086)	(0.70)
ART Proximity	-0.0072	5.77	0.36*	-0.067	0.17
	(0.031)	(4.15)	(0.18)	(0.082)	(0.30)
Sample size	3294	3288	928	1092	1084
Adjusted R^2	0.053	0.10	0.10	0.052	0.11
Panel B: HIV-negative sample					
2010 × ART Proximity	0.094***	17.9**	3.82*	1.03**	0.82
	(0.035)	(7.38)	(2.01)	(0.46)	(0.89)
2008 × ART Proximity	0.10**	15.0*	-0.47	-0.076	-1.38*
	(0.047)	(7.84)	(0.85)	(0.086)	(0.72)
ART Proximity	-0.0045	5.70	0.38**	-0.042	0.19
	(0.031)	(4.31)	(0.19)	(0.088)	(0.32)
Sample size	3147	3138	892	1052	1044
Adjusted R^2	0.056	0.10	0.10	0.054	0.11

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regressions are balanced but do not include individual fixed effects. All specifications include region-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). 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. Regressions in Panel B exclude respondents who ever tested positive for HIV.

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

Table B.10 – Effect of ART Availability on Savings and Investment (Without Individual Fixed Effects) - Robustness

	Saving Behavior				Expenditures on Children (USD)					
Dependent variable:	Has savings		Savings (USD)		Education		Medical		Clothing	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2010 × ART Proximity	0.095**	0.12**	15.2	19.0	3.90*	2.87	1.02**	1.02**	1.04	0.73
	(0.042)	(0.052)	(10.8)	(12.7)	(1.99)	(1.96)	(0.46)	(0.47)	(0.93)	(1.02)
2008 × ART Proximity	0.11**	0.13**	9.47	12.6	-0.26	-1.53*	-0.052	-0.059	-1.27*	-1.76**
	(0.048)	(0.052)	(9.36)	(10.2)	(0.76)	(0.89)	(0.12)	(0.13)	(0.68)	(0.76)
ART Proximity	-0.0072	-0.024	5.77	1.66	0.49	0.0048	-0.040	-0.098	0.18	-0.19
	(0.031)	(0.037)	(4.15)	(3.67)	(0.34)	(0.40)	(0.078)	(0.094)	(0.33)	(0.35)
Spatial controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Sample size	3294	2751	3288	2748	928	872	1092	1036	1084	1032
Adjusted R^2	0.052	0.13	0.10	0.23	0.10	0.13	0.049	0.10	0.11	0.23

Note: Standard errors (in parentheses) are clustered by village and robust to heteroskedasticity. ART proximity is parameterized as the negative of log distance by road. All regression are balanced but do not include individual fixed effects. All specifications include region-year dummies, and month of interview controls. Regressions reported in columns 5-10 are restricted to respondents with school-age children and weighted by inverse of number of household respondents. Columns 5-10 also use data from 2004. Spatial controls include population density and proximity to clinic, market, major road and school (interacted with post). Demographic controls include pre-period wealth, age, household size, gender, education, and marital status.

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