Got Milk? The Impact of Heifer International's Livestock Donation Programs in Rwanda

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Abstract: International animal donation programs have become an increasingly popular way for people living in developed countries to transfer resources to families living in developing countries. We evaluate the impact of Heifer International's dairy cow and meat goat donation programs in Rwanda. We find that the program substantially increases dairy and meat consumption among Rwandan households who were given a dairy cow or a meat goat, respectively. We also find marginally statistically significant reductions in wasting (weight for height) and underweight (weight for age) measures of about 0.4 standard deviations among children aged 0-5 in households that were recipients of meat goats, and reductions in stunting (height for age) of about 0.5 standard deviations among children in households that received dairy cows.

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I. INTRODUCTION

The Food and Agricultural Organization of the United Nations estimates that worldwide 870 million people are undernourished (FAO, 2012). One-third of the world's children are affected by delayed growth and development due to malnutrition, in addition to the 40,000 children who die each day from malnutrition-related causes (Behrman et al., 2003). In many developing countries, decades of official aid appear to have had little impact on reducing poverty and food insecurity (Sabates-Wheeler and Devereux, 2010).

A number of non-profit international development agencies have sought to address this crisis, among them Heifer International, a U.S.-based nongovernmental organization (NGO) whose mission is "to work with communities to end hunger and poverty and care for the Earth" (http://www.heifer.org/ourwork/mission). During the organization's 60 years of operation, Heifer projects have reached millions of people spanning 128 countries through its signature livestock donation programs, complemented by training in livestock care, environmental protection, business development, leadership, and gender equality. The extensive track record and favorable public opinion of Heifer's – and other NGOs' – animal donation programs notwithstanding, there has been no prior rigorous quantitative evaluation of these programs' performance that we or Heifer could identify. Given that animal donations are expensive – Heifer (personal communication) reports that the average full cost of a pregnant cow, delivered to the Rwandan beneficiary households we study, is roughly $3000 –solid evidence of impact is arguably long overdue.

The research we report in this paper evaluates the impact of two of Heifer's animal donation programs in Rwanda, one that donates dairy cows, and one that donates meat goats. One cornerstone goal of the Heifer program is improving the nutritional outcomes of participating households. We therefore examine program impacts on household dietary diversity and on child nutritional attainment as determined by stunting, wasting, and underweight measures.

Using several econometric models, this paper compares beneficiary households with households likewise targeted for animal donations but that have not yet received animals, and with households that were not approved to receive animals. The results show large and highly statistically significant increases in household dairy consumption and household meat consumption among dairy cow and meat goat recipients, respectively. Our findings also indicate that livestock donations positively impact child health and nutrition, as evidenced by anthropometric data. Donations of dairy cows have a significant correlation with improvement in stunting measures of children, but have no effect on wasting measures, whereas donations of meat goats are significantly correlated with improved wasting measures without affecting stunting measures. In some specifications, donations of meat goats as well as dairy cows are also correlated with improved underweight measures.

II. BACKGROUND

Malnutrition results from a combination of an inadequate intake of calories, micronutrients, and high-quality protein (Black et al. 2008, Victora et al. 2008). Research increasingly demonstrates that animal-source foods provide complete protein, energy, and an array of micronutrients that are often limited or unavailable in the rural peasant diet (Scrimshaw, 1994). In addition to providing a good source of protein and calories, meat and milk products are an important source of calcium, selenium, zinc, and vitamins A and B-12. Inadequate intake of these nutrients is associated with anemia, poor growth, rickets, impaired cognitive performance, hypothyroidism, blindness, and neuromuscular deficits. Even relatively small amounts of animal-source foods can substantially increase nutrient adequacy (Murphy and Allen, 2003). While there are other methods of obtaining these micronutrients, it is difficult to even approach meaningful levels of nutrients such as calcium and vitamin B-12 on a plant-based diet with a poverty-level income (Murphy, Beaton, and Calloway, 1992). Low incomes, in tandem with limited access to animals, often means that poor households consume few animal-source foods, are forced to rely on less expensive, imperfect substitutes, and their children suffer malnutrition (Neumann et al., 2002).

In a review of the challenges facing child nutrition in sub-Saharan Africa, Lartey (2008) notes that early childhood malnutrition likely accounts for the high prevalence of stunting and underweight measures reported for children. In Africa, 40% of children younger than five years old are moderately or severely stunted (UNICEF, 2010). Many cross-sectional studies of high-risk children have identified associations between stunting and cognitive ability. Compared with non-stunted children, stunted children are less likely to be enrolled in school, more likely to enroll late, to attain lower achievement levels or grades for their age, and have poorer cognitive ability or achievement scores. Although there are fewer studies concerning younger children, several empirical connections have been established between child development measures and height-for-age, as well as weight-for-age. For an overview of these findings, see Grantham-McGregor et al. (2007).

The earliest stages of life for children are both “sensitive,” since the effects of experience during this time on neural and physical development are unusually strong, as well as “critical,” since these effects are largely irreversible (Knudsen, 2004). In this vein, economic or environmental shocks early in life have been shown to affect future outcomes (Victora et al.

2008). A study of drought and civil war in the first two years of a child's life has shown a reduction in child height and schooling (Alderman et al., 2006), while beneficial rains in the year of a girl's birth are associated with an increase in her adult height, years of schooling, and wealth (Maccini and Yang, 2009) and participation in an early childhood nutrition intervention is associated with increased adult educational attainment, body size and work capacity, as well as higher adult economic productivity and wages (Hoddinott et al. 2008, Maluccio et al. 2009, Martorell et al. 2010) .

For many of the poor in the developing world, livestock ownership offers a potential pathway out of poverty and malnutrition. In a household facing imperfect markets, there are various channels through which livestock ownership impacts the health and nutrition status of households. The following framework (adapted from Nicholson et al, 2003), presents the positive and negative implications of livestock ownership on health outcomes.

The direct health benefits of livestock ownership lie in the increased availability and consumption of animal source foods which provide essential nutrient supplements and dietary diversity and mitigate seasonal fluctuations in food crop availability (Murphy and Allen, 2003; Wilson at al., 2005). Through sales of animal products, livestock ownership also increases household income, which can be used for the purchase of higher-quality healthcare and food thereby increasing nutrient bioavailability to household members (Senauer, 1990; Kennedy, 1994). The gender pattern of income control affects household's propensity to spend additional income on food and health related items (Thomas, 1997; Tangka et al., 2000), since female control of household resources is often associated with consumption preferences which favor basic needs and child welfare (Rogers, 1996). Because women and girls commonly bear husbandry responsibilities for lactating animals (and poultry), increased holdings of such livestock commonly gives women greater control over resources within the household (McPeak and Doss 2006). Additionally, livestock contribute to efficient nutrient cycling by increasing soil nutrient content and crop yields (Delve et al., 2001).

However, due to time and resource constraints, increasing livestock ownership may decrease the (financial and time) resources devoted to food crops, reducing production, consumption and sales. Unconfined livestock also commonly damage standing or stored crops. Animal keeping can also raise the incidence of zoonotic disease, either through direct transmission or contamination of food and/or water resources. By increasing labor demand, especially from the females of the household, animal ownership may decrease the time and quality of care for children (von Braun et al., 1994; Huffman, 1987).

The possibility of both positive and negative effects of transferring livestock to poor, rural households raises the natural question: what net impacts do animal donation programs have? To the best of our knowledge, there has been no prior, rigorous study on the net impact of livestock donations. However, extensive research has been done regarding the impact of animal *ownership* on various health and nutritional outcomes. A comprehensive three-country study showed that the intake of animal-source products positively affected both physical and developmental outcomes in children, illustrating the potential utility of these foods in the diet (Neumann et al., 2002; Neumann and Harrison, 1994; Harrison et al., 1987). Several studies carried out in East Africa have found a positive association between dairy cow ownership and the nutritional status of children. Hitchings (1982) showed a positive correlation between child height and the ownership of a milk cow, conditional on milk being used for family consumption. Leegwater et al. (1991) provide evidence that the nutritional status of pre-school children in the households participating in the National Dairy Development Project in Kenya was better than that of children from non-participating households. Vella et al. (1995) show that the ownership of a cow in rural Uganda is a significant predictor of median child height-for-age, while Grosse (1998) finds that in rural Rwanda, an index of dairy animal ownership has a strong positive association with child height-for-age. In contrast, studies examining the role of non-dairy livestock tend to indicate that ownership of these animals has no strong relationship with child nutritional status (Annan, 1985; Vella et al., 1995).

III. Data And Methodology

Our data come from surveys of 406 households collected during the summer of 2011 in Rwanda, a small, densely populated country in East Africa. Heifer International has many ongoing projects in Rwanda, donating a wide variety of animals and providing various educational interventions. Our research team conducted surveys in two regions, one in which Heifer had initiated a dairy cow donation program and the other in which the organization had carried out widespread donation of meat goats. In the dairy cow region, Ruli (northern Rwanda), 224 households were surveyed. In this region, Heifer donates dairy cows to coffee farmers belonging to two distinct coffee cooperatives. The goal of the program is to increase dairy consumption and production in the region (as well as to increase coffee output via a fertilizer access program).

In order to qualify to receive a dairy cow, applicant households must meet a given set of requirements. The most stringent requirements are that households have at least one hectare of land, and they must commit to constructing a shed with a cement floor and metal roof to house the cow. (Once selected, Heifer provides loans to the beneficiaries to purchase building materials.) Households must not currently own a high-producing dairy cow, however, owning local-breed cows, which have much lower milk yields, is permissible. Note that eligible households are neither the poorest – who cannot afford to meet the program requirements – nor the richest – who might already own the most productive livestock breeds available. This non-random eligibility necessitates paying attention to selection criteria and to making a concerted effort to properly control for prospective ex ante differences between animal donation beneficiaries and non-beneficiaries in program evaluation. Such ex ante differences could easily be independently correlated with differences in food consumption patterns and child anthropometric indicators of nutritional status.

Beyond these requirements, Heifer International was unable to provide a clear set of secondary selection criteria. According to Heifer International staff, beneficiaries are selected based on need as determined by a team of assessors. During the selection process, Heifer staff visit applicant households and review various household characteristics such as income, number of children, widow(er) status, etc. Upon selection, Heifer gives each beneficiary household an imported, pregnant cow. The imported cows produce a significantly greater amount of milk than the local cow breeds (up to 15 liters of milk per day after they give birth). Beneficiary households are required to give away the first female offspring of their cow as part of Heifer's "Pass on the Gift" initiative. If the offspring is a male (bull), beneficiaries may sell it for a considerable profit (approximately US $250-$1,000). Heifer International provides ongoing insemination services to beneficiaries so that the dairy cows may continue to produce milk and offspring. The sample for this research was chosen to include only recipients of first-generation imported dairy cows, not recipients of cows via the "Pass on the Gift" program.

In addition to the dairy cow program, an additional 182 surveys were collected from households in Heifer's meat goat region, Kirehe (eastern Rwanda). Kirehe is near the Tanzanian border, and is home to a large population of refugees who returned to Rwanda after the 1994 genocide. The area is much poorer overall than Ruli, with limited access to markets and less developed infrastructure. In Kirehe, the meat goat program is designed specifically as a poverty reduction tool and thus the participants are noticeably poorer than in Ruli. Researchers noted that Heifer's meat goat donation program is not as well organized or operated as the dairy cow program. While there is still an official requirement that beneficiaries build sheds to house the donated goats, the research team noticed many households where goats were tied to trees, or kept on concrete slabs with no roof. Upon selection into the program, each beneficiary household is given two female goats. A few beneficiaries in each area are also given a male goat to breed with the area's female goats. Heifer expects households to breed the goats for sale and/or consumption.

In both regions, the sample is divided into three groups. The first group consists of households that received an animal (dairy cow or meat goat, depending on the region) one year prior to the survey; we refer to members of this group as "Beneficiaries." The second group consists of households that applied to receive an animal and were approved to receive one in the near future (within a month following the survey); we call members of this group "Prospectives." The last group consists of households that applied to receive an animal in the upcoming cycle, but were excluded by Heifer during the screening process; this group we call "Nevers." For the purpose of this paper, the group "Qualified" includes both Beneficiaries and Prospectives—that is, all households in the sample that were qualified and selected to receive animals from Heifer International either the year prior to or at the time of data collection.

All households surveyed are similar in that they all expressed an interest in receiving an animal by applying to the livestock donation program. Thus, a household's program participation was determined by Heifer's eligibility criteria. We undertook substantial effort to ascertain why the Beneficiaries were given first priority to receive the animals among all qualified families out of concern for unobserved heterogeneity issues, but were never given satisfying answers to this question. It appears that in some cases the first round of donations were distributed to highly prioritized families, while in other cases the decision was made based on logistics. Unfortunately, this decision-making process was not systematic program-wide. To the extent that idiosyncratic factors related to first-round selection are orthogonal to impact variables, we are able to ascribe causality to our impact estimation results. We carry out robustness checks in our estimations to see how sensitive the significance of our results is to potential endogeneity related to the order of animal distribution. If anything, poorer households with more malnourished children and limited access to animal-source foods were targeted for initial donations, so our estimates of program impact should, if anything, be biased against finding a favorable effect on dietary diversity and child nutrition outcomes.

Heifer staff provided lists of Beneficiaries, Prospectives, and Nevers in each region, and the team attempted to survey every listed household. If household members were not easily contacted, multiple efforts were made to reach them, including phoning friends and neighbors, and visiting houses multiple times to establish contact. In the event that the animal recipient or applicant was not present at the time of visit, the spouse or the eldest member of the household was interviewed.

The regressions we estimate take the general form:

$$Y = \beta_0 + \beta_1(Qualified) + \beta_2(Cow\ Beneficiary) + \beta_3(Goat\ Beneficiary) + \beta_4(North) + \gamma(Controls) + e_i \qquad (1)$$

where Y is a measure of nutritional outcomes, "Qualified" is a dummy variable indicating that the household either received an animal last year or will receive one soon (*i.e.*, is either a Beneficiary or Prospective household). The estimated β_2 and β_3 coefficients measure the marginal effect of receiving a cow or goat, respectively, given that a household requested and qualified to receive an animal from Heifer International. The Qualified variable controls for any unobservable characteristics possessed by the Beneficiary and Prospective households that caused the Never households to be rejected for animal donation. The dummy variable "North" ensures that the households in the north and east regions are only compared to others within their region (*e.g.*, cow Beneficiaries, cow Prospectives, and cow Nevers are compared to each other, but not to households in the goat region). This control is important as the regions vary greatly in terms of income, infrastructure, and climate, as well as in animal donation program design. Controls used in the models include household characteristics and asset ownership (as well as child health characteristics, where appropriate). Variables for non-Heifer animal ownership are also included to be sure that the effect captured by the analyses is from receiving the Heifer animal specifically, and not picking up a general effect of animal ownership.

Table 1 presents the mean, standard deviation, minimum, and maximum values for each control variable included in our regressions. The average survey respondent in our sample is 46 years old, and has 4 years of education. The average respondent's household is made up of 5.5 members, and owns 0.7 hectares of land, 2 machetes, and 1 cell phone. The number of food groups consumed by respondents in the last two days ranged from 1 to 16, with an average of 6.63. Qualified households make up 80% of our sample, with 20% and 21% consisting of Goat and Cow beneficiaries, respectively.

IV. Impact on Dietary Diversity

Economic theory suggests that receiving a transfer will have an income effect that increases the number of food groups consumed overall by recipient households, because dietary diversity increases with income (Behrman and Deolalikar 1989). Abundant evidence also shows that when transfers are given in–kind, the induced marginal increases in consumption tend to concentrate disproportionately in the transferred good (Barrett 2002). This implies that in the case of dairy cow and meat goat donations, we would expect households to especially increase dairy and meat consumption, respectively, but perhaps also increase the number of food groups consumed overall by individuals.

Dietary information is notoriously difficult to gather using surveys. If given a lengthy reporting period, respondents often forget what they ate, or report what they think they eat on average during a normal week or month. To avoid these issues, respondents were given defined categories of food and asked how many times they ate foods in each category in the last two days. The survey questions both prompted the respondents to remember everything they ate, and limited the recall period for more accurate results. The survey questions were modified from the 2006 Demographic and Health Survey in Uganda. To measure the monthly consumption of dairy and meat per person in the household, respondents were asked how much milk or meat their household produces each month, how much is sold, and how much is consumed. The amount of total household consumption was then divided by the number of members in the respondent's household to establish the amount consumed per-person-month. If respondents did not know how much meat or milk was produced or consumed in a month, the information was recorded per week or per day and converted into a monthly figure upon entering the data.

Individual Dietary Diversity

Dietary diversity was measured by consumption within 16 dietary food groups from four major categories: staples, fruits and vegetables, starches, and other foods (Appendix A). We begin by testing for an effect of animal donations on the total number of food groups and on the number of non-dairy food groups consumed by the survey respondent in the last two days. Table 2 reports the ordinary least squares (OLS) estimates of equation (1), with robust standard errors, with the number of food groups consumed by survey respondents in the last two days as the dependent variable. There appears to be no effect of meat goat donation on the number of food groups consumed. However, the coefficient on the variable for cow beneficiaries is positive and statistically significant at the one percent level, indicating that receiving a Heifer cow is highly correlated with an average increase of 1.2 food groups consumed in the last two days.

This effect appears to be exclusively driven by the respondents' consumption of dairy products, however. In the second regression in Table 2, where the dairy food groups have been removed, there is no significant effect of being either a cow beneficiary or goat beneficiary on the number of food groups consumed. Dietary diversity appears to increase only via increased dairy consumption by beneficiaries of dairy cow donations. The variable "North" is positive and highly significant in both regressions which is unsurprising as, noted earlier, Ruli is a wealthier region overall than Kirehe. The coefficient estimates related to the various control variables such as land or phone ownership, when statistically significant, conform with expectations based on the pre-existing literature.

We estimate the effect of animal donation on dairy and meat consumption by the survey respondent in the last two days using Poisson regressions. These dependent variables are described by count data between zero and six, with a large number of observations censored at zero. Table 3 shows that cow beneficiaries consumed dairy an average of one more time in the last two days compared to the control groups. This effect is quite significant considering that the entire sample consumed dairy, on average, only 1.4 times in the last two days. The results also show that while wealth indicators, such as the number of cell phones or machetes or the amount of land owned by the household, are highly correlated with respondent meat consumption, we see no effect of being a goat beneficiary on meat consumption in the last two days. This may be because there is no effect, or possibly because meat is consumed too infrequently to be picked up by a dietary diversity measure based only on the last two days.

Household Dairy Consumption

To test whether animal donations affect household-level dairy and meat consumption, we use robust Tobit regression. The Tobit model allows us to estimate the effect of the independent variables on the zero and positive values of the dependent variable separately, but reports a coefficient that is conveniently interpreted as a marginal effect.

Table 4 shows that household monthly per-person dairy consumption is positively associated with being a cow beneficiary. Receiving a Heifer cow one year ago is associated with a statistically significant 9.15-liter increase in monthly per-person dairy consumption today compared to the control groups. This represents a nearly three-fold increase over the sample mean value of 3.6 liters per month. This likely partly reflects Rwandan households' propensity to consume *ikivuguto*, a yogurt-like substance made from fermenting milk. This process reduces the volume of dairy so that what began as a liter of milk becomes less than 0.5 liters of yogurt. Not surprisingly, having a non-Heifer cow is also highly correlated with dairy consumption, highlighting the importance of controlling for non-Heifer animal ownership. Interestingly, the impact coefficients of the Heifer and non-Heifer cows are roughly proportional to the milk yields of the two different breeds.

Household Meat Consumption

Table 4 also shows that being a Heifer meat goat recipient one year ago is correlated with an added monthly per-person meat consumption of 0.2 kilograms, although this result is significant at only the 10-percent level. This effect, however, would constitute a nearly 100-percent increase above the sample mean of 0.27 kilograms of meat per-person per month. As above, households in the north consumed more meat regardless of beneficiary status. Also of note, owning pigs or sheep was significantly correlated with meat consumption.

Household Dairy and Meat Consumption Using Propensity Score Matching

As a check on the Tobit results just discussed, we estimated the average treatment effects on the treated using Propensity Score Matching (PSM). Since every household in the sample expressed interest in receiving an animal, treatment was based on the fulfillment of Heifer criteria, which were largely based on observable household characteristics. Using variables that reflect these criteria to estimate the likelihood of selection into the animal donation program, we estimate propensity scores for each household via probit regressions (Appendix B1). We then match treated households (Beneficiaries) with un-treated households (Prospectives) based on their propensity scores to create "pre-" and "post-treatment" groups among our sample of Qualified households. The mean difference between matched treated and untreated households represents the estimated average treatment effect on the treated. Matching is carried out separately for the northern and eastern sub-samples to make sure that an observation from the north region is not matched to an observation from the east region. Variables are only included in the estimation of propensity scores if they are unaffected by program participation (or the anticipation of it).

Due to a limited sample size, the PSM probit is estimated on a select few control variables. In keeping with the literature on matching models, the controls are selected by finding the top four or five variables that are most correlated with both the treatment and the outcome variable. After running the PSM models, balancing tests verify that there is no statistically significant difference between the means of matched pairs. In order to account for the fact that the PSM variance of treatment effect does not include the variance due to estimation of the propensity scores, imputation of common support, and possibly also the order in which treated individuals are matched (Caliendo and Kopeinig, 2005), we also bootstrap standard errors, re-estimating the results starting from the first step of propensity score estimation 50 different times.

As seen in Table 5, the PSM results for dairy consumption are very similar to the results found using the Tobit regression. We find that receiving a dairy cow has an average treatment effect on the treated (ATT) of 9.32, meaning that in Beneficiary households, members on average consumed 9.32 more liters of milk per month than members of Prospective households. The result is significant at the one percent level. This is statistically indistinguishable from the 9.15 liters estimate above.

Since PSM estimators are not robust to the presence of unobserved characteristics that influence both assignment into treatment and the outcome (Rosenbaum, 2002), Rosenbaum bounds are used to see the degree to which the significance of the results relies on the untestable conditional independence assumption (Becker and Caliendo, 2007). Rosenbaum bounds measure how confounded treatment selection would have to be under the worst-case scenario (of endogeneity bias) for causal effects from a matching analysis to lose their significance (DiPrete and Gangl, 2004). In other words, Rosenbaum bounds measure how strongly an unobserved variable that is correlated with both treatment *and* the outcome variable would need to affect selection into treatment in order to invalidate the results. The Rosenbaum bounds output gives a threshold value, Γ, which represents the threshold effect of unobserved covariates on the odds ratio of treatment at which the significance of the result becomes statistically questionable.

The Rosenbaum bounds test on the dairy consumption PSM results suggest that significance at the five-percent level is only invalidated at a Γ of 5.5 (Table 5). This means that if there is an unobservable characteristic that causes the odds ratio of self-selection to be 5.5 times higher for those who were eventually treated, *and* the characteristic is perfectly correlated with dairy consumption, the results would no longer be valid at the five percent level. While there is no hard-and-fast rule on what Γ threshold is acceptable for ruling out endogeneity as the cause of statistical significance, it seems highly unlikely that selection based on unobservables into dairy cow treatment could be biased to this degree as to invalidate this result.

Table 5 also shows the results for the PSM for goat donation on meat consumption. The estimated average treatment effect on the treated indicates that being a goat recipient is correlated with increased per-person monthly meat consumption of 0.17 kilograms, a result significant at the 10 percent level. The ATT of 0.17 is statistically insignificantly different from the estimated effect of 0.20 kilograms found in the prior Tobit regression without matching.

The Rosenbaum bounds test on the meat consumption PSM results yield a critical level of Γ of 1.4, indicating that the results are moderately sensitive to potential selection on unobservables. As indicated previously, meat consumption is sufficiently rare that the effects of meat goat donation may be very subtle and hard to measure. It is therefore unsurprising that the Γ is considerably smaller for meat consumption than for dairy.

V. Impact on Child Nutritional Status

The nutritional status of children under the age of five years[1] provides a good reflection

[1] Infants typically do not directly consume dairy products, much less meat, so if one were interested exclusively in the effect of animal donation on child nutrition due solely to direct consumption of animal source foods, it might be

of the nutritional well-being of developing countries, since children are the most vulnerable to the problems arising from inadequate food intake and disease. Because insults to child nutritional status tend to persist and are thus strongly correlated with adult stature, which is itself strongly correlated with adult earnings, child nutritional status also offers an important leading indicator of economic productivity in subsequent years (Victora et al. 2008).

Anthropometric measurement of weight and height, as well as data on sex and age, provide the basic information needed to assess a child's nutritional status (Quinn, 1992). Malnutrition is often characterized in chronic or acute forms. Acute malnutrition, or wasting, measured as the ratio of weight to height (WHZ), indicates short-term deficiencies such as illness or severe food shortages. Chronic malnutrition, or stunting, measured as the ratio of height to age (HAZ), is more common than acute malnutrition and reflects past shortage of food intake and recurring bouts of illness. A low weight for age (WAZ), or underweight, indicates that a child is affected by chronic and/or acute malnutrition. These measures are converted to z-scores, the number of standard deviations from a reference population conditional on age and sex, as outlined by the World Health Organization's global child growth reference standards (http://www.who.int/childgrowth/en/), where $z \geq -1.0$ is normal, $-1.0 > z \geq -2.0$ is mild malnutrition, $-2.0 > z \geq -3.0$ is moderate malnutrition, and $z < -3.0$ is severe malnutrition. It is important to note that a *higher* z-score is interpreted as a *lower* degree of stunting or underweight or wasting and vice versa. The standardized z-scores can be compared between age groups as well as between indicators of malnourishment.

We estimate the effect of animal donations on these measures of malnutrition for individual children ages 0-60 months old. The sample is composed of 99 children in the north and 129 children in the east region, 43 and 62 of whom are from beneficiary households that have received a dairy cow or a meat goat, respectively. The distribution of z-scores in the sample indicates the prevalence of malnutrition. As shown in Table 6a, a majority of sample children are at least mildly stunted. But underweight and wasting are far less frequent; indeed, in the northern subsample, there was no moderate or severe wasting, reflecting the fact that recent harvests had been good and economic growth over the past year quite robust in Rwanda. The sample prevalence of moderate and severe malnutrition reasonably closely mimics the Rwandan national pattern, as seen in Table 6b.

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appropriate to restrict the subsample. Because we are interested in the net effects of animal donation, however, which includes effects mediated through the nutrition of breastfeeding mothers, hygiene within the household – which can be affected by the presence of livestock and perishable products in the absence of refrigeration – income effects due to animal ownership, time spent on childcare, etc., we include all children under five years of age. The relatively small size of our sample of children also favors this more inclusive approach for practical, statistical reasons.

We estimate the effect of dairy cow and meat goat donations on individual child nutritional status using a Seemingly Unrelated Regressions (SUR) estimator. The SUR specification allows error terms to be correlated across indicators, which is consistent with both theoretical and empirical findings (Randolph, 1992). The variables used in the regression analysis are described in Table 1b. We check the robustness of the SUR results using a PSM estimator. The limited sample size makes PSM an imprecise approach; in this case it is used as a backup validation technique only.

We estimate equation (1) including a range of control variables. Child-specific characteristics include age (linear and quadratic), sex, and birth order, which have been found to be significant determinants of nutritional and health status (Nicholson et al, 2003). Child health controls, including variables reflecting breastfeeding, hospitalization, incidence of diarrhea, and milk consumption, were taken from the Demographic and Health Survey of Rwanda. Household characteristics contain information about the maximum education level of persons living in the household, mother's age, and number of family members. Finally, asset ownership such as the building material of the house, the household's access to water from a pipe inside the home or a communal well/tap, number of mobile phones and sickles compose a rough wealth index to control for the effects of income on child nutrition.

Estimation Results

Table 7 shows the SUR estimation results. Donations of dairy cows show a positive and statistically significant (at the 10-percent level) effect on the mean height-for-age *z*-score for children, consistent with the results of Vella (1995) and Grosse (1998). The magnitude of 0.57 standard deviations is larger than the effects (of dairy cow *ownership)* reported by Vella (1995) and Grosse (1998) which range from 0.29 to 0.35 standard deviations, but similar to the effects reported by Nicholson et al. (2003) which ranged from 0.60 to 1.12 standard deviations in SUR and random effects models, respectively. However, dairy cow donations do not show a significant effect on wasting or underweight measures (magnitudes of -0.03 and 0.40, respectively, both insignificant at any standard confidence level). The effect on stunting could be interpreted as an indication of the role of dairy cattle as a long-term nutritional solution, consistent with the findings of Hitchings (1982).

In the case of meat goat donations, we do not observe a statistically significant effect on child stunting. However, meat goat donations are found to have a statistically significant and positive impact on wasting measures of 0.47 standard deviations. This is consistent with the idea that the increased household consumption of meat arising from meat goat donations improves a child's nutritional status in the short-term due to the increased uptake of animal-source foods. However, this result begs further analysis in light of contradicting previous literature that states that non-dairy livestock has not been shown to improve nutritional status.

Lastly, the estimation results show that both meat goat and dairy cow donations are associated with increased WAZ, by 0.40 standard deviations (significant at the 10% level for meat goats and marginally insignificant for dairy cows at only the 12% level). Since low underweight measures signify a combination of chronic and acute malnutrition, it is not surprising that increased consumption of animal source foods either from meat goats or dairy cows alleviates acute or chronic malnourishment, respectively, and improves underweight measures.

In the stunting model, being selected into program participation (*i.e.*, either as a beneficiary or a prospective beneficiary) was found to hold an inverse (although insignificant) relationship with HAZ measures. Regional effects are a significant predictor of stunting, which is not surprising given the lower mean stunting *z*-scores in the northern region. Age was found to be significantly negatively related to the height-for-age, albeit at a decreasing rate, as is typical in the literature. As expected, longer periods of breastfeeding correspond to higher HAZ, while a higher incidence of diarrhea corresponds to a lower HAZ. Ownership of a local cow (not of European germplasm) is negatively associated with HAZ, in contrast to the findings of Nicholson et al (2003).

The coefficients of interest found in our model for child wasting measures in Table 7 are the regional effects (mean wasting *z*-scores in the eastern region are lower than mean wasting *z*-scores in the northern region) and the positive effect of consumption of milk in the last two days. In our underweight model, selection into treatment is negatively related with WAZ measures, as is age and incidence of diarrhea over the last two weeks. It is interesting that the number of times a child has visited the hospital in the last month is positively (albeit insignificantly) related to improved anthropometric measures; it is possible that rather than indicating poor child health, this variable instead serves as a gauge of household wealth or health education.

Results from Propensity Score Matching

PSM offers a robustness check on the SUR analysis. Children from Beneficiary households are matched to children from Prospective households (matching is carried out separately for each region). The chosen matching specification is one-to-one nearest neighbor matching with replacement. The focus of this specification is to reduce bias, rather than solicit better hypothesis testing through lower variance. If replacement is allowed, the average quality of matching increases, which in turn decreases the bias of the coefficient estimate. Given the small sample size we do not expect statistically significant coefficient estimates. But if we minimize the bias of the coefficient estimates, the magnitudes can still be interpreted as a check on the magnitude of the more precisely estimated SUR coefficients.

We estimate the effect of dairy cow donations on child health in households in the North, and the effect of meat goat donations on child health in households in the east. We estimate selection into treatment using a Probit estimator (Appendix B2). While each estimation is on common support, balancing tests show that not all variables are balanced between beneficiaries and others.

None of the PSM estimates show a statistically significant effect of animal donations on child nutritional status, likely due to small sample size. Yet point estimates are fairly consistent with the SUR estimate. The estimated effect of dairy cow donations on HAZ (stunting) is 0.55 standard deviations in PSM, which is close to the statistically significant effect of 0.57 in the SUR model. The effect of meat goat donations on WHZ (wasting) is 0.40 standard deviations which is close to the statistically significant effect of 0.47 in the SUR model. The remaining coefficient estimates are shown in Table 8.

The lack of concrete statistical significance across all the models may be due to other factors besides small sample size. Specifically, some subjects did not know the precise date of birth of their children, which is necessary in correctly computing anthropometric *z*-scores. While this issue was treated in accordance with the prescription outlined by Quinn (1992) for conducting child nutritional surveys in developing countries, measurement error is still likely.

Nevertheless, our results point to a likely causal effect of livestock donations on child anthropometrics although the magnitude of the impact is not yet concretely quantifiable. While our estimations are indicative of positive anthropometric impact, they invite further research with larger sample sizes to more precisely gauge the impact of animal donation on children's health and establish the external validity of our results.

VI. Conclusions

The results of our research on the impact of livestock donations are encouraging for organizations looking to improve household dietary diversity and child nutritional status in developing countries. Animal donations appear to have a favorable effect on recipient households' diets, in particular on the consumption of animal source foods, and on child nutritional status in those households. More precisely, we find that the Rwandan households that received a dairy cow increased monthly dairy consumption by 9.15 liters per person, while families that received a donated meat goat increased monthly meat consumption by 0.20

kilograms per person, all relative to otherwise similar households that had not yet received a donated animal. Children under five years of age in households that received dairy cows enjoyed a statistically significant gain in height-for-age of 0.5 standard deviations, on average, and a statistically insignificant gain in weight-for-age of 0.4 standard deviations. Donations of meat goats had a statistically significant effect of 0.4 standard deviations on child weight-for-age, but a much smaller and statistically insignificant 0.1 standard deviation effect on child height-for-age. All of these results are corroborated by propensity score matching results, although the meat consumption impacts appear sensitive to the possible selection-on-unobservables effects.

This analysis underscores the role of livestock in improving diets and child nutritional status among poor rural families in the developing world. The promise evident in animal donation programs is apparent, even if the impacts remain difficult to estimate precisely in small, observational studies such as ours. A follow-up study using a randomized control trial design with long-term tracking would enrich our understanding of how animal donations affect dietary diversity, child and adult nutritional outcomes, and longer-term development results in developing countries, as well as the pathways through which such impacts are realized. This type of research carries important policy implications, not only for international programs like those of Heifer International, but also for local livestock intensification programs that focus on the role of livestock in rural households.

REFERENCES

Alderman, H., J. Hoddinott, and B. Kinsey. 2006. Long term consequences of early childhood malnutrition. *Oxford Bulletin of Economics and Statistics*, 58(4), 450-474.

Annan, A. 1985. The Socioeconomic Determinants of Malnutrition Among Preschool Children in Ghana. Ph.D. Dissertation, Cornell University.

Barrett, C. B. 2002. Food security and food assistance programmes. In Gardner, B. and Rausser, G. (eds.), *Handbook of Agricultural Economics*. Amsterdam: Elsevier Science.

Becker, S., and M. Caliendo. 2007. Sensitivity analysis for average treatment effects. *Stata Journal*, 7, Number 1: 71-83.

Behrman, J., and A. Deolalikar. 1989. Is Variety the Spice of Life? Implications for Calorie Intake. *Review of Economics and Statistics*, vol. 71, no. 4, pp. 666-672.

Behrman, J., Hoddinott, J., Maluccio, J., Quisumbing, A., Martorell, R., and A. Stein. 2003. The impact of experimental nutritional interventions on education into adulthood in rural Guatemala: Preliminary longitudinal analysis. Philadelphia, PA: University of Pennsylvania, Washington, DC: International Food Policy Research Institute, and Atlanta, GA: Emory University.

Black, R.E., L.H. Allen, Z.A. Bhutta, L.E.Caulfield, M. de Onis, M. Essati, C. Mathers, and J. Rivera. 2008. Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet,* (371): 243-260.

Caliendo, Marco & S. Kopeinig. 2005. Some practical guidance for the implementation of Propensity Score Matching. Institute for the Study of Labor Discussion Paper No. 1588.

Delve, R. J., Cadisch, G., Tanner, J. C., Thorpe, W. Thorne, P. and Giller, K. E. 2001. Implications of Livestock Feeding Management on Soil Fertility in the Smallholder Farming Systems of Sub-Saharan Africa. *Agriculture Ecosystems and Environment*, 84, 227-243.

DiPrete, T. A. and Gangl, M. 2004. Assessing Bias in the Estimation of Causal Effects: Rosenbaum Bounds on Matching Estimators and Instrumental Variables Estimation with Imperfect Instruments. *Sociological Methodology*, 34: 271–310.

FAO, The State of Food Insecurity in the World 2012, accessed 12 November 2012 at http://www.fao.org/publications/sofi/en/.

Grantham-McGregor, S., Y. B. Cheung, S. Cueto, P. Glewwe, L. Richter, B. Strupp, and the International Child Development Steering Group. 2007. Child development in developing countries 1: Developmental potential in the first 5 years for children in developing countries. Lancet, 369, 60-70.

Grosse, S. D. 1998. Farm Animals and Children's Nutritional Status in Rural Rwanda. Presentation at the Symposium on Human Nutrition and Livestock, October 14, 1998, Little Rock, Arkansas: Heifer Project International.

Harrison G, Galal O, Kirksey A, and Jerome N. 1987. Egypt Project: the Collaborative Research Support Program on Food Intake and Human Function. Final Report Washington DC., USAID.

Hitchings, J.A. 1982. Agricultural Determinants of Nutritional Status Among Kenyan Children. PhD. Dissertation, Stanford University.

Hoddinott, J., J. Maluccio, J. R. Behrman, R. Flores, and R. Martorell. 2008. Effect of a Nutrition Intervention during Early Childhood on Economic Productivity in Guatemalan Adults. *Lancet* 371 (9610): 411–416.

Huffman, S. L. 1987. Women's Activities and Impacts on Child Nutrition, in *Food Policy: Integrating Supply, Distribution, and Consumption*, J. P. Gittinger, J. Leslie, and C. Hosington, eds. Baltimore: The Johns Hopkins University Press. [EDI Series in Economic Development]

Knudsen, E. I. 2004. Sensitive Periods in the Development of the Brain and Behavior. *Journal of Cognitive Neuroscience*, 16(8), 1412-1425.

Kennedy, E. 1994. Health and Nutrition Effects of Commercialization of Agriculture, in *Agricultural Commercialization, Economic Development, and Nutrition*, J. Von Braun and E. Kennedy, eds. Baltimore: The Johns Hopkins University Press.

Lartey, Anna. 2008. Maternal and child nutrition in Sub-Saharan Africa: challenges and interventions. Proceedings of the Nutrition Society, 67, 105-108.

Leegwater, P., Ngolo, J. and Hoorweg, J. 1991. Dairy Development and Nutrition in Kilifi District, Kenya. Food and Nutrition Studies Programme, Report No. 35. Nairobi, Kenya: Food and Nutrition Planning Unit, Ministry of Planning and National Development; Leiden, Netherlands: African Studies Center.

Maccini, S., and D. Yang. 2009. Under the Weather: Health, Schooling, and Economic Consequences of Early-Life Rainfall. *American Economic Review*, 99(3), 1006-1026.

Maluccio, J. A., J. Hoddinott, J. Behrman, R. Martorell, A. Quisumbing, and A. Stein. 2009. The impact of Nutrition During Early Childhood on Education among Guatemalan Adults. *Economic Journal* 119 (April): 734-763.

Martorell, R., P. Melgar, J.A. Maluccio, A.D. Stein and J.A. Rivera. 2010. The Nutrition Intervention Improved Adult Human Capital and Economic Productivity. *Journal of Nutrition* 140 (2): 411-414.

McPeak, J., and C. Doss. 2006. Are Household Production Decisions Cooperative? Evidence on Pastoral Migration and Milk Sales from Northern Kenya. *American Journal of Agricultural Economics* 88 (3):525-541.

Murphy S. P., Beaton G. H., and D. H. Calloway. 1992. Estimated Mineral Intakes of Toddlers: Predicted Prevalence of Inadequacy in Village Populations in Egypt, Kenya, and Mexico. *American Journal of Clinical Nutrition,* 56:565-572.

Murphy, S. P., and L. H. Allen. 2003. Nutritional importance of animal source foods. *Journal of Nutrition,* 133(11S-II):3932S-3935S.

Neumann C. G., Harris D. M., and Rogers L. M. 2002. Contribution of animal source foods in improving diet quality and function in children in the developing world. *Nutrition Research,* 22.1/2: 193.

Neumann C. G., and G. Harrison. 1994. Onset and Evolution of Stunting in Infants and Children. Examples From the Human Nutrition Collaborative Research Support Program, Kenya and Egypt Studies. *European Journal of Clinical Nutrition*, 48(suppl.1): S90-S02.

Nicholson, C. F., Mwangi, L., Staal, S.J., and P. K. Thornton. 2003. Dairy Cow Ownership and Child Nutrition Status in Kenya. AAEA Meetings Selected Paper.

Quinn, V.J. 1992. A User's Manual for Conducting Child Nutrition Surveys in Developing Countries. Cornell Food and Nutrition Policy Program, Cornell University. [Working Paper 21]

Randolph, T. F. 1992. The Impact of Agricultural Commercialization on Child Nutrition: A Case Study of Smallholder Households in Malawi. PhD dissertation, Cornell University.

Rogers, B. 1996. The Implications of Female Household Headship For Food Consumption and Nutritional Status in The Dominican Republic. *World Development*, Vol. 24, No. 1, pp. 113-128.

Rosenbaum, P. R. 2002. *Observational Studies.* 2nd ed. New York: Springer.

Sabates-Wheeler, R., and S. Devereux. 2010. Cash transfers and high food prices: Explaining outcomes on Ethiopia's Productive Safety Net Programme. *Food Policy,* 35.4: 274-285.

Scrimshaw N. 1994. The Consequences of Hidden Hunger for Individuals and Societies. *Food and Nutrition*, 15: 3-23.

Senauer, B. 1990. Household Behaviour and Nutrition in Developing Countries. *Food Policy*, 15(5):408-417.

Tangka, F. K., M. A. Jabbar and B. I. Shapiro. 2000. Gender Roles and Child Nutrition in Livestock Production Systems in Developing Countries: A Critical Review. Nairobi, Kenya: International Livestock Research Institute. [Socio-economics and Policy Research Working Paper 27]

Thomas, D. 1997. Incomes, Expenditures, and Health Outcomes: Evidence on Intrahousehold Resource Allocation, in Intrahousehold Resource Allocation in Developing Countries: Models, Methods, and Policy, L. Haddad, J. Hoddinott, and H. Alderman, eds. Baltimore: The Johns Hopkins University Press.

UNICEF State of the World's Children. Special Edition on Children's Rights. 2010.

Vella, V., A. Tomkins, J. Nviku, and T. Marshall. 1995. Determinants of Nutritional Status in Southwest Uganda. *Journal of Tropical Pediatrics*, 41:89-98.

Victoria C. et al. 2008. Maternal and Child Undernutrition: consequences for adult health and human capital. *The Lancet*, Vol. 371: 340-57.

Von Braun, J. H. Bouis, and E. Kennedy. 1994. Conceptual Framework, in Agricultural Commercialization, Economic Development, and Nutrition, J. Von Braun and E. Kennedy, eds. Baltimore: The Johns Hopkins University Press.

Wilson, T., A. Pearson, N. Bradbear, A. Jayasuriya, H. Laswai, L. Mtenga, S. Richards, and R. Smith. 2005. Livestock products–Valuable and more valuable. Pages 109–126 in *Livestock and Wealth Creation: Improving the Husbandry of Animals Keptby Resource-Poor People in Developing Countries*. E. A. Owen, A. Kitalyi, N. Jayasuriya, and T. Smith. ed. Nottingham Univ. Press, Nottingham, UK.

World Health Organization Nutrition Landscape Information System, Country Profile: Rwanda (2010-11). Accessed at: http://apps.who.int/nutrition/landscape/report.aspx?iso=rwa

Table 1a: Description of Variables, By Region (Whole Sample)

Variable	Description	North		East	
		Mean	**Std. Dev.**	**Mean**	**Std. Dev.**
Cow Beneficiary	Dummy indicating that the household received a cow one year ago	0.39	0.49	0.00	0.00
Goat Beneficiary	Dummy indicating that the household received a goat one year ago	0.00	0.00	0.46	0.50
Qualified	Dummy indicating that the household either received an animal or will receive one soon (beneficiary or prospective)	0.82	0.38	0.77	0.42
Non-Heifer Cow	Number of non-Heifer cows a household currently has (includes Heifer offspring)	0.60	0.92	0.09	0.34
Non-Heifer Goat	Number of non-Heifer goats a household currently has (includes Heifer offspring)	1.29	1.43	1.17	1.66
North	Dummy variable for location; =1 if household is in the dairy cow zone (Ruli), =0 if the household is in the meat goat zone (Kirehe)	1.00	0.00	0.00	0.00
	Dietary Diversity				
Groups	Number of food groups consumed by the respondent in the last two days (out of 16)	7.79	2.72	5.21	2.21
Groups, Non-dairy	Number of non-dairy food groups consumed by the respondent in the last two days (out of 14)	7.04	2.28	4.91	1.98
Ind. Dairy	Number of times milk or yogurt was consumed by the respondent in the last two days	1.07	1.56	0.40	1.04
Ind. Meat	Number of times meat was consumed by the respondent in the last two days	0.51	0.87	0.26	0.73
PPMeat	Kilograms of meat consumed by the household per person per month	0.30	0.51	0.23	0.44
PPDairy	Liters of dairy (milk and yogurt) consumed by the household per person per month	5.79	8.78	1.17	2.70
	Household Characteristics & Asset Ownership				
Household Size	Number of persons in household	6.11	2.00	4.89	1.75
Age	Age (years) of household head (respondent)	49.76	11.25	40.66	13.61
Land Size	Amount of land owned by household (hectares)	1.61	1.34	0.69	0.59
Phones	Number of cell phones owned by household	1.06	1.00	0.47	0.67
Education	Respondent's level of education (in years)	4.62	3.82	3.70	3.14
Labor	Amount spent on hired labor (thousands of Francs/month)	4707.99	11683.79	3944.03	13056.80
Machetes	Number of machetes owned by the household	2.30	0.68	1.30	0.70
Beef	Number of beef cattle owned by the household	0.14	0.43	0.03	0.32
Bull	Number of bulls owned by the household	0.21	0.44	0.02	0.15
Pigs	Number of pigs owned by the household	0.38	0.89	0.14	0.80
Sheep	Number of sheep owned by the household	0.46	1.11	0.03	0.25
Chickens	Number of chickens owned by the household	1.63	7.50	0.62	1.83
Rabbits	Number of rabbits owned by the household	0.89	1.73	0.03	0.23
Observations		194		173	

Table 1b: Description of Variables, by Region
(Sample: Households with Children 0-5 Years Old)

Variable		North		East	
		Mean	**Std. Dev.**	**Mean**	**Std. Dev.**
Cow Beneficiary (1=Yes, 0=No)	Dummy indicating that the household received a cow one year ago	0.43	0.50	0.00	0.00
Goat Beneficiary (1=Yes, 0=No)	Dummy indicating that the household received a goat one year ago	0.00	0.00	0.48	0.50
Qualified (1=Yes, 0=No)	Dummy indicating that the household either received an animal or will receive one soon (beneficiary or prospective)	0.86	0.35	0.80	0.40
NonHeifer Cow (number)	Number of non-Heifer cows a household currently has (includes Heifer offspring)	0.68	0.82	0.12	0.39
NonHeifer Goat (number)	Number of non-Heifer goats a household currently has (includes Heifer offspring)	1.41	1.41	1.04	1.82
Region dummy (1=North, 0=East)	Dummy variable for location; =1 if household is in the dairy cow zone (North), =0 if the household is in the meat goat zone (East)	1	0	0	0
	Child Characteristics				
Stunting (HAZ)	Height-for-age z-score	-1.29	1.34	-1.01	1.51
Wasting (WHZ)	Weight-for-height z-score	0.27	1.00	0.17	1.08
Underweight (WAZ)	Weight-for-age z-score	-0.72	1.07	-0.62	1.22
Age (months)	Age of child, in months	34.20	16.83	28.68	16.34
Sex (1=Male, 0=Female)	Sex of child	0.55	0.50	0.57	0.50
Birth order	Order or birth of child (compared to siblings)	1.18	0.41	1.24	0.45
	Health Characteristics				
Age Stopped Breastfeeding (months)	Age at which child discontinued being breastfed, in months	26.89	13.30	20.03	11.89
Hospital Visits Last Month	Number of child's hospital visits in the last month	1.82	0.56	1.88	0.32
Incidence of diarrhea last 2 weeks	Number of times child had diarrhea in the last two weeks	0.52	1.70	1.68	3.17
Times given animal milk last 2 days	Number of times child was given animal milk in the last two days	1.95	2.50	0.90	2.24
	Household Characteristics & Asset Ownership				
Max education in household, years	Maximum years of schooling among household members	8.15	2.43	5.67	2.21
Household members	Number of persons in household	6.89	1.74	5.40	1.58
Mother's age, years	Age of child's mother, in years	34.50	8.71	31.92	7.70
Access to pipe/tap water (1=Yes, 0=No)	Dummy indicating whether household has access to water from a pipe or tap	0.69	0.46	0.61	0.49
Building material wood (1=Yes, 0=No)	Dummy indicating house is built of wood	0.08	0.27	0.34	0.48
Building material self-made bricks (1=Yes, 0=No)	Dummy indication house is built of self-made bricks	0.75	0.44	0.66	0.48
Phones	Number of cell phones owned by household	1.20	0.98	0.60	0.69
Sickles	Number of sickles phones owned by household	2.56	1.22	0.39	0.59
Observations		98		129	

Table 2: Respondent Dietary Diversity

Dependent Variables: Number of Food Groups Consumed by Respondent in the Last Two Days
--OLS Regression with Robust Standard Errors—

	All Food Groups (Max 16)	Non-Dairy Food Groups (Max 14)
Cow Beneficiary	1.19***	0.42
	(0.36)	(0.32)
Goat Beneficiary	0.36	0.31
	(0.34)	(0.32)
Qualified	-0.24	-0.19
	(0.35)	(0.31)
Non-Heifer Cow	0.23	0.11
	(0.17)	(0.14)
Non-Heifer Goat	-0.07	-0.04
	(0.07)	(0.07)
North	1.11***	1.16***
	(0.41)	(0.37)
Household Size	-0.24***	-0.23***
	(0.07)	(0.059)
Age (Respondent)	-0.02**	-0.02*
	(0.01)	(0.00)
Log Land Size	0.94***	0.86***
	(0.35)	(0.31)
Phones	0.66***	0.49***
	(0.14)	(0.13)
Education	-0.05	-0.03
	(0.04)	(0.03)
Labor	0.04***	0.03***
	(0.01)	(0.00)
Machetes	0.64***	0.63***
	(0.16)	(0.14)
Beef	0.61*	0.30
	(0.35)	(0.30)
Bull	-0.60	-0.62*
	(0.39)	(0.37)
Pigs	-0.1	-0.10
	(0.12)	(0.10)
Sheep	0.13	0.07
	(0.13)	(0.12)
Chickens	0.01	0.01
	(0.01)	(0.01)
Rabbits	0.21*	0.17*
	(0.11)	(0.09)
Constant	5.74***	5.25***
	(0.68)	(0.60)
Observations	369	369
R-squared	0.43	0.38

Robust standard errors in parentheses, * p<.1, ** p<0.05, *** p<0.01

Table 3: Respondent Dairy and Meat Consumption

Dependent Variables: Respondent Consumption in the Last Two Days (Frequency)
--Poisson Regression—

	Dairy Consumption (Frequency)	Meat Consumption (Frequency)
Cow Beneficiary	1.17***	-0.29
	(0.21)	(0.27)
Goat Beneficiary	0.25	0.04
	(0.35)	(0.47)
Qualified	-0.18	-0.23
	(0.31)	(0.32)
Non-Heifer Cow	0.19**	0.12
	(0.07)	(0.08)
Non-Heifer Goat	-0.08*	-0.02
	(0.05)	(0.09)
North	0.33	0.49
	(0.30)	(0.38)
Household Size	-0.02	-0.27***
	(0.04)	(0.06)
Age (Respondent)	-0.02**	-0.01*
	(0.01)	(0.01)
Log Land Size	0.07	0.53*
	(0.21)	(0.28)
Phones	0.28***	0.23**
	(0.07)	(0.12)
Education	-0.06**	-0.10***
	(0.02)	(0.03)
Labor	.01*	0.00
	(0.00)	(0.01)
Machetes	-0.01	0.44***
	(0.09)	(0.12)
Beef	0.23**	-0.08
	(0.10)	(0.28)
Bull	0.06	-0.17
	(0.17)	(0.27)
Pigs	-0.06	-0.01
	(0.08)	(0.07)
Sheep	0.11*	0.02
	(0.06)	(0.15)
Chickens	-0.01*	-0.07
	(0.01)	(0.07)
Rabbits	0.10**	0.03
	(0.04)	(0.05)
Constant	0.40	-0.03
	(0.46)	(0.64)
Observations	369	369

Robust standard errors in parentheses, * p<.1, ** p<0.05, *** p<0.01

Table 4: Household Dairy and Meat Consumption

Dependent Variables: Monthly Household Consumption Per-Person

--Tobit Regression with Robust Standard Errors—

	Dairy Consumption (Liters)	Meat Consumption (Kilograms)
Cow Beneficiary	9.15***	-0.23
	(1.34)	(0.15)
Goat Beneficiary	-0.35	0.20*
	(0.91)	(0.11)
Qualified	0.96	-0.06
	(0.83)	(0.10)
Non-Heifer Cow	3.38***	0.02
	(0.59)	(0.08)
Non-Heifer Goat	-0.36	-0.01
	(0.24)	(0.02)
North	1.09	0.30**
	(1.05)	(0.13)
Household Size	-0.98***	-0.10***
	(0.21)	(0.02)
Age (Respondent)	-0.05	-0.01*
	(0.03)	(0.00)
Log Land Size	1.59	0.30**
	(1.31)	(0.13)
Phones	1.37***	0.13**
	(0.47)	(0.05)
Education	0.04	-0.00
	(0.11)	(0.01)
Labor	0.02	0.00
	(0.03)	(0.00)
Machetes	-0.14	0.20***
	(0.57)	(0.06)
Beef	-0.13	-0.03
	(0.61)	(0.07)
Bull	2.37	0.16
	(1.76)	(0.16)
Pigs	-0.21	0.07*
	(0.49)	(0.04)
Sheep	0.25	0.16***
	(0.53)	(0.06)
Chickens	-0.11**	0.01
	(0.05)	(0.02)
Rabbits	0.16	-0.02
	(0.50)	(0.04)
Constant	3.65*	0.25
	(1.91)	(0.21)
Observations	322	284

Robust standard errors in parentheses, * p<.1, ** p<0.05, *** p<0.01

Table 5: Household Dairy and Meat Consumption

Dependent Variables: Monthly Household Consumption Per-Person

--Propensity Score Matching: Nearest Neighbor, with Replacement—

	Dairy Cow Milk consumption (Liters)	**Meat Goat** Meat consumption (Kilograms)
ATT Coefficient	9.32	0.17
Bootstrapped SE	*(1.64)*	*(0.09)*
Rosenbaum Bounds Gamma (*Γ*)	*5.5*	*1.4*

Table 6a: Nutritional Status of Children

	Stunting (HAZ)		**Wasting (WHZ)**		**Underweight (WAZ)**	
	North	**East**	**North**	**East**	**North**	**East**
Percentage of Children [a]						
Normal	40.8%	50.0%	88.8%	88.1%	67.3%	62.2%
Mild stunting	36.7%	25.4%	11.2%	8.7%	23.5%	22.8%
Moderate stunting	11.2%	15.1%	0.0%	2.4%	6.1%	13.4%
Severe stunting	11.2%	9.5%	0.0%	0.8%	3.1%	1.6%

[a] Categories of wasting and stunting are based on z-scores, where $z \geq -1.0$ is normal, $-1.0 > z \geq -2.0$ is mild malnutrition, $-2.0 > z \geq -3.0$ is moderate malnutrition, and $z < -3.0$ is severe malnutrition (Quinn, 1992).

Table 6b: Comparison to Rwandan Country Profile

	Moderate and Severe Malnutrition		
	Stunting (HAZ<-2)	**Wasting (WHZ<-2)**	**Underweight (WAZ<-2)**
Sample	23.7%	1.8%	12.4%
National[b]	44.3%	3.0%	11.7%

[b] Taken from WHO's Nutrition Landscape Information System, Country Profile: Rwanda (2010-11).

Table 7: Estimated Effects on Child Nutritional Status

Dependent Variables: Height for Age, Weight for Height, Weight for Age

--Seemingly Unrelated Regressions--

	Height for age (HAZ)	Weight for height (WHZ)	Weight for age (WAZ)
Cow Beneficiary	0.57*	-0.03	0.40
	(0.32)	(0.23)	(0.25)
Goat Beneficiary	0.11	0.47**	0.40*
	(0.28)	(0.21)	(0.23)
Qualified	-0.45	-0.17	-0.45**
	(0.28)	(0.21)	(0.23)
Non-Heifer Cow	-0.35**	0.19	-0.11
	(0.16)	(0.12)	(0.13)
Non-Heifer Goat	0.03	0.01	0.02
	(0.06)	(0.04)	(0.05)
North	-1.03***	0.73***	-0.27
	(0.37)	(0.27)	(0.3)
Age (Child)	-0.07***	-0.01	-0.05***
	(0.03)	(0.02)	(0.02)
Age squared	0.0007*	0.0001	0.0006**
	(0.00)	(0.00)	(0.00)
Male	-0.06	0.02	0.01
	(0.19)	(0.14)	(0.15)
Birth order	-0.01	0.10	0.08
	(0.26)	(0.19)	(0.21)
Age Stopped Breastfeed	0.03**	0.00	0.01
	(0.01)	(0.01)	(0.01)
Hospital Visits Last Month	0.26	0.12	0.26
	(0.22)	(0.16)	(0.18)
Diarrhea Incidence Last 2 Wks	-0.08**	0.00	-0.07**
	(0.04)	(0.03)	(0.03)
Animal Milk Last 2 Days	-0.05	0.07**	0.00
	(0.04)	(0.03)	(0.04)
Max Educ of Household	-0.04	-0.03	-0.04
	(0.05)	(0.03)	(0.04)
Household Size	0.07	0.01	0.04
	(0.07)	(0.05)	(0.06)
Mother's Age	0.01	-0.02	0.00
	(0.02)	(0.01)	(0.01)
Single Mother	-0.05	-0.19	-0.07
	(0.36)	(0.26)	(0.29)
Phones	0.10	-0.04	0.07
	(0.13)	(0.10)	(0.11)
Water Access	-0.14	-0.03	-0.16
	(0.22)	(0.17)	(0.18)
House Material: Wood	-0.75	-0.22	-0.70*
	(0.47)	(0.35)	(0.38)
House Material: Self Made Brick	-0.49	-0.2	-0.49
	(0.41)	(0.3)	(0.33)
Sickles	0.24**	-0.19**	0.04
	(0.11)	(0.08)	(0.09)
Constant	-0.04	0.86	0.36
	(0.97)	(0.71)	(0.78)
N	218	218	218
R^2	0.19	0.12	0.14

Standard errors in parentheses, * p<.1, ** p<0.05, *** p<0.01

Table 8: Estimated Effects on Stunting, Wasting & Underweight

Dependent Variables: Height for Age, Weight for Height, Weight for Age

--Propensity Score Matching, Nearest Neighbor, With Replacement--

Treatment		HAZ	WHZ	WAZ
Dairy Cow	**ATT Coefficient**	0.55	-0.05	0.61
	SE	*(0.46)*	*(0.32)*	*(0.38)*
Meat Goat	**ATT Coefficient**	0.28	0.40	0.60
	SE	*(0.57)*	*(0.35)*	*(0.45)*

Appendix A: Dietary Diversity Survey

In the last 7 days, did you (adult taking survey) eat:
(Answer: Yes, No, or Don't Know)

A) STAPLE FOODS
1) Starchy fruits such as cooking banana-matoke?
2) Cassava, yams, sweet potatoes, Irish potatoes or other roots and tubers?
3) Rice, posho, porridge, bread, chapatti, pasta/macaroni, pizza, or other foods made from maize, millet, sorghum or other grains?

B) PROTEIN
4) Beans, peas, cow peas, nuts, seeds ,oil seeds, soya beans or other legumes or seeds
5) Meat (beef, pork, goat, lamb, chicken, duck) or other meat?
6) Eggs (Chicken eggs, duck eggs etc)?
7) Fresh fish, dry fish or shell fish?

C) VEGETABLES AND FRUITS
8) Dark green leafy vegetables like dodo, nakati spinach, amaranths, bugga, sungsa, jjobyo, Marakwang?
9) Orange-colored vegetables such as pumpkins, carrots, orange fleshed sweet potatoes?
10) Any bio-fortified food (Orange-fleshed sweet potatoes)?
11) Orange colored fruits like ripe mangoes, pawpaw?
12) Other fruits or vegetables (passion fruit, jack fruit, pineapples, oranges etc)?

D) OTHER FOODS
13) Any milk?
14) Cheese, yogurt, or other milk products?
15) Cooking oil, margarine, butter or other oils/fats?
16) Any sugary foods such as chocolates, sweets, candies pastries, cakes or biscuits?

Appendix B1: Selection into Treatment – Dietary Diversity

Dependent Variables: Cow Beneficiary, Goat Beneficiary

--Probit Estimation--

	Dairy Cow Beneficiary	Meat Goat Beneficiary
Non-Heifer Cow	-0.24	
	(0.13)	
Household Size		-0.07
		(0.07)
Log Land Size	-0.06	0.43
	(0.32)	(0.37)
Phones	0.25	0.02
	(0.14)	(0.18)
Machetes	0.08	-0.15
	(0.17)	(0.19)
Rabbits	0.07	
	(0.07)	
Constant	-0.44	0.76
	(0.42)	(0.43)
N	133	121
Pseudo R^2	0.06	0.02

Standard errors in parentheses, * p<.1, ** p<0.05, *** p<0.01

Probit Post-Estimation Classification

	Dairy Cow Beneficiary		Meat Goat Beneficiary	
	0.50 Cut-off	0.43 Cut-off[a]	0.50 Cut-off	0.48 Cut-off[a]
Sensitivity	71.62%	89.19%	100.00%	100.00%
Specificity	57.63%	28.81%	2.50%	0.00%
Correctly Classified	65.41%	62.41%	67.7%	66.94%

[a]Proportion of treated households as the cut-off rate

Appendix B2: Selection into Treatment – Child Nutritional Status (Sample: Households with Children 0-5 Years Old)

Dependent Variables: Cow Beneficiary, Goat Beneficiary

--Probit Estimation--

	Dairy Cow Beneficiary	Meat Goat Beneficiary
Non-Heifer Cow	0.76***	0.05
	(0.27)	(0.44)
Non-Heifer Goat	0.15	0.45***
	(0.14)	(0.12)
Age (Child)	-0.01	0.003
	(0.02)	(0.01)
Male	-0.48	-0.52
	(0.36)	(0.32)
Birth order	0.27	
	(0.46)	
Age Stopped Breastfeed	-0.002	-0.03
	(0.03)	(0.02)
Max Educ of Household	0.01	0.01
	(0.09)	(0.07)
Household Size	-0.07	-0.38**
	(0.12)	(0.13)
Mother's Age	-0.04	0.05**
	(0.03)	(0.03)
Mobile	-0.04	0.14
	(0.22)	(0.27)
Water Access	-0.16	
	(0.37)	
House Material: Wood	0.46	0.66
	(0.76)	(0.37)
House Material: Self-Made Brick	1.13*	
	(0.50)	
Sickles	-0.003	
	(0.13)	
Constant	0.53	0.99
	(1.29)	(0.91)
N	85	102
Pseduo R^2	0.22	0.25

Standard errors in parentheses, * p<.1, ** p<0.05, *** p<0.01

PSM – Probit Post-Estimation Classification

	Dairy Cow Donations		Meat Goat Donations	
	0.50 Cut-off	0.43 Cut-off[a]	0.50 Cut-off	0.48 Cut-off[a]
Sensitivity	74.42%	81.40%	85.48%	87.10%
Specificity	73.81%	64.29%	67.50%	65.00%
Correctly Classified	74.12%	72.94%	78.43%	78.43%

[a]Proportion of treated households as the cut-off rate

How does improving access to rural water supply change household time use in Ethiopia?

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Abstract

What is the impact of providing convenient water supply on water carriers' pattern of time use? We measure changes in time use among female water carriers and their household members in 452 households before and after new water systems are installed in three rural villages in the Oromia region of Ethiopia. We use a quasi-experimental design and innovative approaches to measuring time use in a low-literacy environment. Our results indicate that the water projects reduced household water collection times, on average, by 27 minutes in one treatment village and 75 minutes in the second, though our results are sensitive to the time use elicitation procedure used. We find a statistically significant increase in time spent in food preparation, household chores and socializing among women who have smaller water collection times. Non-water collectors who live in households with lower water collection times spent less time farming, and more time on miscellaneous work, socializing and bathing/hygiene.

1. Introduction[1]

Improving access to safe, convenient drinking water remains a key development challenge in many parts of the world. According to the WHO and UNICEF Joint Monitoring Programme (2010), approximately 884 million people worldwide, 37 percent of whom live in sub-Saharan Africa, still use unimproved drinking water sources. Among policy-makers and researchers in the water sector, the focus has been predominantly on the health benefits of improving access to safe water, particularly in preventing diarrheal disease (see Zwane and Kremer 2007 for a useful review of this literature). The establishment of community or household water taps can, however, also significantly reduce the time spent collecting water, typically a task for women and girls. A number of studies based on household surveys have found that water project beneficiaries often perceive the increased convenience and time savings as equally or more important than health benefits (Hope 2006). Cairncross and Valdmanis (2007) observed that "given the relevance of the time-saving benefit to water supply policy and the fact that the benefit is usually uppermost in the mind of the consumer, it is remarkable how few data have been collected on the amounts of time spent collecting water". A World Bank study proposed that "public policy can address inequalities in the household division of labor by supporting initiatives that reduce the amount of time women spend doing unpaid

[1] We would like to thank our respondents and enumerators, especially Kibatu Berede; project partners Water1st International (Kirk Anderson and Karen Nilson), Water Action (Adane Kassa, Fasika Yetbarke, Girmay Hailu), and Addis Ababa University (Tekie Alemu & Jonse Boka); Kate Schneider and Kyle Schoenfeld for excellent research assistance; Travis Reynolds, Sara DeRucyk, and Anne Marie Kimball for discussions and early conceptual work on the project; The University of Washington Center for Studies in Demography and Ecology for use of GIS equipment and Matt Dunbar for GIS assistance; and Edward Miguel, Robert Plotnick, Jason Williams, Wolfram Latsch, and Leigh Anderson for helpful comments. Funding for the research was provided by the University of Washington's Royalty Research Fund and the Evans School of Public Affairs.

work…Examples of such intervention are improved water and sanitation services, rural electrification, and better transport infrastructure" (World Bank 1995, p.19).

What is the impact of providing convenient water supply on water carriers' pattern of time use? How much of the freed time is reallocated to paid market work, education (for girls), agricultural labor, or leisure? Does this lead to a reallocation of leisure time to other household members? These questions are an important, but largely missing, piece of the economic evidence base for investment in the water supply sector. Our study helps to fill this evidence gap by measuring changes in time use among water carriers in 454 households before and after new water projects are installed in three rural villages in the Oromia region of Ethiopia. We also measure time use for roughly 1,600 household members over the age of 10. Because the timing of completion of the projects is staggered over time, our quasi-experimental design allows us to control for any region-wide changes in time use. We use this rare panel dataset with both pre- and post-project time use data to examine not only the effects on water carriers' time use but also any intra-household reallocation of time savings.

2. Literature

A number of reports acknowledge anecdotally the direct time savings of bringing water sources closer to homes (Elmendorf and Isley 1982; Jiggins 1989; Hoffman 1992; Floro 1995; Luby, Agboatwalla *et al*. 2006). These studies often claim that water projects increase women's leisure time, allow greater market work or subsistence farming, and free girls to attend school. There is, however, insubstantial quantitative evidence to support this, and very few studies have attempted a careful analysis of who is saving time, how much time is saved, and what is really being done with it. Prokopy (2005) asked 1,523 households in 45 Indian villages that had received a new water scheme in the past 1-2 years whether the project saved them time collecting water. Sixty-four percent of households reported time savings. In Ethiopia, Gibson and Mace (2006) found that self-reported water collection times dropped following the installation of 40 water taps in 8 villages, from 3-6 hours per woman per day to less than 30 minutes per woman per day on average. Interviews suggested that the extra time was employed in more social activities. Ilahi & Grimard (2000) used cross-sectional, national-level survey data in Pakistan on the quality and quantity of water infrastructure and the time women allocate to three categories of activities (market-oriented activities, water collection, and leisure). They found that women who lived farther away from their water source spent more time on water collection and less time on market activities and leisure. Koolwal and van de Walle (2010) similarly rely on a cross-sectional approach, finding that water infrastructure does not increase women's off-farm labor. In contrast, Meeks (2011) finds that water infrastructure in rural Kyrgyzstan save adults approximately 160 minutes per day which they use for increased leisure and farm work, leading to an increased output of cash crops. Devoto et al. (2011) randomly offered households in the city of Tangiers, Morocco a simplified procedure for connecting to the piped distribution system. Households who chose to connect and cease using the system of free public taps consumed significantly more water and saved a substantial amount of time. This time was used for increased leisure and social activities, but not productive activities.

We contribute to this literature in two ways. First, with the exception of Meeks (2011) and Devoto et al (2011), existing studies have been limited to single cross-sectional comparisons rather than panels or repeated cross-sections. The placement of water infrastructure may be influenced by a number of factors that could be correlated with time use patterns (e.g., socioeconomic status, regional or tribal differences, political allegiance). Furthermore, households with higher opportunity costs of time may consider water supply availability when making locational decisions, especially in urban areas (Anselin, Lozano-Gracia *et al*. 2008). A quasi-experimental, panel approach controls for these confounding factors.

Second, we believe our time use elicitation procedure is more reliable than most existing studies. These are mainly retrospective and ask respondents to recall time use over long periods. Prokopy (2005) and Gibson and Mace (2006) depend on respondents' recollections of the time they spent gathering water before the project was implemented. For respondents in Prokopy (2005), this was on average one year prior to the survey, although time use was not the primary research focus and the question was a simple binary one ("did the project save you time?"). Respondents in Gibson and Mace (2006) were asked to recall time use three years before the survey. The 1991 Living Standards Measurement Survey (LSMS) data used by Ilahi and Grimard (2000) asked respondents to think back over the previous <u>week</u> and, for various activities, report how many times they performed the activity and "how much time [they] normally spent doing the activity each time".[2] Similarly, Devoto et al. appeared to use a series of recall questions over the previous week, although there are few details provided on the time use elicitation procedure.

Recall data can be inaccurate, as studies that compare recall data with observational data have shown (Betzig and Turke 1985). Most time-use researchers have agreed that recall periods beyond the previous day are unreliable (Harvey and Taylor 2001). Like this study, Meeks (2011) uses time use data asking subjects to recall the previous day, although unfortunately the time use module in the national survey did not specifically ask about water collection activities.

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[2] This type of "activity-specific" recall question is also similar to the one used in the more recent Demographic and Health Surveys (DHS) in several countries, including Ethiopia. The DHS asks the wife to identify the main source of drinking water and then asks: "How long does it take to go there, get water, and come back?"

Furthermore, any method which asks respondents to report how many minutes they spent on activities will be difficult and unreliable for respondents who do not use watches and whose daily experiences do not revolve around time-keeping devices, as is true in many parts of rural Africa. We rely on a pictorial time use elicitation approach that we feel is clear and understandable to a wide range of participants, uses recall from the previous day, and provides time use allocations that do not exceed the total number of hours in the day.

3. Research design and study site

We use a quasi-experimental research design because it was not possible to randomize whether villages received an improved water project nor the order in which projects were constructed. This design used the existing plans of our two NGO collaborators, U.S.-based Water 1st International and Ethiopia-based Water Action, to provide three villages in the Oromia region of Ethiopia with improved water service, hygiene education and toilet construction (see Appendix 1 for a map of the study site). The water projects entailed capping existing unprotected springs, pumping water to centralized storage tanks, and distributing water by gravity to a number of new public taps located throughout the villages. The public taps were located with the expectation that water collection times would fall significantly for most households. Although the NGOs felt that all three were comparably "in need" by their criteria and all three eventually received water projects, they were forced to build only one system per year because of funding constraints. There were, however, observable differences among the villages at baseline (discussed below) and some indication that the order in which villages were slated for improvements was influenced by total project costs, proximity to paved roads, and prioritization by district government. The three villages – Bishikiltu, Tutekunche, and Kelecho

Gerbi – are located within a 200-square kilometer area[3] and are thus subject to the same weather. Although it is possible to walk from one village to another, we do not find evidence that households in villages without an improved system walked to a neighboring village that had received a new water system. The villages differ somewhat in topography. Bishikiltu and Tutekunche are both located on slopes, while Kelecho Gerbi is flat and expansive. This makes the types of existing water sources somewhat different, with the former two villages more likely to use streams and seasonal runoff, and the latter more likely to use shallow, hand-dug wells. In addition, Tutekunche is farther from the main road than either of the other two.

Our design entails interviews of randomly selected households[4] before and after implementation of the water project, as illustrated by Table 1. The water droplet in the table shows when the improved water systems came online in each village. "Pre" and "Post" refer to the household survey efforts. Our identification strategy, discussed below, uses two differencing approaches that depend on using the village of Tutekunche as a control that was untreated during our study period. The first survey round in 2009 was a pilot survey with only two enumerators and therefore much smaller sample sizes (Table 2). Because the main time use elicitation approach did not change, however, we include results from the 2009 pilot in identifying the effects of the Bishikiltu water project.

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[3] As points of reference for U.S. readers, this is slightly larger than the District of Columbia (177 km^2) and much smaller than the state of Rhode Island (4,002 km^2).

[4] Details of our sampling approach are provided in Appendix 2.

4. Methods

Our household survey has two main components.[5] The first component collected data on the household, including composition, basic demographics, socioeconomic indicators (income, expenditures, literacy, employment status, housing quality), health indicators, agricultural activities, water source choice, water use and water collection activities. These components of the interview were conducted with the head of household and the spouse. One pair of interviewers[6], typically one male and one female, was assigned to each household, with the female interviewer asking the wife about some sections of the survey (i.e. water collection, health) and the male interviewer asking the husband about other sections (i.e. agriculture). This also allowed most respondents to answer a number of household bargaining questions in private.

We measure time use in two different ways. The first is an activity-specific recall question, which we will refer to as "direct recall": "How much time did you spend collecting water yesterday?" We ask this question for all household members who collected water and construct total household water collection times. This is similar in formulation to most recall-based time use studies in multinational surveys or in well-educated countries; it relies on the assumption that respondents have a clear sense (and memory) of time because clocks and watches are ubiquitous and the sense of budgeting one's time is salient.

The second approach uses an exercise adapted from participatory rural appraisal (Narayan-Parker 1993a; Narayan-Parker 1993b) that asks respondents to recall how they spent their time yesterday without requiring a familiarity with "minutes". This approach is described

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[5] The full household survey used is available on the first author's website: http://faculty.washington.edu/jhcook/. The survey used during the 2009 fieldwork was a "pilot" version, and a number of questions were added in 2010, although the time use module remained the same. The 2010 and 2011 questionnaires are nearly identical.

[6] Interviewers were nearly all students from Addis Ababa University. They were native speakers of Oromifa/Afaan Oromo, the language used in our study site. The survey instrument was developed in English, translated and tested in Oromifa, and re-translated back to English by a third party to ensure the accuracy of the translation.

in detail in Masuda et al (2012), but we provide a brief description here. First, the respondent is shown fifteen cards that describe different types of activities that a person might do during a typical day. Because of low literacy rates, the cards contain only pictures of the activities, and enumerators were carefully trained to read a pre-written description of the activities for each card. The cards and descriptions are provided in Appendix 3. The enumerator then went through each card and asked whether the respondent did that activity during the previous day. If not, the card was put aside. Respondents reported what time they woke up and what time they went to bed the previous day, and enumerators gave them pieces of macaroni (commonly available and familiar in rural Ethiopia) that corresponded to the number of hours they were awake, where each piece corresponds to 20 minutes[7]. They were then asked to allocate the macaroni pieces to the activity cards in proportion to the amount of time they spent on the activity the previous day. For example, if a respondent spent two hours collecting water, she would allocate six macaroni pieces to the activity card representing water collection. The enumerator counted the macaroni pieces and repeated back to the respondent the time spent on each activity. The respondent was allowed to revise her responses. We also had respondents rank-order all activity cards according to which they enjoyed doing most and least.

This exercise was performed for all household members older than age ten in 2010 and 2011. We did not have sufficient resources to record time use for all household members over age ten in the smaller 2009 survey round; we focused on measuring time use for the household's primary water carrier. Again, however, we do have total household water collection times using the direct recall approach described above for all three survey rounds.

All interviewed households were geocoded using a hand-held GPS device. We also

[7] Respondents who do not know what time they woke or went to sleep were assumed to be awake for 16 hours.

geocoded the location of schools and all water sources (rivers, streams, and springs, existing and new taps).

5. Econometric approach

The analysis plan centers on a difference-in-difference approach that uses the panel nature of our dataset to control for many individual- and household-specific, village-specific and factors that might affect time use (Imbens and Wooldridge 2009). Our basic difference-in-difference model is:

$$Y_{h,j,t} = \beta_0 + \beta_1 Post_t + \beta_2 Water_{j,t} + \beta_3 Water_{j,t} * Post_t + \beta_4 \boldsymbol{Z_{h,t}} + \beta_5 V_j + \varepsilon_{h,j,t} \qquad (1)$$

The dependent variable Y is the household's total water collection time per day and is subscripted over households h, village j, and years t. *Post* is a dummy variable for whether the observation of Y occurred after implementation of the water system. *Water* is also a binary variable that captures whether the observation occurred in a village that received a system. The interaction of these two dummy variables identifies the effect of the water system (the treatment effect). The vector $\boldsymbol{Z}$ captures household characteristics related to water collection, most importantly household size, and the binary variable V introduces village fixed effects. For dependent variables at the individual level (water collection times and time spent in various categories of activities), we add a subscript i to dependent variable Y, and add a vector of individual-level characteristics $\boldsymbol{X_{i,j,h,t}}$.

Because we did not collect data on Kelecho Gerbi households in 2009, we analyze the data as two separate pairwise comparisons. The first compares observations in Bishikiltu and

Tutekunche across 2009 and 2010, and the second compares observations in Kelecho Gerbi and Tutekunche across 2010 and 2011. For the first comparison, for example, the model becomes:

$$Y_{h,j,t} = \beta_0 + \beta_1 Y10 + \beta_2 BK + \beta_3 Y10 * BK + \beta_4 \boldsymbol{Z_{h,t}} + \varepsilon_{h,j,t} \qquad (2)$$

Here β_0 describes the average household collection times in Tutekunche at baseline in 2009, β_1 reports the time trend in collection times between 2009 and 2010, β_2 reports pre-existing differences in collection times between Tutekunche and Bishikiltu, and β_3 is the mean treatment effect.

Because we collect time use data on the same households and individuals over multiple years, we are also able to use a first-difference approach. We again focus on pair-wise comparisons. The time subscript *t* drops out, as do any time-invariant household- or individual-level characteristics:

$$\Delta Y_{h,j} = \beta_1 \Delta Water + \beta_2 \boldsymbol{\Delta Z_{j,t}} + \Delta\varepsilon_{h,j,t} \qquad (3)$$

Consider the variable Δ*Water* . If *Water* indexes whether a village has received an operational system, then *Water* is equal to zero for Tutekunche for both 2009 and 2010, and Δ*Water* equals zero. For Beshikiltu, however, *Water* is equal to zero in 2009 but one in 2010, so Δ*Water* equals one. β_1 therefore identifies the average treatment effect, and in a first-difference model has the advantage of controlling for time-constant household or individual-level unobservables that might be correlated with water collection times.

6. Results

6.1. Characteristics of households and water carriers

Table 3 reports characteristics of households in summer 2010, or baseline for the comparison between Kelecho Gerbi and Tutekunche. Households have an average of 5.5

members, of whom approximately two are involved in water collection. Education of the household is quite low, as is literacy among all household members. As discussed above, somewhat less than half of households in our study do not own a watch, clock, or cell phone and may not be accustomed to carefully monitoring their time use in minutes.

Household members who collect water are very likely to be women, as is common in rural Ethiopia and many rural areas of poor countries. They are on average young adults (average age of 27, but median of 20); the age distribution is shown in Figure 1. They make, in total as a household, just over one trip per day to fetch water, collecting an average of approximately 450 liters per week in the two villages without water projects in 2010, but 660 liters per week in Bishikiltu. A quarter of households used donkeys[8] to transport water in 2010 in Bishikiltu and Kelecho Gerbi, but nearly half used them in Tutekunche. Another important difference is that nearly half of households in Kelecho Gerbi had access to a private well in 2010, while we observed no households with them in either of the other two villages. These private wells are nearly all shallow, hand-dug, un-protected wells that offer no protection from contaminated animal waste washing into the well. Households recognized this poor quality, but valued the convenience of these wells.

6.2. How much time is saved by the projects?

Figure 2 presents raw data on changes at the household level in water collection times with our two sources of time use data: the pictorial PRA approach and the direct recall approach. The figure displays two sets of comparisons for Bishikiltu and Tutekunche. The first compares

[8] One person typically will carry one 20-L "jerrican" on their back. A donkey is typically loaded with two 20-L jerricans, so using a donkey can reduce the burden of a collection trip (donkey carries 40L, person walks beside) or increase the water collected per trip (collect 60L).

2009 (before the Bishikiltu project became operational) to 2010, and the second compares 2009 to 2011. We include the second comparison because we expect that households may take some time to fully adjust to the presence of the new water taps; the 2010 survey was fielded only two months after the taps had become fully operational. We include similar comparisons for Tutekunche not because we expect any such adjustment, but because our difference-in-difference models below identify the treatment effect by using Tutekunche as the control. The figure excludes 109 households who had private wells in Kelecho Gerbi in 2010. Using either of the two time use datasets, the raw data clearly shows a reduction in collection times in Bishikiltu and Kelecho Gerbi. They also show a statistically significant reduction in collection times in Tutekunche between 2009 and 2010, which could indicate a region-wide event or change in 2010 that lowered collection times in all villages.

Our difference-in-difference (DD) model controls for those region-wide, time-varying effects, and the results confirm that the projects did in fact save households time (Table 4). Columns A and B identify the effects of the Bishikiltu system using two sets of comparisons, as described above, and using PRA time use data. Comparing Bishikiltu and Tutekunche between 2009 and 2011 we find that the Bishikiltu project reduced water collection times by 75 minutes per day at the household level. The results also indicate that Bishikiltu households in 2009 (pre-project) were spending 29 more minutes collecting water per day than Tutekunche households. The savings are smaller (44 minutes) when comparing 2009 and 2011 data, suggesting that some Bishikiltu households may have adjusted to the system by collecting more water or perhaps returning to non-project water sources.

Columns C and D evaluate the effect of the Kelecho Gerbi system by comparing it to Tutekunche. Note that the sample size is significantly larger because the Bishikiltu results above rely on use of the smaller 2009 "pilot" survey. Column C shows that no significant time savings from the project. Households in Kelecho Gerbi also had lower collection times at baseline (2010, pre-project) than those in Tutekunche. This is driven by the predominance of private wells in Kelecho Gerbi. Excluding those households who have private wells, Column D shows that the project did in fact reduce water collection times by 27 minutes for that subset of project beneficiaries.

Columns E, F and G show a similar pattern of results using the "direct recall" time use data. The Bishikiltu project saved an average of 165 minutes in the first few months after the project and 151 minutes a full year later. Excluding households with private wells, the Kelecho Gerbi project saved households an average of 49 minutes per day.

The results from a first-difference model for the comparison between Kelecho Gerbi and Tutekunche (not shown) also indicate that projects saved households time. Again dropping households with private wells, the projects reduced water collection times by 37 minutes (standard error 2.9 minutes) using the PRA approach, and 41 minutes (standard error 2.3 minutes) using the direct recall approach.

6.3. How is time re-allocated?

We asked water carriers who had spent at least 20 minutes collecting water to imagine "reliving your day yesterday, but instead imagine spending only twenty minutes collecting water." This question was asked in the context of the PRA exercise, so that the interviewer removed all but one piece of macaroni from the water collection picture and handed them back to the respondent to reallocate to other activities.[9] Respondents reported that they would have spent the majority of saved time on household labor (food preparation, household chores, firewood collection) and only five percent on socializing (Figure 3). Only five percent of time was reallocated to farm work and six percent to caring for animals, both traditionally male tasks in our study site.

Table 5 presents 90% confidence intervals around changes in household time use between 2010 and 2011 for water collectors and other household members. These report averages over change at the individual level (first-difference). It does not control for village or generalize to all water collectors, but instead focuses only on water collectors who reported spending less time collecting water in 2011. In addition to this drop in water collection, Column A shows a statistically significant reduction among water collectors in time spent collecting firewood and caring for children, and statistically significant increases in minutes spent on traveling to market, "other work", socializing and bathing.

Because some households do not collect water every day, however, it is possible that the first-difference approach is simply capturing the next most likely activity. As an example, suppose a woman normally collects water on Mondays and collects firewood on Thursdays. In 2010, suppose she was interviewed on Tuesday and reported spending 75 minutes collecting water the previous day (Monday). In 2011, suppose she was interviewed on Friday and reported spending three hours collecting firewood. Even if nothing about her water collection activities has changed, Table 5 would indicate a drop in water collection times and an increase in firewood collection. Controlling for the day of the week in which the interview was conducted would be a weak control because these type of activity patterns are likely to vary across households. This

[9] Because the PRA exercise focused on activities done yesterday, the interviewer placed all of the possible activity cards back in front of the respondent.

illustrates a general problem with using a first-difference approach on our time use data: it may be difficult to tease apart structural changes in time use from overall fluctuations in how household members choose to spend their time day to day.

To mitigate this concern, Column B of Table 5 presents similar raw data only among water collectors who saved time and reported collecting some water the previous day in 2011. Here the raw data indicates water carriers spent more time on food preparation (from 31 to 64 minutes more), household chores, and socializing.

Column C shows changes in time use for members of households where water collection times fell but who do not collect water themselves. These results indicate a large and statistically significant drop in time spent farming, ranging from 95 to 177 minutes. If we observed a similar *increase* in farm labor among water collectors in Panel B, this would suggest a reallocation of farm labor from male household members to women. The change in farm labor among water collectors is not statistically significant, however, and is in fact negative on average. Non-water collectors in column C spent more time in other work, socializing and bathing.

7. Discussion

We pair a uniquely-rich set of time use data collected using innovative pictorial approaches with a quasi-experimental design that controls for the possible endogeneity of placement of water systems. We find that the water projects do save households time, although our estimates are quite dependent on whether we use time use data using a standard direct recall approach or our pictorial PRA approach. The time savings remain using a difference-in-difference approach which treats our data as repeated cross-sections, or a first-difference approach that differences away time-invariant household and individual characteristics.

Our results, preliminary as of January 2013, indicate that some reallocation of time savings is occurring. Non-water collectors (primarily men) spend less time on farm labor, but more time doing other work, socializing and bathing. Unlike Meeks (2011), we do not find evidence that water collectors are more likely to engage in farm labor. They are in fact more likely to spend their time on food preparation or other household chores, precisely as they said they would in a hypothetical, stated behavior question. These time savings are real and beneficial to women, though they may be more difficult to value in a benefit-cost framework evaluating water supply investments.

8. Literature cited

Anselin, L., N. Lozano-Gracia, U. Deichmann and S. Lall (2008). Valuing access to water - A spatial hedonic approach applied to Indian cities. Policy Research Working Paper, World Bank Development Research Group.

Betzig, L. L. and P. W. Turke (1985). "Measuring time allocation: observation and intention." Current Anthropology **26**(5): 647-650.

Cairncross, S. and V. Valdmanis (2007). Water supply, sanitation and hygiene promotion. Disease Control Priorities in Developing Countries. D. Jamison, J. Breman, A. Meashamet al, Oxford University and the World Bank.

Devoto, F., E. Duflo, P. Dupas, W. Pariente and V. Pons (2011). "Happiness on tap: Piped water adoption in urban Morocco." NBER Working Paper **No. 16933**.

Elmendorf, M. and R. B. Isley (1982). Water and sanitation related health constraints on women's contributions to the economic development of communities. Conference on Women, Health, and International Development, Michigian State University.

Floro, M. S. (1995). "Economic restructuring, gender and the allocation of time." World Development **23**(11): 1913-1929.

Gibson, M. A. and R. Mace (2006). "An energy-saving development initiative increases birth rate and childhood malnutrition in rural Ethiopia." PLoS Medicine **3**: e87.

Hoffman, L. (1992). "Women handpump mechanics in Kenya " Waterlines **11**: 19-21.

Hope, R. A. (2006). "Evaluating water policy scenarios against the priorities of the rural poor." World Development **34**(1): 167-179.

Ilahi, N. and F. Grimard (2000). "Public infrastructure and private costs: Water supply and time allocation of women in rural Pakistan." Economic Development and Cultural Change **49**: 45-75.

Imbens, G. W. and J. M. Wooldridge (2009). "Recent Developments in the Econometrics of Program Evaluation." Journal of Economic Literature **47**: 5-86.

Jiggins, J. (1989). "How poor women earn income in sub-Saharan Africa and what works against them." World Development **17**(7): 953-963.

Koolwal, G. and D. v. d. Walle (2010). Access to water, women's work and child outcomes. World Bank Policy Research Working Paper. Gender and Development Unit.

Luby, S., M. Agboatwalla, J. Painter, A. Altaf, W. Billhimer, B. Keswick and R. Hoekstra (2006). "Combining drinking water treatment and hand washing for diarrhea prevention: A cluster randomized control trial." Tropical Medicine and International Health **11**(4): 479-489.

Masuda, Y. J., L. Fortmann, M. K. Gugerty, M. Smith-Nilson and J. Cook (2012). "Pictorial approaches for measuring time use in rural Ethiopia." Social Indicators Research **forthcoming**.

Meeks, R. (2011). "Water works: The economic impact of water infrastructure." Working Paper.

Narayan-Parker, D. (1993a). Participatory evaluation: tools for managing change in water and sanitation. Washington DC, World Bank.

Narayan-Parker, D. (1993b). Towards participatory research. Washington DC, World Bank.

Prokopy, L. S. (2005). "The relationship between participation and project outcomes: Evidence from rural water supply projects in India." World Development **33**(11): 1801-1819.

WHO/UNICEF (2010). Progress on sanitation and drinking water: 2010 update, WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation.

World Bank (1995). Toward Gender Equality: The Role of Public Policy. . Washington DC, The World Bank.

Zwane, A. P. and M. Kremer (2007). "What works in fighting diarrheal diseases in developing countries? A critical review." World Bank Research Observer **22**(1): 1-24.

Tables and Figures

Table 1. Timeline of water system implementation and data collection (households surveyed)

	July-Aug 2009	May 2010	July-Aug 2010	May 2011	July-Aug 2011	Jan. 2012
Beshikiltu	76		143		142	
Kelecho Gerbi			180		179	
Tutekunche	73		133		131	

Notes: Droplet indicates completion of the new Water1st/Water Action distribution system.

Table 2. Number of household members and water carriers interviewed for time use with PRA

Household members	**2009**	**2010**	**2011**
Bishikiltu	144	493	498
Tutekunche	117	469	482
Kelecho Gerbi	--	627	675
Total	*261*	*1589*	*1655*

Water carriers	**2009**	**2010**	**2011**
Bishikiltu	84	159	141
Tutekunche	89	125	129
Kelecho Gerbi	--	197	178
Total	*173*	*481*	*448*

Table 3. Household characteristics in summer 2010

	Bishikiltu Mean (SD)	**Tutekunche** Mean (SD)	**Kelecho Gerbi** Mean (SD)
Households			
Household size	5.3 (2.2)	5.7 (2.5)	5.5 (2.3)
Household head's education (yrs)	1.9 (3.0)	2.3 (3.4)	1.9 (2.7)
Literacy (over 5 yr old)	34%	50%	44%
Monthly household income (Ethiopian birr[a])	3290 (3527)	3576 (4075)	3650 (4548)
Owns mobile phone	9.8%	9.8%	9.4%
No watch, clock or mobile in household	47%	45%	44%
Have private well	0%	0%	49%
Use donkey to collect water	23%	48%	26%
Number of household members who collected water in the past week	1.8 (1.1)	1.7 (0.85)	1.8 (0.9)
Total water collected per week (Liters)	660 (648)	451 (604)	472 (370)
Trips per day, all household members	1.2 (0.68)	1.1 (0.44)	1.24 (0.69)
Total water collection time per day (mins, direct recall)	65 (60)	72 (66)	56 (68)
Total water collection time per day (mins, PRA)	82 (82)	106 (89)	77 (70)
Water collectors			
Female	85%	84%	85%
Age	27 (16)	27 (16)	27 (16)

[a] 1 Ethiopian birr ≈ 0.074 US$ in July 2010, so 3000 birr ≈ US$222

Table 4. Difference-in-difference, total household water collection times (minutes)

	Minutes based on PRA exercise								**Minutes based on direct recall**					
	A		**B**		**C**		**D**		**E**		**F**		**G**	
	Bishi vs. TK, 2009-2010		**Bishi vs. TK, 2009-11**		**KG vs. TK, 2010-11, ALL**		**KG vs. TK, 2010-11, No Private Wells**		**Bishi vs. TK, 2009-2010**		**Bishi vs. TK, 2009-11**		**KG vs. TK, 2010-11, No Private Wells**	
VARIABLES	β	se	β	se	β	se	β	se	β	se	β	se	β	se
Bishi	29	(13)**	29	(14)**					138	(29)***	135	(29)***		
y10	19	(14)							-38	(29)				
y10_Bishi	-75	(19)***							-165	(41)***				
HH size	12	(2)***	11	(2)***	6	(1)***	5	(1)***	23	(4)***	18	(4)***	5	(1)***
y11			7	(14)	-8	(9)	-10	(9)			-40	(29)	13	(9)
y11_Bishi			-44	(19)**							-151	(41)***		
KG					-27	(8)***	-13	(10)					13	(9)
y11_KG					1	(12)	-27	(15)*					-49	(13)***
Constant	20	(16)	29	(16)*	74	(9)***	80	(11)***	0	(34)	29	(34)	44	(10)***
Observations	286		286		620		425		286		286		425	
R-squared	0.16		0.1		0.07		0.07		0.23		0.19		0.07	

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 5. Changes in minutes spent on activities by individuals, 2011-2010 (from PRA exercise)

	A: Water collectors who saved time			**B: Water collectors who saved time but collected some water in 2011**			**C: Non-water collectors in hhs that saved time**		
Time use category	Obs	90% CI		Obs	90% CI		Obs	90% CI	
Eating	302	(-3 ,	4)	119	(-11 ,	1)	323	(-8 ,	0)
Food prep	265	(-12 ,	16)	111	**(31 ,**	**64)**	97	(-4 ,	58)
Water collection	302	**(-76 ,**	**-66)**	119	**(-70 ,**	**-57)**			
Wood collection	182	**(-47 ,**	**-15)**	92	(-21 ,	27)	42	(-55 ,	29)
Household chores	275	(-16 ,	2)	115	**(7 ,**	**35)**	120	(-12 ,	25)
Childcare	175	**(-29 ,**	**-4)**	68	(-38 ,	0)	124	(-22 ,	17)
Going to market	95	**(25 ,**	**118)**	36	(-32 ,	118)	76	(-44 ,	74)
Farming	142	(-29 ,	55)	43	(-126 ,	20)	197	**(-177 ,**	**-95)**
Caring for animals	203	(-9 ,	30)	75	(-36 ,	13)	288	(-15 ,	19)
Other work	96	**(41 ,**	**108)**	27	(-9 ,	105)	174	**(24 ,**	**78)**
Social	301	**(23 ,**	**48)**	118	**(2 ,**	**36)**	316	**(12 ,**	**45)**
Bathing	301	**(5 ,**	**16)**	119	(-2 ,	18)	321	**(4 ,**	**16)**
Sanitation	302	(-4 ,	1)	119	(-9 ,	-1)	323	(-5 ,	0)
Sick/care-giving	59	(-43 ,	7)	18	(-37 ,	35)	67	(-31 ,	53)
Playing	42	(-34 ,	31)	15	(-86 ,	49)	51	(-41 ,	42)

Notes: Bold type indicates CI does not include zero. The complete panel of individuals with time use data in both years is 1,264. 302 individuals reported spending less time on water collection in 2011 than 2010. [a] If a respondent did not complete the time use exercise, data is coded as missing. If they completed the exercise but reported spending no time on the category yesterday it was recorded as a zero. Data were recoded to missing if the individual did not report spending time on activity in **both** 2010 and 2011 so as not to bias the difference variable towards zero. An individual in 2011 who reported zero water collection yesterday may be enjoying a reduced average water collection burden, or may (by chance) be doing other activities (e.g. going to the market) and not collecting water that day. Column B recodes all zeros in 2011 as missing; this therefore includes only people who spent some time on water collection in both 2010 and 2011, and that time decreased.

Figure 1. Age distribution of water collectors, 2010

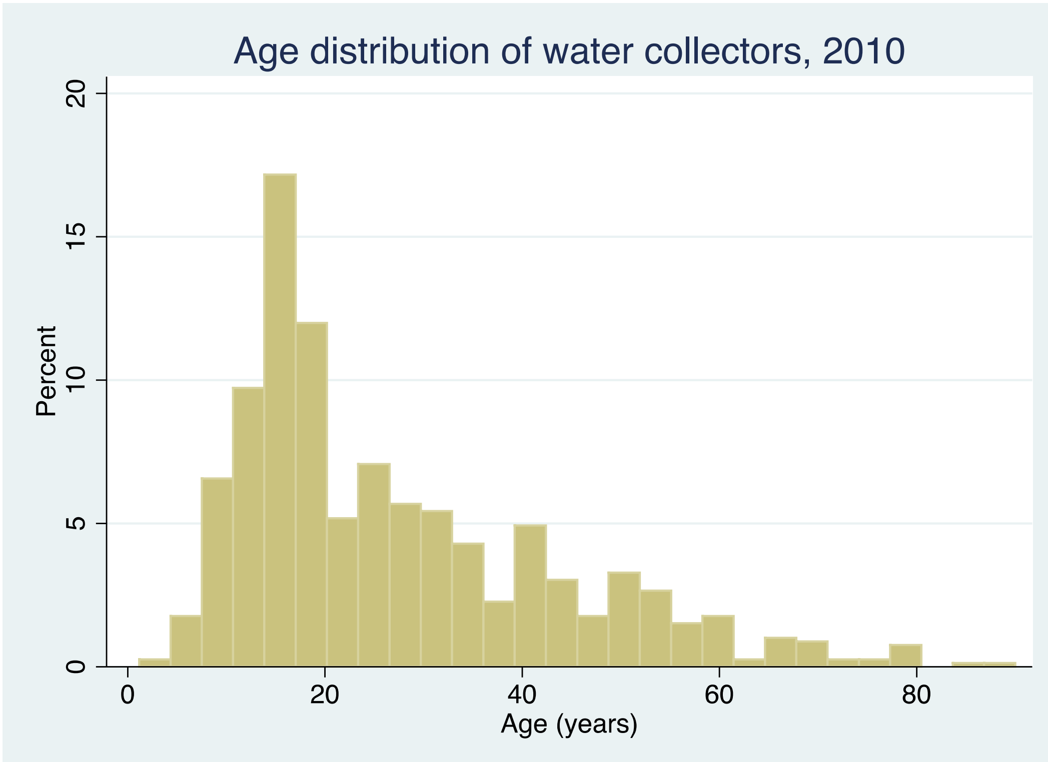
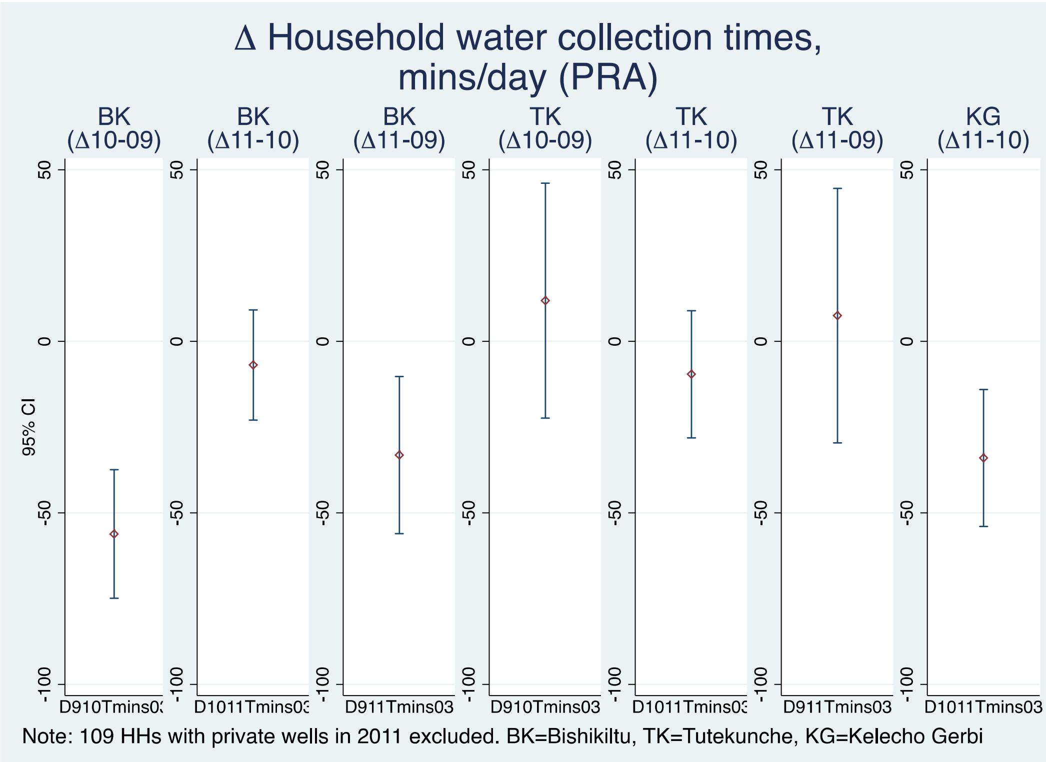


Figure 2. Changes in water collection times, household-level (first differences); direct recall and PRA



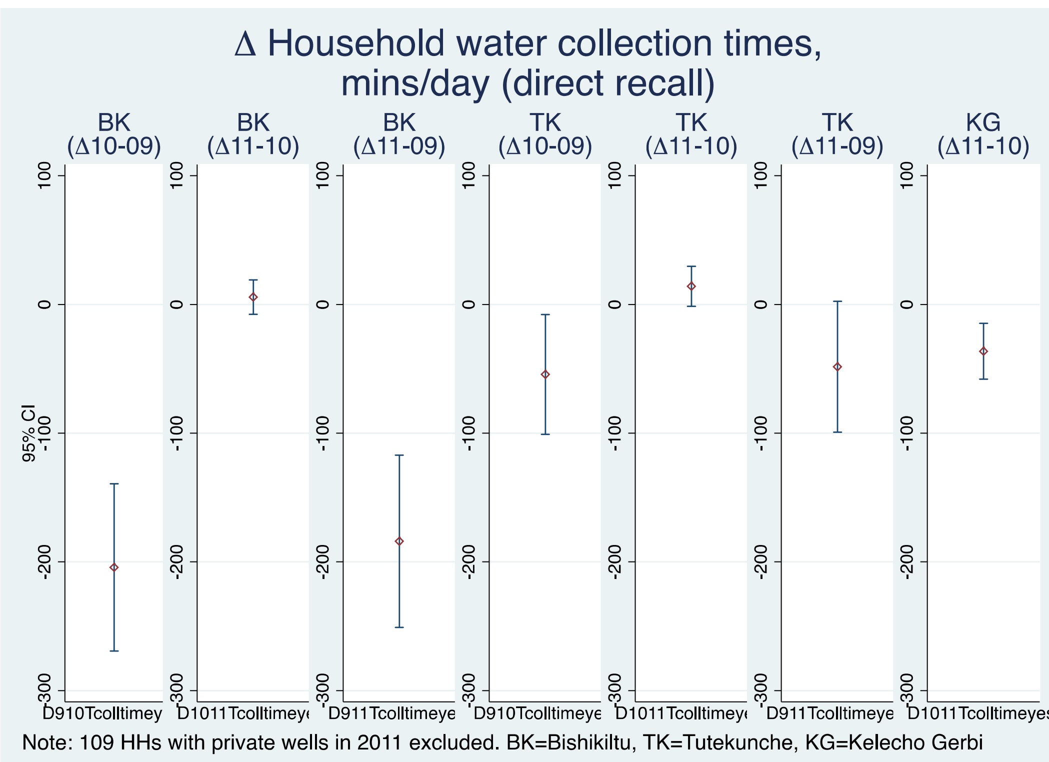
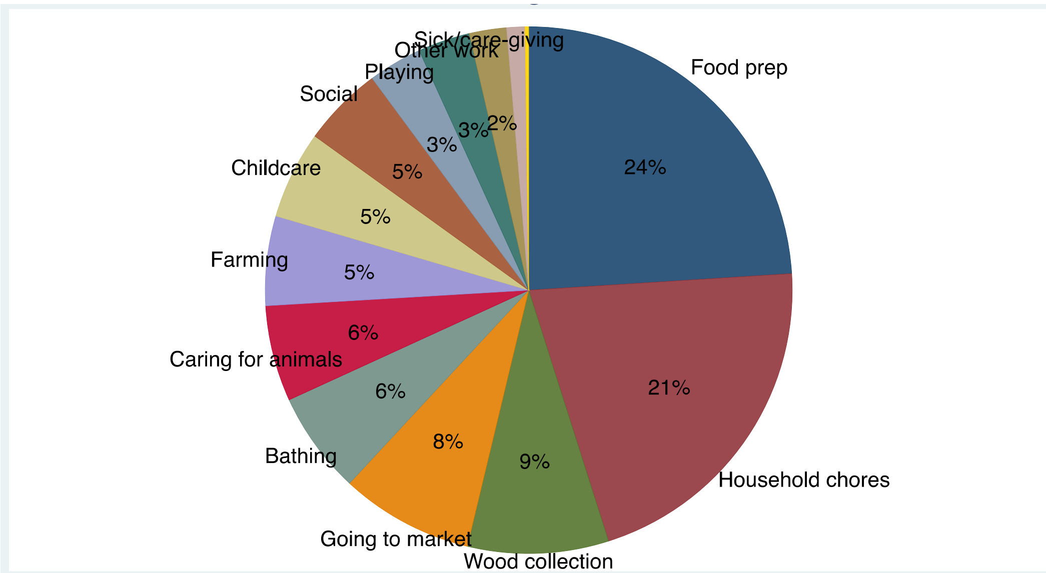


Figure 3. Water collectors' stated used of time saved from water collection



Notes: n=400 individuals who spent>20 mins collecting water in 2010; 78% female. Question was: "Now I want you to imagine reliving your day yesterday, but instead imagine spending only 20 minutes collecting water. How would you reallocate the time that is freed from collecting water?"

Remittances and Measurement Error: Evidence from India

Randall Akee*, Devesh Kapur **

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Abstract

Utilizing a novel data set on remittance data for India that matches household surveys to administrative bank data, we investigate the differences in self-reported and actual deposits to Non-Resident Indian (NRI) accounts. There is a striking difference between the perceived and actual frequency, as well as the amount of deposits, to NRI accounts. Our results indicate the presence of non-classical measurement error in the reporting of remittances in the form of deposits to NRI accounts. As a consequence, regression analyses using remittances as an explanatory variable contain large upward biases instead of the usual attenuation bias. On the other hand, using four different reports of total household remittances contained in the same survey indicates a high level of consistent reporting. We are able to conclude that the measurement error in this variable is classical in nature and can be treated as white noise in regression settings.

Keywords: Remittances; Measurement Error; Migration; India.

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I. Introduction

Remittances to India have grown dramatically in the past two decades. According to official Reserve Bank of India (RBI) data remittances have grown enormously from $2.1 billion in 1990-91 to $53.9 billion in 2009-10.[1] The share of private transfer receipts in India's GDP rose from 0.7 per cent in 1990-91 to 3.6 per cent in 2009-10. During this period there has been a concerted shift in the sending of remittances from informal to more formal channels. Overseas remittance inflows to India come primarily through two channels:

i) Inward remittance towards family maintenance.

ii) Non-Resident Indian (NRI) deposits schemes with the banks in India.[2]

The first channel was previously dominated by informal methods such as *hawala*, but Western Union and other forms of wire transfers are the most common means today - accounting for almost half of the remittance flows to India. There has been a similar growth in the flow of funds through the NRI accounts as well. These NRI accounts allow the immigrant abroad to deposit funds to a bank account held in India that can be accessed by specifically designated parties (typically household members). Local withdrawals from NRI bank deposits previously accounted for around 30 per cent of remittance flows in the late 1990s; in the last decade, however, that amount has grown to between 45-50 percent. According to estimates by the RBI, in 2009-10 total private transfer inflows into India were $53.9 billion. Of this $29.4 billion was "inward remittances for family maintenance" and $23.6 billion were "local withdrawls from NRI deposits."[3]

[1] Official Indian data is reported by Financial Year which is from April-March. Thus the data for 2009-10 is from April 1, 2009 to March 31, 2010.

[2] While inflows from overseas Indians for deposits in the NRI deposit schemes are treated as capital account transactions, funds domestically withdrawn from the Non-Resident (External) Rupee Account [NR(E)RA] and Non-Resident Ordinary (NRO) Rupee Account are included in the current account as private transfers. NRI deposits in India grew from $17.2 billion in March 1995 to $47.9 billion in March 2010.

[3] RBI Bulletin, May 2011, Table 9.

Other developing countries are increasingly turning to these overseas bank accounts as a more secure and efficient method of securing remittances; for instance, the Philippine Central Bank has made a concerted effort to encourage the use of Philippines Payment and Settlement System (PhilPass) for remittances from overseas Filipinos.

As the increase in formality of remittances flows has increased in India, we would expect the accuracy of reporting both on an aggregate and individual level to improve. Unfortunately, at the aggregate level at least, there appears to be a large discrepancy between the official RBI Balance of Payments data on remittances to India and aggregated amounts on nationally representative household surveys conducted by the National Sample Survey (NSS).

In principle the aggregation of the micro-household data at the all-India level should be equal to the macro-BOP data – or at least close to it. In reality there is a huge difference – by an order of magnitude.[4] The NSS 64th Round conducted between July 2007 – June 2008 focused on "Migration in India" and total remittances from those whose present place of residence was "another country" was Rs 167.06 billion.[5] The macro-numbers from the RBI put the figure for remittances for 2007-08 at Rs 1640.17 billion – a ten-fold difference.[6] Researchers have found consistent under reporting in

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[4] In India the difference between NSS aggregates and macro numbers are not unique to remittances. There has been growing concern, for instance at the widening discrepancies between NSS consumption figures and national income accounts. In 1972-73 consumption measured by the NSSO surveys amounted to 87% of consumption estimated by national accounts (which measures GDP). This proportion of consumption captured by the NSSO has steadily declined over the years, to 48.8% in 2005-05 and to just 43% as per the most recent 2009-10 survey. But even then the ratio is double, not an order of magnitude.

[5] Appendix Table 14, p. A-57, NSS Report No. 533 (64/10.2/2).

[6] RBI Bulletin March 2010, Statement 5, p. 588. While the RBI's data is from April 2007-March 2008 and the NSS covers July 2007-June 2008, the fact that remittances have been growing steadily should have led the aggregate NSS data to be greater (not less) than the RBI data. There is a possibility that the NSS question on remittances "whether sent remittances during the last 365 days" could imply that the aggregation should be done over 2006-07 instead of 2007-08; but even then the RBI data for remittances in 2006-07 is Rs. 1331.12 billion – eight times the NSS aggregate. A different way to cross-check data would be to compare the numbers for remittances *outflows* from a country to India provided by that country with the numbers for remittance *inflows* into India from that country provided by Indian authorities. Earlier RBI estimates of the geographical break-up of remittance inflows put the share of North America between 30 – 35 per cent in one report and 44 per cent in another (RBI, 2006a, RBI 2006b). The Appendix Table 1 compares the estimates of remittance flows from the United States to India from a recent report from the Congressional Budget Office with corresponding figures from the RBI for remittance inflows from North America. The discrepancy is almost a factor of five. If we grant that the RBI data is for North America and not just for the US, the difference would still be at least a factor of four since the Indian-born population in the US is at least four times that in Canada and an important factor underlying the large increase in remittances to India in the last decade appears to have been the influx of Indian IT-workers to the US through the H1-B visa program.

household surveys relative to balance of payment figures in other countries as well, but none have been as large as in the case of India (Andriasik, 2005; Acosta et al, 2006; Shonkwiler et al, 2011).

Accurately measuring remittances flows is particularly important in developing countries where the flows may account for a large proportion of household income. In India, the BOP estimates would indicate that remittances are approximately 4% of GDP, whereas the NSS household aggregate measure would put it only at 0.4% of GDP. The large margin of error is a big area of concern for policymakers. Estimates of income mobility, inequality and growth will all be affected by this mis-measurement. The results point to the need to more carefully check the accuracy of the international remittance flows.

At the microeconomic level, mis-reporting at the household level may significantly affect attempts to estimate the effect of remittances on various types of household investment and consumption expenditures.[7] Specifically, the use of mis-reported remittance variables in regression equations may significantly overstate (or understate) the role of remittances in household consumption and investments.

In our analysis we focus on total remittances as reported in a household survey that are reported in four different ways. We compare the consistency of the reporting of this amount, which is fairly good. Examining the relationship between the four reports of total remittances, we conclude that the remittance reporting is highly consistent even when asked in different ways. While we have no validation data for this data, we are able to conclude that any measurement error is classical in nature.

Additionally, we examine a single remittance channel where we do have validation data – deposits to NRI accounts. The withdrawals from deposits by immigrants abroad to NRI accounts comprise almost half of all remittance flows to India. Restricting our analysis to the NRI accounts allows us to use administrative data (Reserve Bank of India data on NRI credits and debits) to verify self-reported amounts on household surveys. In this study, a random sample of Non-Resident Indian (NRI) households in four Indian States (Kerala, Gujarat, Maharashtra, Punjab) are surveyed. Households are

[7] See McKenzie, et al (2007) for a discussion of the difficulties in estimating the effect of remittances on desired outcomes. Also see Adams (2006) and Rapoport et al (2006) for reviews of the kinds of estimations typically conducted in the literature on remittances.

asked to report in a survey the amount of remittances received annually by several different remittance channels.[8] This household survey is then linked to administrative data from the Reserve Bank of India for these same NRI accounts. To our knowledge, this is the first research which has a matched data set between administrative and survey data on remittances. Because of time and cost, the administrative data is provided for only a subset of the original household survey respondents. However the matched data is representative of our sample of NRI account households and provides several important insights into the nature of measurement error of this remittance channel.

We find that the differences between the self-reported frequency of remittances and actual deposits are large; the modal value for self-reports is 12 deposits per year while the administrative data indicate just 1 deposit per year. Second, the average annual self-reported amount from the household surveys is 266,411 rupees, while the actual average amount deposited per year is 411,158 rupees. There is strong evidence that the mis-reporting displays mean-reversion; individuals with above average levels of remittances tend to underreport the amount that they receive and those with below average remittances tend to over report the amount that they receive. This non-classical measurement error entails complications for regression analysis.

We also examine the role that household characteristics, specifically human capital variables, play in reporting error in remittances. It appears that more highly educated households tend to be more accurate in their survey responses. Households with more financial knowledge and banking experience also tend to more accurately report the amount of remittances to NRI accounts. We also find that the larger the prior remittance amount in a previous year, the more likely a household is to report an accurate remittance flow to their NRI account in the current year.

Finally, we explore how the non-classical measurement error in remittance data can adversely affect ordinary least squares regression results. We use the self-reported and administrative data on NRI remittances to explain household investment in land and property. Our results are troubling, given the non-classical nature of the measurement error in our data, the estimated coefficients are much larger in magnitude than the

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[8] The eight different categories were: direct credit to NRI accounts, demand drafts, internet based money transfer service, formal money transfer services, family member cash transfer, friends cash transfer, international debit or credit cards, other means.

coefficients from the administrative data. We also use the four different measures of total household annual remittances in a similar regression. Due to the high level of consistency across all four measures, we find that the coefficients are all very similar to one another. While we do not have validation data for this measure, we do have confidence that the measurement error, if any, is classical in nature. Our results suggest that detailed questions on remittances may pose a bigger challenge for household survey respondents than for a general question on total remittances. We explore why this might be the case in the discussion section.

The next section discusses previous remittance research. The following section provides information on the data collection and characteristics of the data set. In Section 4 we describe the nature of measurement error contained in the total annual remittance responses. We then turn to a discussion of the measurement error contained in a single channel of remittances – NRI deposits in Section 5. We explore the effect of these different measures on regression results in Section 6. In Section 7 we discuss the implications of measurement error in surveys and regression results and conclude.

II. Previous Literature

There have been very few studies examining the discrepancies in actual and reported remittance flows. Existing studies have compared differences in Balance of Payment data and aggregated household survey amounts. For instance, in Kyrgyz Republic, Andriasik (2005) finds that the remittances recorded in the Balance of Payments figures are twice as large as the household survey remittance aggregate. Shonkwiler, et al (2011) find qualitatively similar results in Armenia and propose an econometric solution for underreporting. Acosta et al (2006) find similar results for 11 countries in Latin America. Our study differs from these previous ones in that we have actual microeconomic data between self-reported household surveys and administrative measures of flows to the NRI accounts.

In this regard, our research fits into the existing measurement error literature on self-reported salary and wage income. Several authors have investigated the nature of measurement error in US wage and salary data. Duncan and Hill (1985), Bound and coauthors (1991;1994;2001), Pischke (1995) and Moffit and Gottschalk (2002) have found that the self-reported data tends to contain non-classical measurement error with mean reversion. Akee (2011) found similar results in a developing country context; however, the degree of measurement error was far worse than that in the US. Antman and McKenzie (2007) examine the implications of measurement error on measures of earnings mobility. Gine and de Nicola (2012) examine accuracy in income and asset accumulation for self-employed in India. Their findings indicate that accuracy is related to the recall period as expected. Additionally, they find that individuals most involved with the business are more accurate than spouses. These studies are unique in that they have a generally accepted check on self-reported information which is generally unavailable in standard data sets.

III. Data Set Collection and Description

a. Data Set Creation

We obtained the data for this analysis from the Reserve Bank of India. The research division commissioned a survey of households that had an operating NRI account in the four states of Gujarat, Kerala, Maharashtra and Punjab. Therefore, the population studied here are households with an operating (any transactions in the last two years) NRI account in these four Indian states. The household survey was intended to provide information on the amounts, uses and characteristics of migrants in NRI account-holding households in four Indian states that receive the highest volume of remittances. A small subset of this household survey was linked to RBI administrative data on NRI account transactions. Our analysis in this paper is conducted on the subset of matched data.

A survey firm, hired by the RBI, conducted the household survey from December 2009-July 2010. The RBI provided the survey firm with approximately 4000 names and addresses of randomly selected NRI account holder households. Enumerators contacted households by phone and by going to the address directly. The final household survey contained 2756 observations for a response rate of almost 70%.

The household survey contained several modules with questions on household demographics, consumption, asset ownership and liabilities, migrant information, uses of remittances, pattern of debits and credits to NRI accounts, and finally a section on the modes of sending remittances. The official, administrative data from the RBI provided information on the number of credits and debits to the NRI accounts in the previous two years as well as the total amount credited to the account in the previous year. The RBI provided account data for approximately 50 accounts from each of the 4 different states; these accounts were merged according to address information. The characteristics of the matched and non-matched sample do not differ significantly with respect to education levels, household income levels, or marital status. However, the matched sub-sample is about 3 years older than the non-matched sample and is 10 percentage points more likely to be male. Our final sample, which matched observations between the household survey and RBI data, is 197.[9]

b. Data Description

We present a description of the data in Table 1. The first four rows provide the total amount of remittances received by our survey households from all remittance sources. This question was asked in four different parts of the household survey in four completely different ways. The first question asks the respondent to provide the amount of annual remittances sent by each international migrant from their household in the past year.[10] The second measure asks the respondent to provide the amount of remittances sent in the past 12 months from abroad in a section on remittance use. The third measure comes from the section on Household Income and asks the respondent about the amount received annually from international remittances. Finally, the fourth measure asks the respondent for the amount of remittances sent from abroad via eight different channels. We sum these eight different remittance channels by household and compute a total remittances received for the previous year. Overall, all four measures are fairly close in value to one another. On average, a household in our survey received approximately 430,000 Rs. in international remittances from all sources in the year 2008. These results agree with Gine et al (2012) that placing a question in different locations in a survey does not affect the accuracy of reporting by household members.

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[9] It is important to note that previous studies on measurement error in survey responses typically have similar small sample sizes. For instance, Bound and Krueger (1991) have just 444 observations in their Current Population Survey – Social Security match dataset for their research on measurement error in wage reporting; Pischke (1995) has just 234 observations in his panel data using the Panel Study of Income Dynamics (PSID) data and 351 (437) observations in his 1982 (1986) cross-section.

[10] We restrict our analysis to migrant households with only a single migrant abroad. We do this in order to reduce the possibility of measurement error. There are very few households with multiple migrants, less than 5% of our sample and as a result we only lose a small amount of observations.

Our results for the total remittances differs dramatically from our results for deposits to Non-Resident Indian (NRI) accounts. We find that there is a big discrepancy between the measure of remittances sent via NRI accounts. Our measure of NRI deposits comes from a section detailing all possible channels of remitting from abroad. The respondent is asked to provide the annual amount sent by the international migrant for each possible channel. The average amount reported by households is 266,411 Rs. which is considerably smaller than the previous measure. We also have a measure of the actual amounts deposited to the same households' NRI accounts in the same time period. The average amount by household (provided by the RBI) is 411,158 Rs. This administrative data is lower than the total amount reported by households in the four measures discussed above. However, it is still worrying that there is such a large difference between the self-reported remittances via NRI channels and the administrative data. This difference is about 144,747 Rs. on average.

We also have information on the frequency of total remittances and the frequency of deposits to the NRI accounts provided in the household survey as well as from the RBI administrative data. These three measures are provided in the next section of Table 1. The first measure gives us the survey respondents' answer to the number of times a household received any type of remittance in the past year. The average reporting frequency is about 9 times per year, however, the modal response is 12 times per year with over 50% reporting this amount. The self-reported frequency of NRI deposits closely matches that of the overall report of receiving remittances from abroad. The results for this measure is very similar to that of the total remittance frequency at 8.4 for the mean and 12 for the mode. However, the RBI administrative data indicate that the average number of deposits to NRI accounts is around 5, with the mode being 1. Survey respondents are greatly overestimating the number of deposits to NRI accounts. In fact, they are equating it with the frequency of remittances from all sources. It appears that individuals are reporting the frequency of remittances from a single channel with that of the overall frequency of remittances.

The next section provides information on the head of household and family characteristics. In our sample, 74% of the household heads have a high school education or less, they are about 51 years of age and 56% are males. Almost all of the household heads are married (91%) and there are on average three people in a household. Forty three percent of survey households are urban and very few own any livestock, but on average all households have at least one vehicle. The average household salary income is about 69,000 Rs. per year. The migrant is on average 38 years old, a male, has had some college training and has spent about 10 years abroad.

Almost all of the NRI accounts are jointly administered by the head of household and the migrant. The other 12% of accounts are managed directly by the migrant. Our survey households have on average 2 bank accounts. Only a sub-sample answered the question regarding how much they had in all of these accounts and the average is 470,000 Rs. Finally, we provide the distribution of survey households by the four states. The majority is found in Maharashtra and Gujarat. We also report the self-reported deposits to NRI accounts from the household survey in 2007 which was 380,000 Rs. on average.

IV. Discussion of Measurement Error

In the case where a particular variable is measured with error we are typically are unable to separate out the signal and noise components of the variable. When there is administrative or validation data, however, one can simply subtract out the difference between the two separate reported values. On the other hand, if there are multiple measures of the same variable provided, one could potentially use these measures (if they are independently provided) to identify the true signal component in a variable with measurement error.

In this section, we discuss how we can assess the accuracy of the multiple measures of a single variable. In a regression setting that is common for remittances, we are concerned with the effect of remittance flows on household investment.[11] The regression equation would be described by the following:

(1) $Y_i = \beta X_i^* + \varepsilon_i$

In this case, we have an outcome variable, Y, which is assumed to be measured with no error and a variable, X^*, which in our case is the true remittance amount. Finally, there is

[11] This section follows Bound, et al. (2001)

the usual error term, ε_i. In reality, we seldom have the actual X^*, but instead we have the variable X which contains some measurement error. With multiple measures of X^*, we would have the following:

(2) $X_1 = X^* + u_1$

(3) $X_2 = X^* + u_2$

The main assumption for classical measurement error is that the error terms in the two equations above must be unrelated to the actual value of X^*. In addition, these error terms must also be unrelated to the error term in the regression equation. It is possible, with multiple measures of X^* to test whether this assumption of classical measurement error holds. For instance, if all three error terms above are unrelated to one another and to X^*, then it must be the case that :

(4) $Cov(X_1, Y) = Cov(X_2, Y)$

Substituting in for the definitions of Y, X_1 and X_2 gives us the following:

(5) $\beta\sigma_{X^*}^2 + \sigma_{\varepsilon,X^*} + \beta\sigma_{u_1,X^*} + \sigma_{u_1,\varepsilon} = \beta\sigma_{X^*}^2 + \sigma_{\varepsilon,X^*} + \beta\sigma_{u_2,X^*} + \sigma_{u_2,\varepsilon}$

We know that the third and fourth terms on each side of the equal sign should be zero if the measurement error is classical. The second term on both sides of the equal sign should also be zero by construction in the original regression equation; essentially this assumes that there is no endogeneity bias. The remaining term is the regression coefficient and the variance of the true value of X^*. The covariances of Y and the variables X_1 and X_2 are actually observed in our data. Therefore, it is possible to test whether or not the measurement error in the data is classical or not. If the measurement error is classical, we will have the usual attenuation bias of coefficients. Alternatively, with non-classical measurement error it is possible that OLS regression coefficients can be biased upwards.

In Table 2, we compute the covariances between an outcome variable that is contained in our data – the log of household property value – and the four measures of total remittances contained in our data. The covariances range in value from 66155.7 to 71463.5. We test the hypothesis that the first covariance is equal to the other three covariances. The p-values are given for each of those tests in the next column. We fail to reject the null hypothesis of equality in all three cases. This strongly indicates that the measurement error, if there is any, contained in the four measures of total remittances received is classical in nature.

These results are good news for the measure of total remittances received by a household. Additionally, it is instructive to learn that the four different methods of asking this question resulted in a very consistent and accurate response from survey respondents.

On the other hand, conducting the same analysis for the NRI remittances channel with the administrative and self-reported data indicates that the measurement error is not classical. We explicitly compare the self-reported value of X^* with the administrative value in this comparison. We reject the null hypothesis that the two covariances are the same, the p-value is less than 0.001. This was suspected given the large discrepancy between the self-reported amount and the administrative amount in Table 1.

We further investigate the nature of the measurement error for the NRI deposit channel. In Table 3, we compute the actual measurement error as is standard in the literature (Bound and Krueger, 1991):

(6) $Error = X_1 - X^*$

Where X_1 is the self-reported value of NRI deposits and X^* is the administrative data on NRI deposits. Finally, we compute the correlation between these three variables. The first figure indicates that there is a positive relationship between the self-reported and administrative values of NRI deposits; however, the correlation is quite low. Worse, we find that the relationship between the administrative data and the measurement error is negatively and large in magnitude. If the measurement error had been classical, this correlation would have been approximately zero. These results confirm the findings in the previous table. Finally, we report that there is a positive relationship between the measurement error and the self-reported remittances via NRI accounts.

In Figure 1, we plot the distribution of the measurement error. While the errors are centered on zero, there is a large left-hand tail in the distribution indicating that there is underreporting of NRI deposits.

V. Determinants of Measurement Error

For the NRI remittance flow it is possible to explain the differences in the measurement error using household characteristics and experience. This is a useful undertaking in order to understand what qualities may be particularly important in biasing the self-reporting of remittances. In Table 4, we regress the following ordinary least squares model:

(7) $Error_i = \beta_0 + \beta' Q + \nu_i$

In the equation above, the vector Q contains household head characteristics such as education, gender and age, asset ownership and migrant characteristics. We also include a number of financial knowledge and experience variables to explain the measurement error and υ_i is the regression error term.

Given that on average there is severe underreporting of NRI deposits, a negative coefficient indicates that this particular characteristic intensifies the reporting error and a positive coefficient does the opposite. In the first column of Table 4, we regress the basic household head characteristics on measurement error. Relatively low educated household heads with a high school equivalent or less are more likely to underreport NRI remittance amounts. In fact, the amount of underreporting is approximately 200,000 Rs. which closely matches the difference in self-reported and administrative reports of NRI deposits. A likely candidate for mis-reporting may simply be low education levels in survey data. We consistently find that the coefficient on this variable is negative in all regression specifications, however, it loses statistical significance in several specifications.

In the next two columns we include additional household characteristics as well as characteristics of the migrant himself (93% of migrants are male). We don't find that these characteristics significantly affect the observed measurement error.

In the next four columns, we sequentially include various financial characteristics and previous remittance experience in the regression. We find that all of these variables have positive coefficients and they reduce the reporting error in NRI deposits. Having a jointly administered NRI account increases the self-reported amount of NRI deposits by over 400,000 Rs. relative to the household head who is not authorized to access the account. This result indicates that more access and knowledge of the particular NRI account results in more accurate reporting on household surveys.

The next two columns include the number of bank accounts owned by the household and amount in those accounts. Households with more reported bank accounts are more likely to report accurately by almost 100,000 Rs. For households that reported the amount in their accounts (only 120 responded), having an additional 100,000 Rs. in total bank accounts results in a higher self-report of NRI deposits by 20,000 Rs.

In the final column, we explore the effect of the prior year's remittances on reporting in the current year. We first regress the total amount of remittances from all sources reported by the household head in 2007 on the current measurement error in NRI deposits. Having reported 100,000 Rs. more in previous year's remittance amounts results in an increase of 65,000 Rs. in the self-reported NRI deposits in the current year. Assuming that the self-report on total remittances from the previous year is also accurate indicates that experience with high remittance volumes tends to improve the accuracy of reporting in the current period for NRI deposits.

VI. Potential Bias in Estimation Results when Remittances Measures contain Measurement Error

It is a well-known fact that classical measurement error leads to attenuation bias in ordinary least squares regressions. When the measurement error is non-classical, however, there is a possibility that the estimated coefficient will be greater than the true effect.

For instance, assume that we are concerned with the cross-section analysis described earlier in equation 1. Our interest is in estimating the effect of X^*, which can be thought of as remittances received by the individual household i on a measure of investment, Y. Instead, we actually estimate the following:

(8) $Y_i = \beta X_i \;\; + \varepsilon_i$

In the presence of classical measurement error in the X variable, ordinary least squares estimates of the slope coefficient tends to be biased towards zero. Assume that the measurement error in the right hand side variable is determined in the following manner:

(9) $X = X^* + u$

where X is the self-reported value of remittances received in a household survey, for instance. The variable X^* is the true (unobserved) measure of remittances and u is the measurement error. In this case, ordinary least squares will produce the following slope estimate:

(10) $plim\hat{\beta}\,\frac{\beta(\sigma^2_{X^*}+\sigma_{u,X^*})}{\sigma^2_{X^*}+\sigma^2_{\varepsilon}+2\sigma_{u,X^*}}$

Assuming that there is classical measurement error implies that $\sigma_{u,X^*} = 0$ and the estimated coefficient will be downward biased away from the true population parameter since $\sigma^2_{\varepsilon} > 0$. In our case we know that the measurement error is not classical and is negatively related to the true value of the variable being measured. Therefore, in this situation the estimated OLS coefficient may be either larger or smaller than the true population coefficient depending on which effect is larger σ_{u,X^*} or σ^2_{ε}; the first is a negative term and the second is a variance which is always positive.[12]

[12] Instrumental variables are not guaranteed to solve the problem in this case either. The estimated coefficient from an IV regression may also potentially be biased upward in the presence of non-classical measurement error.

As an example, we provide a regression explaining land and property investment for households in Table 5. We regress the log value of property owned by the survey households on the total amount of annual remittances (in 100,000s rupees) reported by the household. Remittances are often viewed as affecting both direct consumption and investment in assets in developing countries. In the first column we regress a number of household characteristics on the log value of property. Only total household salary income is statistically significant and negative. The coefficient indicates that for every additional 100,000 Rs. in household salary income there is a 9.8 percent decrease in property investment. This may mean that households that are more engaged in the wage sector invest in assets other than land; specifically, they are less likely to be rural households and less likely to invest in agricultural lands.

We also regress the value of NRI deposits as provided by the RBI data for these households on the log value of property. The coefficient indicates that an increase of 100,000 Rs. will increase the total invested in property by 2%. The same regression using the self-reported NRI deposits in the next column indicates that the effect is 5%, two and half times larger than the effect of the administrative data. Given the non-classical measurement error, the OLS coefficient is biased upward, not downward, from its true value.

In the next four columns we regress the four different measures of total remittances on the log value of property. The coefficients on all of these variables range in size from 0.043 to 0.047. While we do not have a measure to validate the reporting of these four total remittance variables, we have shown earlier that they are likely reporting the true value of total remittances. Any measurement error contained in those measures would be classical and would not produce any upward bias on the estimated coefficient in an OLS regression.

This regression provides an example of the problems with using a measure of remittances that contains non-classical measurement error. On the one hand, using the self-reported measure of NRI deposits, one would conclude that the effect on property investment is about a 5% increase for every 100,000 Rs. in additional remittances sent via this channel. On the other hand, regressing total remittances on the same outcome would provide a slightly perverse result which indicates that the effect is less than 5% for each additional 100,000 Rs. in total remittances. One might falsely conclude that NRI deposits have a large effect on property investment in India using just the self-reported data. As we have shown, it is likely that the first estimate is biased upward by two and a half times.

VII. Discussion and Conclusion

There are two main findings from our research. First, we find that asking households the total amount of annual remittances is consistent across our four different survey questions. Also, placement of the question within the survey does not appear to affect the accuracy of reporting. While we are not able to discern the size of measurement error in this data, we are able to conclude that any measurement error is classical for this variable.

Our second finding is that the self-reported data for a single, large remittance flow is severely underreported relative to administrative data for this variable. The deposits to NRI accounts are underreported on average by almost 35%. We also conclude that the measurement is not classical and is negatively correlated with the true value of NRI deposits. Attempting to explain these measurement errors, we find that the knowledge and experience with the previous year's remittance amounts and financial experience tended to reduce the measurement error.

We have evidence that there is greater underreporting of NRI deposits when the survey respondent has lower levels of education, does not jointly administer the NRI account and reports lower remittances flows in the previous year. This measurement error results in an upward bias of coefficients in a simple investment regression by two and a half times.

Our research suggests that there is considerable room for improvement in the collection of remittance data and survey questions. While the overall data on total household remittances appears to contain only classical measurement error, if at all, we still do not know the overall accuracy of this measure. Experimentally testing and validating different forms of remittance survey questions would be an important step in assessing the usefulness of remittance survey questions (see, for instance De Mel, et al 2007).

References

Adams, Richard. 1998. “Remittances, investment and rural asset accumulation in Pakistan.” Economic Development and Cultural Change. V. 47, pp. 155-173.

Adams, Richard. 2006. “International remittances and the household: analysis and review of global evidence.” Journal of African Economies. V. 15 no 2, pp. 396-425.

Adams, Richard and J. Page. 2005. “Do International Migration and Remittances reduce poverty in developing countries?” World Development. V. 33 no 10, pp. 1645 – 1669.

Adams, Richard and A. Cuecuecha. 2010. “Remittances, Household Expenditure and Investment in Guatemala.” World Development. V 38 no 11, pp. 1626-1641.

Akee, R. 2011. “Errors in self-reported earnings: The role of previous earnings volatility and individual characteristics. Journal of Development Economics, forthcoming.

Angrist, J. and A. Krueger. 1999. "Empirical Strategies in Labor Economics." in Handbook of Labor Economics. O. Ashenfelter and D. Card, eds. Amsterdam: North-Holland. V. 3A, 1277-1366.

Antman, Francisca and David J. McKenzie. 2007. "Earnings Mobility and Measurement Error: A Pseudo-Panel Approach." Economic Development and Cultural Change, 56(October): 125-161.

Black, D. and M. Berger and F. Scott. 2000. "Bounding Parameter Estimates with Nonclassical Measurement Error." Journal of the American Statistical Association, 95(451):739-748.

Bound, John and Alan B. Krueger. 1991. "The Extent of Measurement Error in Longitudinal Earnings Data: Do Two Wrongs Make a Right?" Journal of Labor Economics, 9(1): 1-24.

Bound, J. and Charles Brown, Greg J. Duncan and Willard L. Rodgers. 1994. "Evidence on the Validity of Cross-sectional and Longitudinal Labor Market Data." Journal of Labor Economics, 12(3): 345-368.

Bound, J. and Charles Brown and Nancy Mathiowetz. 2001. "Measurement Error in Survey Data." In The Handbook of Econometrics, Volume 5. eds. James J. Heckman and Edward Leamer, 3705-3843. New York : Elsevier Science. Cappellari, Lorenzo. 1999. "Minimum Distance Estimation of Covariance Structures." Fifth UK Meeting of STATA Users, Royal Statistical Society, London, UK.

Brown, R. and E. Jimenez. 2008. “Estimating the Net Effect of Migration and Remittances on Poverty and Inequality: Comparison of Fiji and Tonga.” Journal of International Development V 20, pp. 547-571.

Cox Edwards, A. and M. Ureta (2003): International migration, remittances and schooling: evidence from El Salvador, *Journal of Development Economics*, 72, 2: 429-61.

de la Brière, B., E. Sadoulet, A. de Janvry and S. Lambert. 2002. “The roles of destination, gender, and household composition in explaining remittances: An analysis for the Dominican Sierra.” *Journal of Development Economics*, 68, 2: 309-28.

De Mel, Suresh and David McKenzie and Christopher Woodruff. 2007. "Measuring Microenterprise Profits: Must we ask how the sausage is made?" Journal of Development Economics, doi: 10.1016/j.jdeveco.2008.01.007.

Duncan, Greg J. and Daniel H. Hill. 1985. "An Investigation of the Extent and Consequences of Measurement Error in Labor-economic Survey Data." Journal of Labor Economics, 3,(4) : 508-532.

El- Qorchi, Mohammed, Samuel Munzele Maimbo, and John Wilson, 2003, “Informal Funds Transfer Systems: An Analysis of the Informal Hawala System.” IMF Occasional Paper No. 222 (Washington: International Monetary Fund).

Funkhouser, E. (1995): Remittances from international migration: a comparison of El Salvador and Nicaragua, *Review of Economics and Statistics*, 77, 1: 137-46.

Gine, Xavier and Francesca de Nicola. 2012. “How accurate are recall data? Evidence from coastal India.” World Bank Policy Research Paper, WPS6009.

Lucas, R and O. Stark. 1988. “Migration, remittances, and the family.” Economic Development and Cultural Change. V 36 no 3, pp. 465 – 481.

McKenzie, David; Gibson John; Stillman, Steven. 2006. “How Important is Selection? Experimental versus Non-Experimental Measures of the Income Gains from Migration.” World Bank Policy Research Working Paper 3906.

McKenzie, David and M. Sasin. 2007. Migration, Remittances, Poverty and Human Capital: Conceptual and Empirical Challenges. World Bank Policy Working Paper No. 4272. Washington, DC: World Bank.

Moffit, Robert and Peter Gottschalk. 2002. "Trends in the Transitory Variance of Earnings in the United States." The Economic Journal. 112(March) : 68-73.

Pischke, Jorn-Steffen. 1995. "Measurement Error and Earnings Dynamics: Some Estimates from the PSID Validation Study." Journal of Business and Economic Statistics. 13(3) : 305-314.

Rapoport, Hilel and F. Docquier. 2006. "The economics of migrants' remittances. In: Kolm, S. and J. Mercier Ythier (Eds.), Handbook of the Economics of Giving, Altruism and Reciprocity. North Holland, pp. 1135-1198.

Reserve Bank of India, 2006a, "Report of the Working Group on Cost of NRI Remittances," May. Available at: http://rbidocs.rbi.org.in/rdocs/PublicationReport/Pdfs/72983.pdf

Reserve Bank of India, 2006b, "Remittances from Overseas Indians: A Study of Methods of Transmission, Cost, and Time," *RBI Bulletin* November 2006, Annex 3.

Reserve Bank of India. 2008. "India's Balance of Payments Developments during Fourth Quarter of 2007-08" Unpublished Document.

Shonkwiler, J. Scott and David Grigorian and Tigran Melkonyan. 2011. "Controlling for the underreporting of remittances." Applied Economics, 43(30), 4817-4826.

Yang, Dean. 2008. "International Migration, Remittances, and Household Investment: Evidence from Philippine Migrants' Exchange Rate Shocks." *Economic Journal*, 118(528): 591-630.

Table 1 : Means

	Observations	Mean	Std. Dev.	Min	Max
Total Household International Remittances					
Total Remittances Sent in the Past 12 Months- All Sources, Section D	197	444,553.30	386902.5	50000	2500000
Total Remittances Sent in the Past 12 Months - Purposes, Section E	197	427,954.30	379735	0	2500000
Total Remittances Sent in the Past 12 Months - Income, Section A	197	434,984.80	386090.7	50000	2500000
Total Remittances Sent in the Past 12 Months - Modes, Section G	196	443,989.80	388778.4	50000	2500000
Deposits to NRI Accounts, 2008					
Total Non-Resident Indian Account Deposits; Annual Amount	197	266,411.20	385809.5	0	2500000
Total Non-Resident Indian Account Deposits; Annual Amounts - Reserve Bank of India Data	197	411,158.90	674620.5	0.87	3746000
Difference between Self-Reported NRI Deposits and RBI Administrative Data	197	-144747.7	717274.6	-3499423	1907000
Frequency of Deposits to NRI Accounts					
Frequency of All Types of Remittances	197	8.76	4.026562	1	12
Frequency of NRI Deposits, Self-Reported	197	8.4	3.955825	1	15
Frequency of NRI Deposits, RBI Report	196	5.07	5.070851	1	37
Household and Migrant Characteristics					
High School Education or Less	197	0.74	0.44	0	1
Age	197	50.94	14.83	20	85
Male	197	0.56	0.50	0	1
Married	197	0.91	0.29	0	1
Number in Household	197	3.03	1.38	1	6
Urban Household	197	0.43	0.50	0	1
Number of Livestock Owned	197	0.16	0.67	0	7
Number of Vehicles Owned	197	1.67	1.50	0	8
Total Salary Income in 100,000 Rs.	197	0.69	1.17	0	4.5
Current Age	197	38.40	9.48	24	86
Male	197	0.93	0.25	0	1
Education prior to migration	197	6.25	1.64	3	10
Number of Years Abroad	197	10.81	7.33	0	46
NRI Account Jointly Administered	197	0.88	0.32	0	1
Number of Bank Accounts in Household	197	2.25	1.79	0	10
Total Amount in All Accounts in 100,000 Rs.	120	4.77	8.84	0	75
Maharashtra	197	0.29	0.45	0	1
Gujarat	197	0.30	0.46	0	1
Kerala	197	0.20	0.40	0	1
Punjab	197	0.21	0.41	0	1
Deposits to NRI Accounts, 2007					
Total Non-Resident Indian Account Deposits in 2007; Annual Amount - Self-Reported Data in 100,000 Rs.	197	3.80	3.60	0	25

Table 2: Covariances of Log Property Value and Various Measures of Remittances

	Log of Property Value	P-Scores of Equality of Covariances of Log Prop Value and Sec D Total Remittances Sent in the Past 12 Months- All Sources, Section D
Total Remittances Sent in the Past 12 Months- All Sources, Section D	67451	
Total Remittances Sent in the Past 12 Months - Purposes, Section E	71463.5	0.9711
Total Remittances Sent in the Past 12 Months - Income, Section A	66155.7	0.9999
Total Remittances Sent in the Past 12 Months - Modes, Section G	71426.5	0.9983

N =196

	Log of Property Value	Total Non-Resident Indian Account Deposits; Annual Amounts - Reserve Bank of India Data
Total Non-Resident Indian Account Deposits; Annual Amounts - Reserve Bank of India Data	0.981942	
Total Non-Resident Indian Account Deposits; Annual Amount	0.756702	<0.001

N =196

Table 3: Simple Correlations and Reliability Ratios for Administrative, Reported Earnings Data and Reporting Errors

A. Correlation Coefficients	
Correlation (Administrative Remittances, Self-Reported Remittances)	0.172
Correlation (Administrative Remittances, Measurement Error)	-0.848
Correlation (Self-Reported Remittances, Measurement Error)	0.3762

Note: Sample size = 197

Table 4: Determinants of Measurement Error

VARIABLES	(1) Measurement Error in NRI Remittances	(2) Measurement Error in NRI Remittances	(3) Measurement Error in NRI Remittances	(4) Measurement Error in NRI Remittances	(5) Measurement Error in NRI Remittances	(6) Measurement Error in NRI Remittances	(7) Measurement Error in NRI Remittances
Household Head Characteristics							
High School Education or Less	-2.194**	-2.139*	-1.882	-1.615	-1.981*	-1.748	-1.125
	(1.090)	(1.213)	(1.203)	(1.189)	(1.177)	(1.687)	(1.088)
Age	0.002	0.004	-0.014	-0.021	-0.002	0.005	-0.018
	(0.036)	(0.043)	(0.041)	(0.041)	(0.040)	(0.060)	(0.039)
Male	-0.399	-0.350	0.114	0.616	0.241	0.387	0.153
	(1.139)	(1.232)	(1.424)	(1.495)	(1.427)	(2.201)	(1.354)
Married	-0.121	-0.165	-0.464	-0.812	-0.673	-1.614	-0.722
	(1.775)	(1.928)	(1.921)	(1.919)	(1.918)	(1.718)	(1.692)
Household Characteristics							
Number in Household	0.600*	0.646	0.591	0.740**	-0.067	0.458	0.088
	(0.354)	(0.410)	(0.359)	(0.344)	(0.381)	(0.549)	(0.351)
Urban Household		-0.340	-0.473	-0.116	-0.189	-0.121	-0.913
		(1.084)	(1.094)	(1.119)	(1.127)	(1.554)	(1.046)
Number of Livestock Owned		-0.596	-0.530	-0.550	-0.551	-0.430	-0.729
		(0.788)	(0.824)	(0.831)	(0.806)	(0.802)	(0.799)
Number of Vehicles Owned		-0.156	-0.195	-0.328	-0.493	-0.480	-0.023
		(0.379)	(0.304)	(0.311)	(0.346)	(0.363)	(0.282)
Total Salary Income in 100,000 Rs.		0.226	0.314	0.469	0.509	0.255	0.532
		(0.459)	(0.550)	(0.499)	(0.597)	(0.784)	(0.551)
Migrant Characteristics							
Current Age			0.088	0.067	0.160*	0.105	0.098
			(0.083)	(0.082)	(0.091)	(0.093)	(0.070)
Education prior to migration			0.234	0.260	0.009	-0.055	-0.213
			(0.353)	(0.349)	(0.353)	(0.422)	(0.372)
Number of Years Abroad			-0.046	-0.002	-0.151	-0.059	-0.048
			(0.113)	(0.116)	(0.125)	(0.108)	(0.098)
Remittance Variables							
NRI Account Jointly Administered				4.057**			
				(1.882)			
Number of Bank Accounts in Household					0.964***		
					(0.352)		
Total Amount in All Bank Accounts in 100,000 Rs.						0.249***	
						(0.038)	
Total Remittances in 2007; Self-Reported Data in 100,000 Rs.							0.655***
							(0.209)
Constant	-1.427	-1.321	-4.707	-8.471**	-5.296	-4.158	-3.604
	(2.720)	(3.050)	(3.896)	(4.186)	(3.849)	(4.472)	(3.660)
Observations	197	197	197	197	197	120	197
R-squared	0.0337	0.0405	0.0479	0.0774	0.0790	0.137	0.123

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Dependent Variable is given in 100,000 Rs.

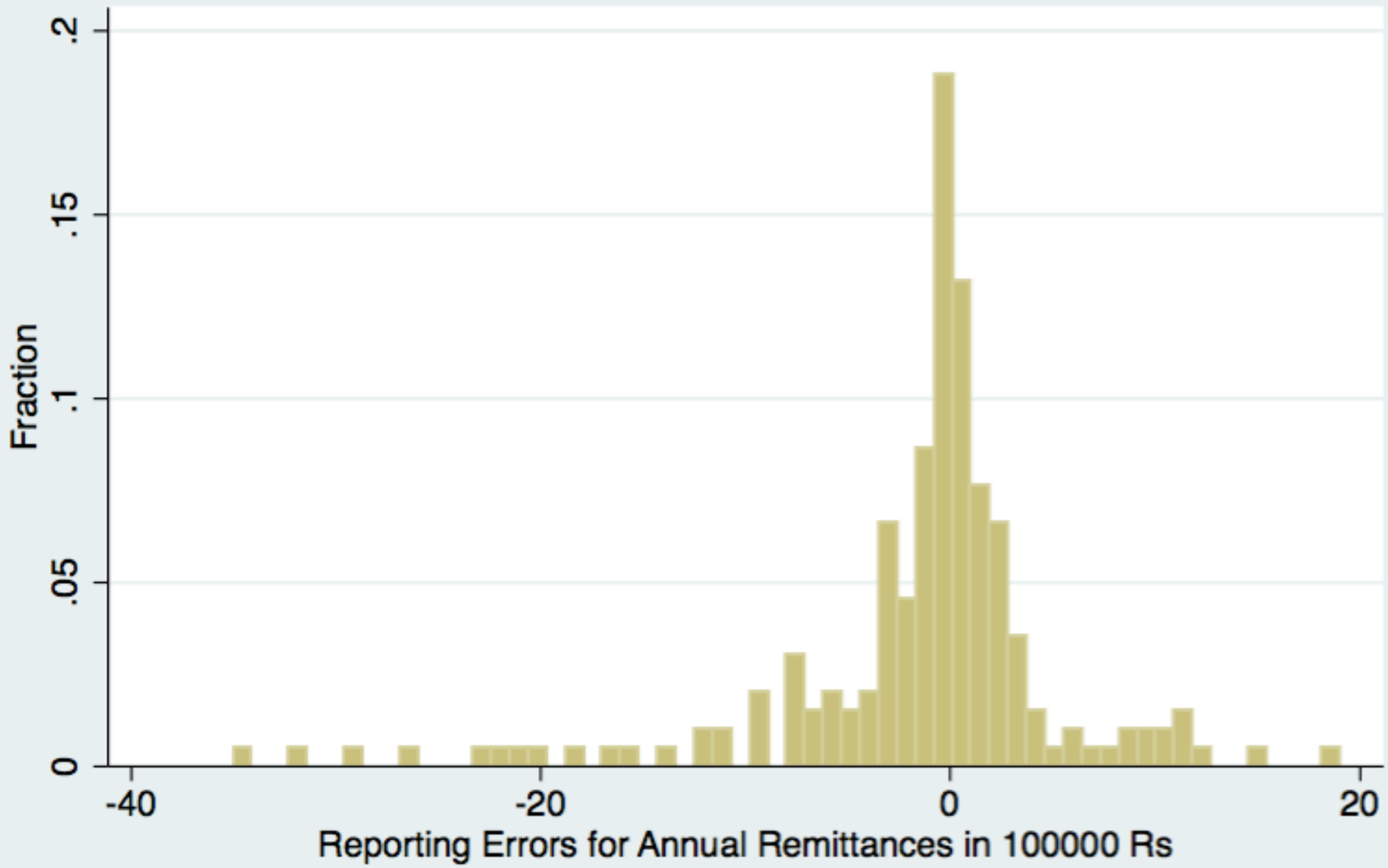
Table 5: OLS Regression of Log Property Value on Remittance Variables

VARIABLES	(1) Log Value of Property Owned by Household	(2) Log Value of Property Owned by Household	(3) Log Value of Property Owned by Household	(4) Log Value of Property Owned by Household	(5) Log Value of Property Owned by Household	(6) Log Value of Property Owned by Household
Household Head Characteristics						
High School Education or Less	-0.049	0.062	0.063	0.062	0.060	0.063
	(0.130)	(0.131)	(0.125)	(0.125)	(0.125)	(0.125)
Age	0.006	0.005	0.006	0.006	0.006	0.006
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Male	0.156	0.186	0.172	0.157	0.179	0.172
	(0.126)	(0.123)	(0.126)	(0.123)	(0.127)	(0.125)
Married	-0.328	-0.320	-0.364*	-0.353	-0.389*	-0.368*
	(0.227)	(0.212)	(0.215)	(0.215)	(0.219)	(0.215)
Household Characteristics						
Number in Household	0.066	0.039	0.031	0.030	0.029	0.033
	(0.043)	(0.044)	(0.047)	(0.047)	(0.048)	(0.046)
Total Salary Income in 100,000 Rs.	-0.098**	-0.115***	-0.088**	-0.085**	-0.085**	-0.090**
	(0.043)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)
Remittance Variables						
Total Non-Resident Indian Account Deposits; Annual Amounts - Reserve Bank of India Data in 100,000 Rs.	0.020***					
	(0.007)					
Total Non-Resident Indian Account Deposits; Annual Amount - Self-Reported Data in 100,000 Rs.		0.050***				
		(0.014)				
Total Remittances Sent in the Past 12 Months- All Sources, Section D in 100,000 Rs.			0.043**			
			(0.021)			
Total Remittances Sent in the Past 12 Months - Purposes, Section E in 100,000 Rs.				0.047**		
				(0.021)		
Total Remittances Sent in the Past 12 Months - Income, Section A in 100,000 Rs.					0.044**	
					(0.021)	
Total Remittances Sent in the Past 12 Months - Modes, Section G in 100,000 Rs.						0.046**
						(0.019)
Constant	14.550***	14.532***	14.474***	14.452***	14.512***	14.486***
	(0.323)	(0.304)	(0.311)	(0.307)	(0.311)	(0.309)
Observations	196	196	196	196	196	195
R-squared	0.117	0.141	0.125	0.131	0.125	0.130

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Fig. 1: Distribution of Errors in Annual Remittances

2008



Appendix Table 1.

US-India Remittance Flows

	2006-07	2007-08	2008-09
CBO	2.475	2.975	2.975
RBI	10.02	14.24	13.79

Source: Congressional Budget Office *Migrants' Remittances and Related Economic Flows* February 20111, Exhibit 4; *RBI Bulletin*, Table 6, p. 787, April 2010.

The Dirty Business of Open Defecation: Lessons from a Sanitation Intervention

Lisa Cameron, Paul Gertler, and Manisha Shah

WSP Asked “What works?”

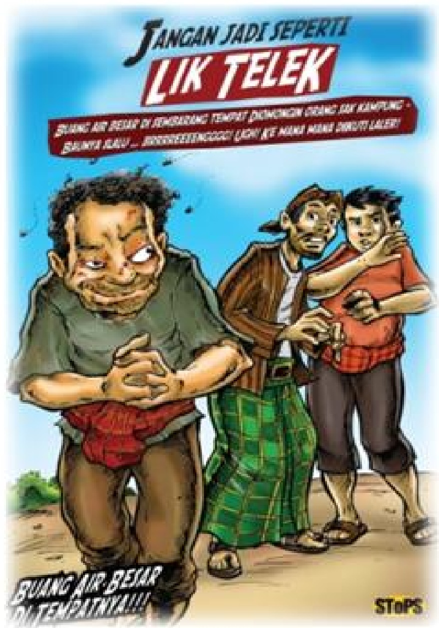
- Evaluation of “at scale” interventions in 7 countries
  - 4 TSSM
  - 3 Hand Washing
- Coordinated
  - Same outcomes
  - Rigorous causal methods
- WSP learning agenda
  - Large team of IE experts & operational staff
  - BMGF funding

Total Sanitation and Sanitation Marketing in Indonesia (SToPs)

Demand side

1 Community-led Total Sanitation:

- ☑ Stop OD by raising awareness
- ☑ “map” the village
- ☑ “walk of shame”
- ☑ Triggers community action
- ☑ Action plan & monitoring



2 Behavior Change Communications

- ☑ Social Marketing Events +
- ☑ Communication Campaign

Supply side

3 Social Marketing of Sanitation:

- ☑ Popularize improved sanitation
- ☑ Sanitation choice catalogue
- ☑ Training masons

Basic IE Questions

What is the overall Impact of TSSM on

- Sanitation improvement and construction
- Open Defecation
- Health
  - Diarrhea
  - Parasites
  - Anemia
  - Height and weight

Advanced IE Questions

2. Decomposition of overall OD effect into
   - Sanitation construction
   - Increased use of sanitation (behavioral)
3. Liquidity constraints
4. Effects of stronger implementation

Today….

I. Theory of Change

II. IE Design

III. Results

  I. Sanitation

  II. Open Defecation

  III. Health Outcomes

IV. Implementation issues

V. Policy Messages

Conceptual Framework

Decompose Open Defecation Rate into:

$$D = D_T T + D_{NT}\left(1 - T\right)$$

D = Open Defecation Rate

T = Share of households that have sanitation

D_T = Open Defecation Rate of HHs with Sanitation

D_{NT} = Open Defecation Rate of HHs without Sanitation

TSSM Pathways To Reduce OD

1. Sanitation construction $= \Delta T\left(D_T - D_{NT}\right)$
2. Δ in use of those who have san $= \Delta D_T T$
3. Δ in use of those who do not have san $= \Delta D_{NT}\left(1 - T\right)$

Indonesia and East Java

http://education.yahoo.com/reference/factbook/id/map.html

Sampling & Experimental Design

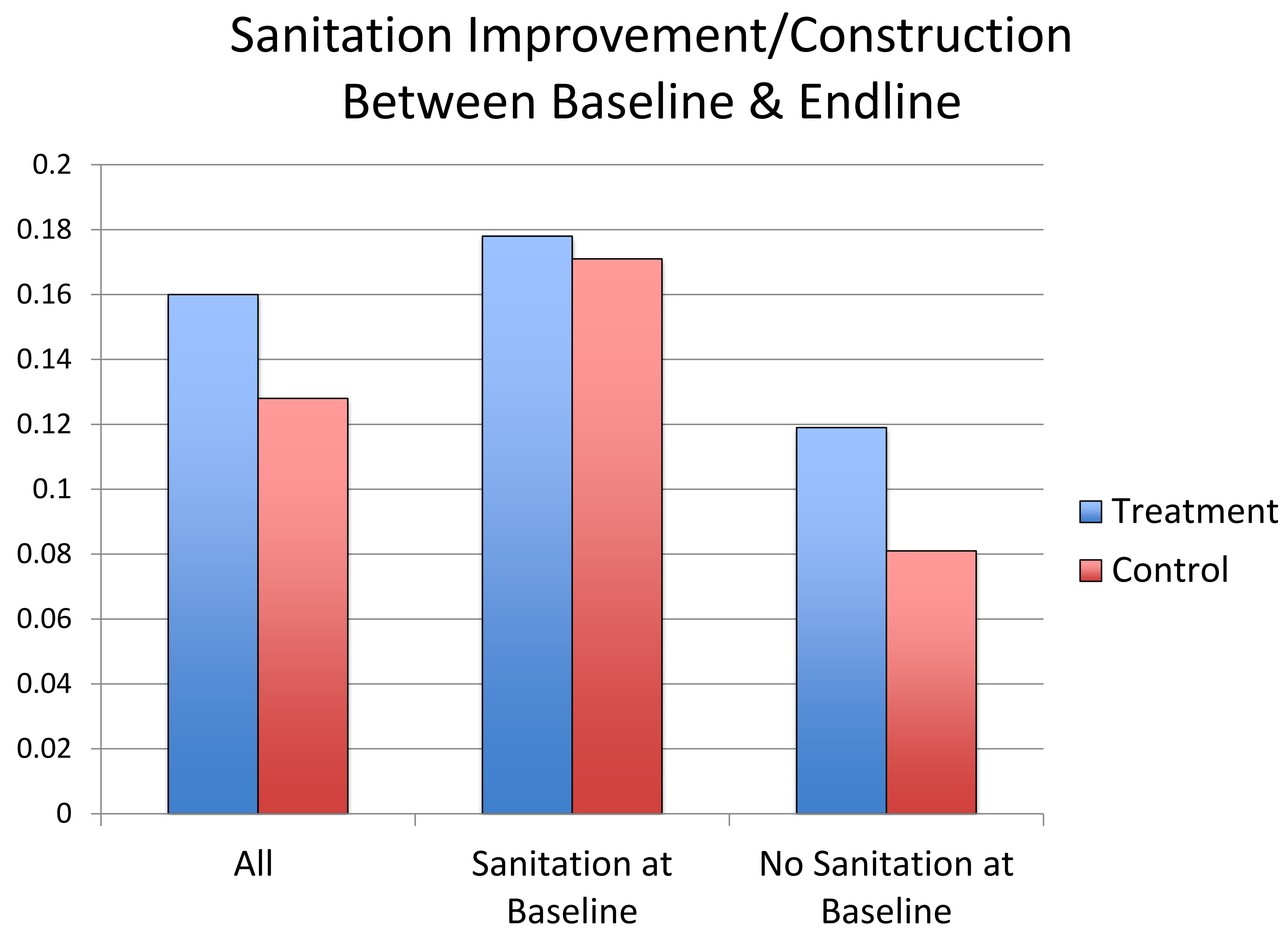
East Java: 29 districts total
10 districts in TSSM Phase 2

8 of 10 districts participated in study

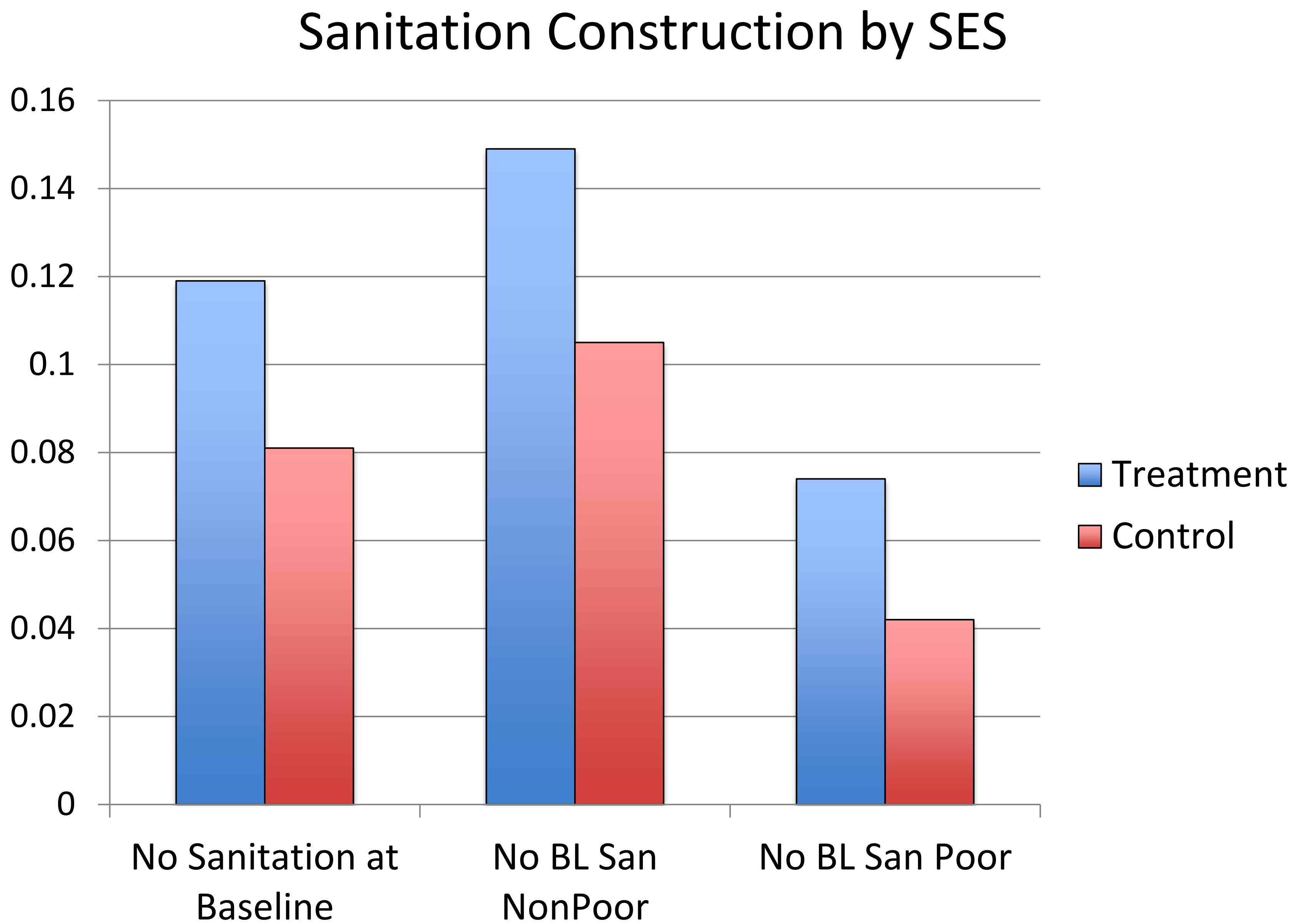
Randomly Sampled 160 communities
('dusun' or hamlet)
Randomly Assigned to

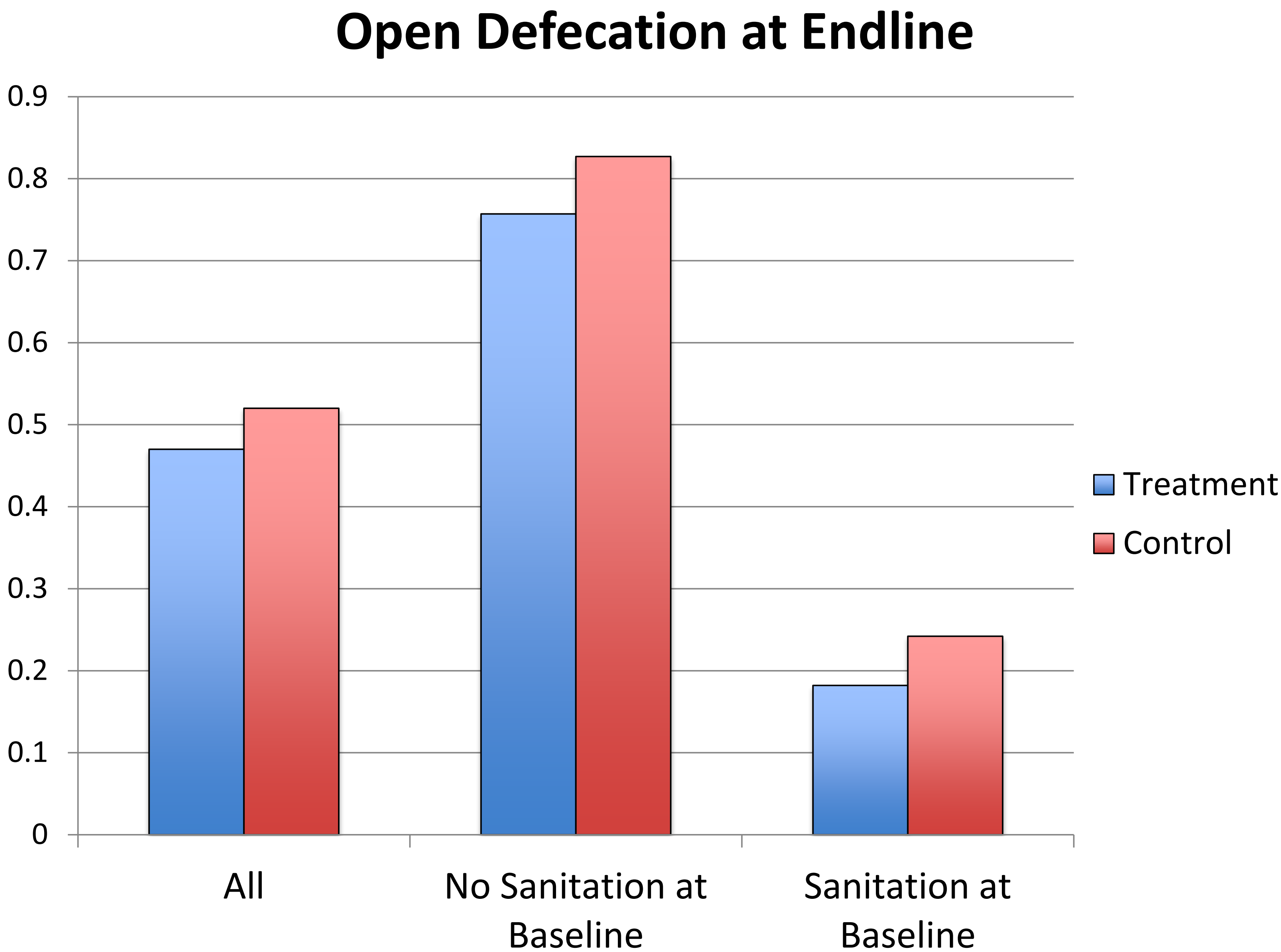
Treatment
80 dusuns
Random Sample
1046 HHs

Control
80 dusuns
Random Sample
1041 HHs



Sanitation Improvement/Construction Between Baseline & Endline
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
All
Sanitation at Baseline
No Sanitation at Baseline
Treatment
Control


Sanitation Construction by SES
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Treatment
Control
No Sanitation at Baseline
No BL San NonPoor
No BL San Poor


Open Defecation at Endline
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
All
No Sanitation at Baseline
Sanitation at Baseline
Treatment
Control

Open Defication

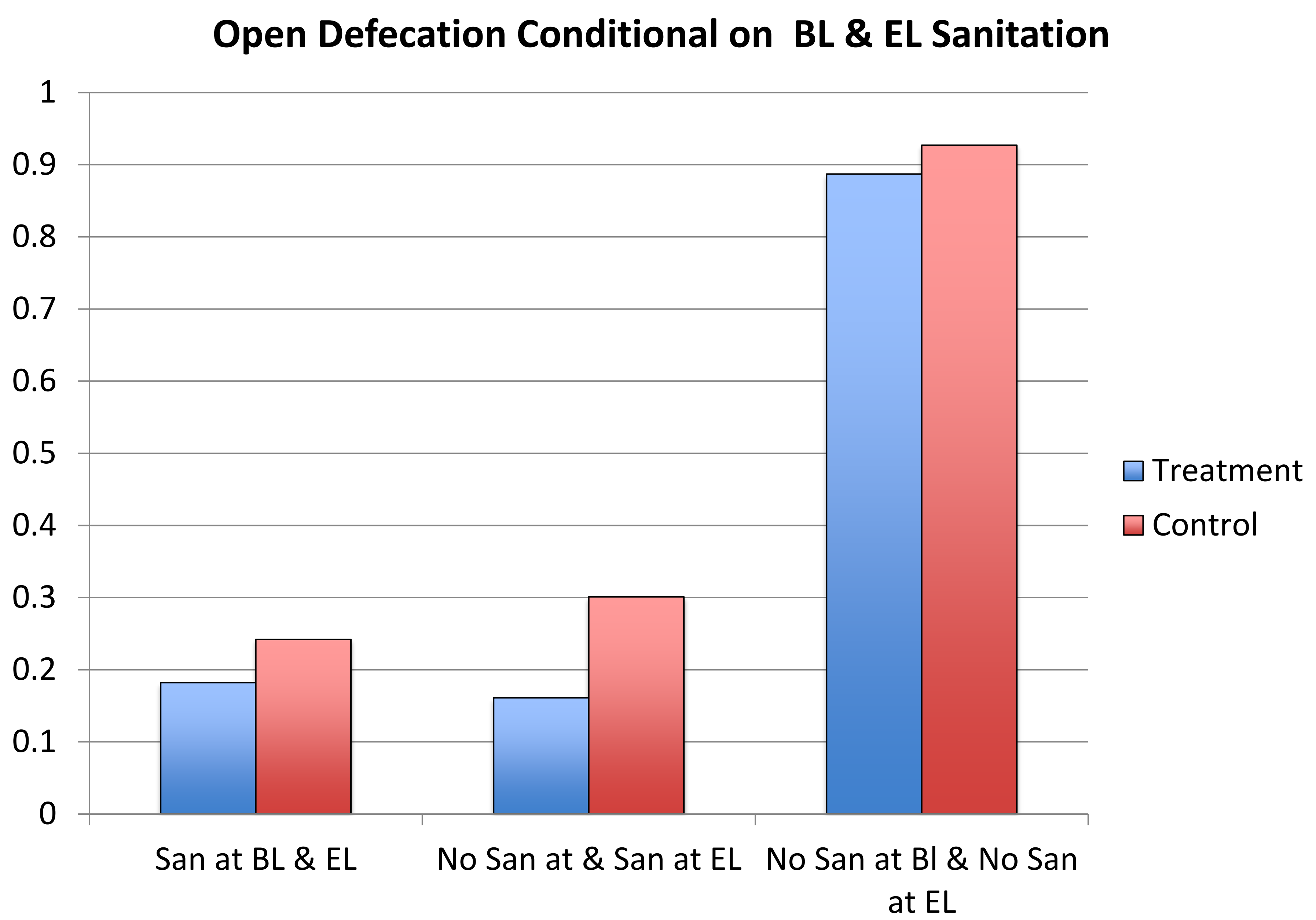
	Sanitation at Baseline	No Sanitation at Baseline		
		All	Non-Poor	Poor
Anyone				
Treatment	-0.06**	-0.06***	-0.06**	-0.06*
Control Mean	0.24	0.83	0.80	0.86
Women				
Treatment	-0.01	-0.06**	-0.05*	-0.07*
Control Mean	0.072	0.77	0.73	0.83
Men				
Treatment	-0.03*	-0.07**	-0.05*	-0.08*
Control Mean	0.12	0.79	0.77	0.83
Children				
Treatment	-0.04**	-0.07**	-0.07**	-0.07*
Control Mean	0.18	0.79	0.75	0.84
Observations	967	939	596	333

Open Defication

	Sanitation at Baseline	No Sanitation at Baseline		
		All	Non-Poor	Poor
Anyone				
Treatment	-0.06**	-0.06***	-0.06**	-0.06*
Control Mean	0.24	0.83	0.80	0.86
Women				
Treatment	-0.01	-0.06**	-0.05*	-0.07*
Control Mean	0.072	0.77	0.73	0.83
Men				
Treatment	-0.03*	-0.07**	-0.05*	-0.08*
Control Mean	0.12	0.79	0.77	0.83
Children				
Treatment	-0.04**	-0.07**	-0.07**	-0.07*
Control Mean	0.18	0.79	0.75	0.84
Observations	967	939	596	333

Open Defication

	Sanitation at Baseline	No Sanitation at Baseline		
		All	Non-Poor	Poor
Anyone				
Treatment	-0.06**	-0.06***	-0.06**	-0.06*
Control Mean	0.24	0.83	0.80	0.86
Women				
Treatment	-0.01	-0.06**	-0.05*	-0.07*
Control Mean	0.072	0.77	0.73	0.83
Men				
Treatment	-0.03*	-0.07**	-0.05*	-0.08*
Control Mean	0.12	0.79	0.77	0.83
Children				
Treatment	-0.04**	-0.07**	-0.07**	-0.07*
Control Mean	0.18	0.79	0.75	0.84
Observations	967	939	596	333



Open Defecation Conditional on BL & EL Sanitation
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
San at BL & EL
No San at & San at EL
No San at Bl & No San at EL
Treatment
Control

Decomposition of Δ in OD

- Total estimated effect of TSSM on OD = -.07
- Components:
  - Δ in sanitation

    .038*(.24-.83) = -0.038*0.61 = -0.02
  - Δ in use of those that have sanitation

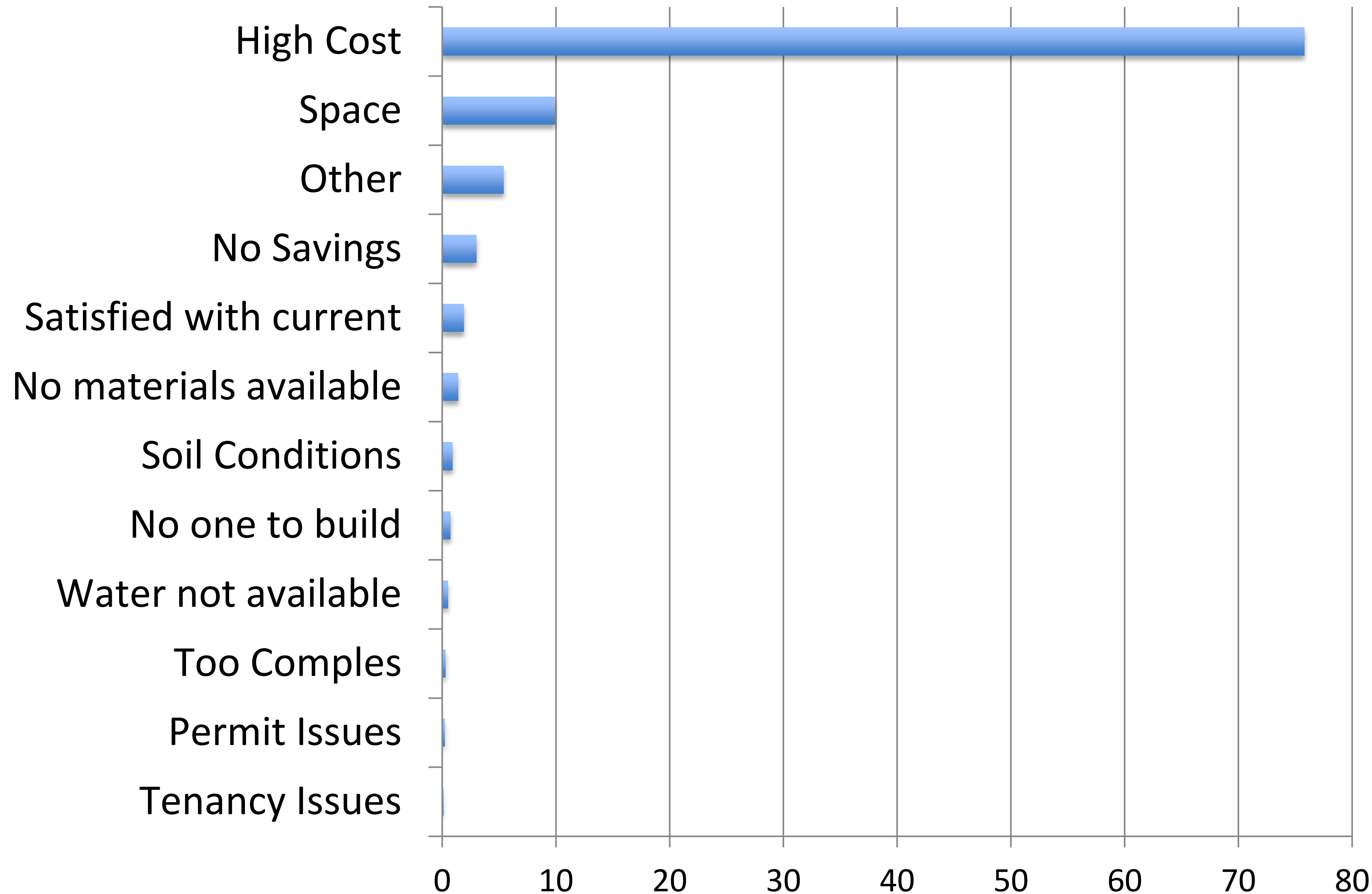
    -0.06*0.5 = -0.03
  - Δ in use of those who do not have sanitation

    -0.04*0.5 = -.02
- Note that they add up to -0.07

Messages

- TSSM reduced mostly through behavioral change
  - Explained 70% of the reduction in OD
- Less successful through sanitation construction
- Big potential gains from sanitation construction
  - 8% reduction in OD from 10% in sanitation
    - 6% from sanitation construction (.24-.83)
    - 2% from increased use of sanitation (0.6 – 0.2)
  - TSSM in Indonesia only increased sanitation by 3.8%
  - At baseline only 50% had sanitation

Obstacles to Building Sanitation



Health Impacts

	Sanitation at Baseline	No Sanitation at Baseline		
		All	Non-Poor	Poor
Diarrhea				
Treatment	-0.01	-0.03***	-0.02*	-0.05**
Control Mean	0.03	0.05	0.04	0.08
Worms				
Treatment	-0.06	-0.04*	-0.11**	0.03
Control Mean	0.13	0.15	0.16	0.14
Anemia				
Treatment	0.005	0.00	0.02	-0.03
Control Mean	0.44	0.46	0.48	0.42
Weight				
Treatment	-0.01	0.19***	0.22**	0.25*
Control Mean	12.6	12.3	12.3	12.1
Height				
Treatment	-0.18	0.44*	0.60*	0.01
Control Mean	90.9	90.3	90.4	90.00
Observations	985	940	598	332

Health Impacts

	Sanitation at Baseline	No Sanitation at Baseline		
		All	Non-Poor	Poor
Diarrhea				
Treatment	-0.01	-0.03***	-0.02*	-0.05**
Control Mean	0.03	0.05	0.04	0.08
Worms				
Treatment	-0.06	-0.04*	-0.11**	0.03
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Control Mean	90.9	90.3	90.4	90.00
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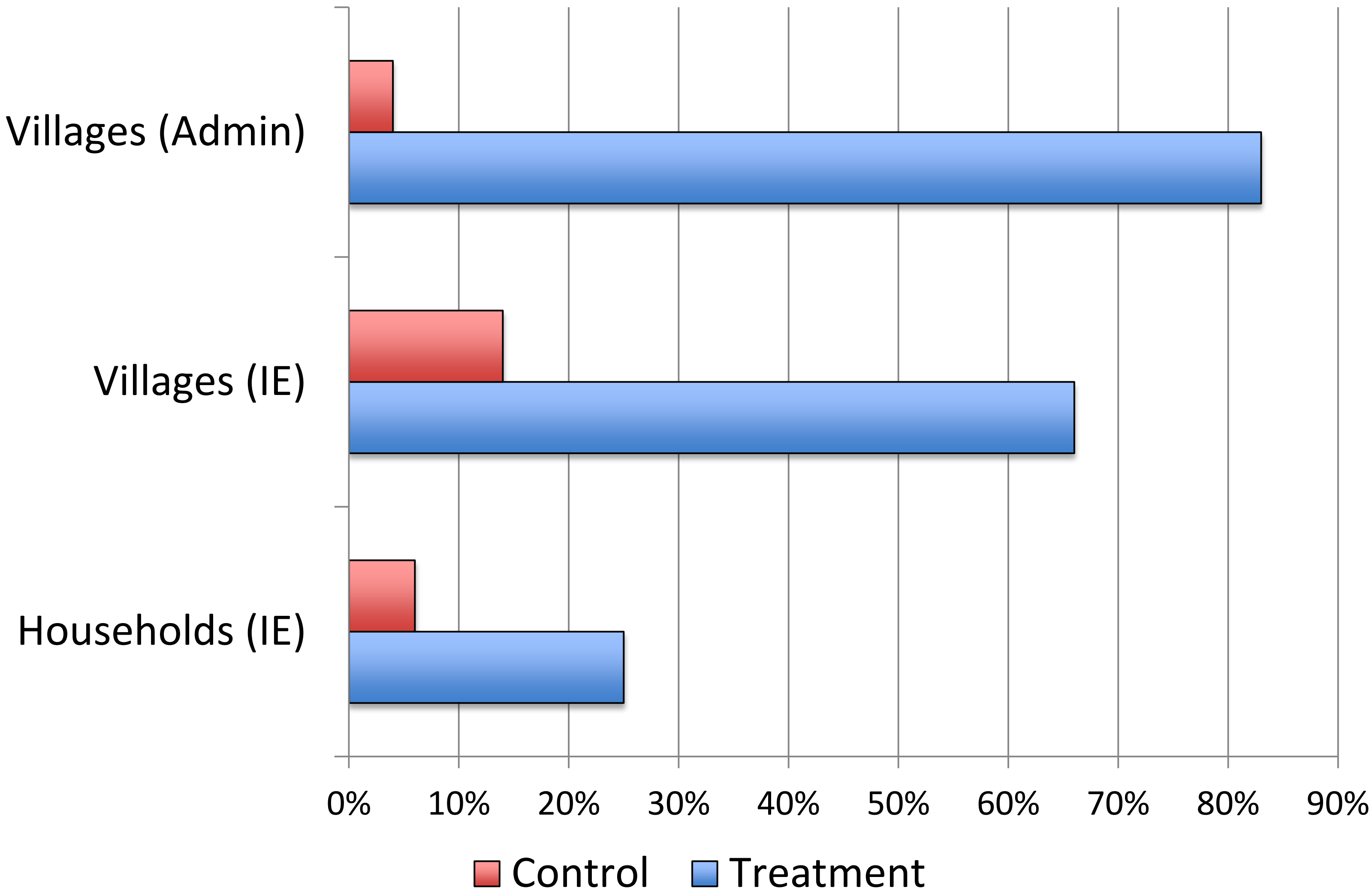
Implementation: % Triggered



What If All Villages Were Triggered?

	Observed Triggering (ITT)	Full Triggering (TOT)
Sanitation Construction	0.04**	0.10**
Open Defecation	-0.06*	-0.14**
Diarrhoea	-0.03**	-0.04**
Worms	-0.11**	-0.24**
Weight	0.22**	0.49**
Height	0.60*	1.30*

Results Summary

- TSSM was successful at
  - Reducing OD
  - Improving health outcomes
- Mostly worked through behavioral change
- Less successful at motivating sanitation construction
- Big potential gains through sanitation construction
  - Cost and liquidity constraints biggest obstacles
- Full implementation increases effects by 40%
- Repeating with India Data now & Tanzania soon

Policy Messages

- TSSM (CLTS) model
  - Improves health primarily thru behavioral change
  - Less successful through sanitation construction
- Need to strengthen sanitation components
  - Subsidized prices
  - Credit
  - Community financing
- Need to Improve implementation