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Access to Water, Women's Work and Child Outcomes

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Abstract

Poor rural women in the developing world spend considerable time collecting water. How then do they respond to improved access to water infrastructure? Does it increase their participation in income earning market-based activities? Does it improve the health and education outcomes of their children? To help address these questions, a new approach for dealing with the endogeneity of infrastructure placement in cross-sectional surveys is proposed and implemented using data for nine developing countries. The paper does not find that access to water comes with greater off-farm work for women, although in countries where substantial gender gaps in schooling exist, both boys' and girls' enrollments improve with better access to water. There are also some signs of impacts on child health as measured by anthropometric z-scores.

This paper—a product of the Gender and Development Unit, Poverty Reduction and Economic Management Network—is part of a larger effort in the department to understand the constraints, including infrastructure-based, to women's participation in market activities and the externalities for children. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at dvandewalle@worldbank.org.

Access to Water, Women's Work and Child Outcomes

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World Bank

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1. Introduction

Women's off-farm labor force participation remains low in many poor countries. Everywhere in the developing world, women appear to be mired in time-consuming domestic and child care activities for which they typically hold primary responsibility. And they often spend substantial amounts of time in activities such as collecting water and firewood.

It is widely believed that greater participation by women in market–based activities would yield desirable development outcomes. Work allowing women enhanced control over the resources they produce can raise their financial independence, their status and bargaining power inside the household, and also raise child welfare, on the grounds that extra income to women is likely to be invested in children (see, for example, Strauss and Thomas, 1995; Behrman, 1997; and Schultz, 2001).

Infrastructure has been widely identified as one factor constraining women's economic opportunities. Decision making processes about basic infrastructure provision ─ whether by household heads, village or higher level authorities ─ may be undervaluing women's time in domestic labor and so, be placing inadequate weight on the implications for women. As a result, women spend too much time in domestic labor tasks and too little time in other productive tasks including market-based labor activities.

This has led to calls for better tailoring infrastructure to women's needs, so as to reduce the time needed for domestic chores. Women's freed up time could then be used in income generating activities and they could better contribute to growth (see, for example, Ilahi and Grimard, 2000; Morrison et al. 2007; Ray 2007).

The implications for children are naturally of concern. It is sometimes argued that greater female labor force participation has deleterious effects on poor children, who receive less care at home. The implications of improved infrastructure are far from obvious. The income effect of higher female labor-force participation will make schooling and health care more affordable. But there could also be offsetting substitution effects in time allocation, such as if teenage girls are taken out of school to look after younger children or do household chores when the mother takes up work outside the home. Alternatively, if water collection or other burdens already fall heavily on children, enhanced productivity of domestic labor from improved infrastructure access may liberate them to attend school, though with little or no effect on mothers' market labor supply.

What does the evidence suggest? Do women with better access to basic infrastructure tend to participate more in market-based work? What about the health and schooling of their children? There appears to be little rigorous empirical evidence to address these questions. And there are some other questions left begging by the arguments: to what extent is infrastructure per se a key binding constraint to women's labor force participation? The literature points to other barriers to entry into market-based activities that may well be more important (Mammen and Paxson 2000).

This paper explores these issues in more depth empirically. We specifically focus on the effects of rural water infrastructure, since the argument about implications for women's work is perhaps most compelling with respect to water access. We test the claim made by policy studies that by reducing the time needed for water collection, investments in water infrastructure can enhance women's participation in market-based work (for example, Barwell, 1996; UNDP, 2006) or time spent on better child care or children's schooling (King and Alderman, 2001; CEDC-Africa, 2008).

A number of serious endogeneity and selection issues make these questions methodologically difficult. Infrastructure is typically endogenously placed across households and women's decision to participate in labor markets may well be jointly determined with infrastructure placement. As a result, few studies have tested these assumptions (some recent exceptions are discussed below).

This paper offers a new approach to purge the outcome and infrastructure variables of endogeneity and enable a test of the proposition that reducing women's time in water collection will augment their participation and time in income-earning activities. We begin by recognizing that the endogeneity concern has two distinct aspects, namely a geographic or between-community component, and a household or individual-related component within each community. It is questionable that one could deal adequately with the latter component by collecting data on observed characteristics, given the potentially large numbers of latent individual factors involved. Using observables to deal with endogenous placement is clearly easier for the component based on geographic characteristics. A contribution of this paper is a methodology that addresses the problem of latent heterogeneity at the individual level within disaggregated geographic areas, while assuming that the endogeneity problem between areas can be addressed through controlling for geographic observables influencing infrastructure placement.

We apply our method to nationally representative survey data for rural areas across several countries where water access and women's time burdens for collecting water have been highlighted as important policy issues. We examine impacts of water access on women's off-farm work. In addition, we also look for signs of intra-household responses. As mentioned, easier access to water may result in a reallocation of domestic chores that allows children to attend school. We examine this question and then turn to the potential impacts on child health as measured by anthropometric outcomes. Although easier access to water does not ensure improved water quality, health may be indirectly affected. A reduction in the price of water should increase its consumption with potential beneficial effects. Moreover, women's freed up time may be devoted to child nutrition and health needs, including visits to health centers.

The following section briefly reviews the literature. Section 3 proposes a simple model of time allocation that clarifies what the theory predicts. Our proposed approach to testing these issues is outlined in Section 4. Section 5 discusses the data and Section 6 our results. A final section concludes.

2. Literature review

Resource constraints in rural areas, including household burdens for collecting water and fuel, have been longstanding policy concerns for developing countries. Women, in particular, often shoulder a large share of this burden, particularly for collecting water. Based on data for 18 African countries, a recent UN report shows that women are five times more likely than men to collect drinking water for the household (UNICEF and WHO, 2008). Studies also indicate that water collection is borne primarily by women in South Asia,[1] and in countries across North Africa and the Middle East, including Morocco

[1] See World Bank (2005a), for evidence for Pakistan; Loughran and Pritchett (1997) for evidence for Nepal; and National Commission for Women, India (2005).

and Yemen.[2] One possible reason for women's share of this burden is that access to water affects several domestic tasks, such as cooking, laundry, cleaning and caring for children.

Furthermore, given that water (unlike fuel) has few alternatives, and that access to water in rural areas is often limited to wells, public standpipes or natural sources, substantial time can be spent in collecting water. Although few nationally-representative time use studies have been conducted (see Rosen and Vincent, 1999, and Blackden and Wodon, 2006), rural women in Africa and South Asia are frequently reported to spend at least an hour and up to several hours a day fetching water for the household. Water shortages and uneven supply compound this effort.

The relationship between women's water collection burdens and the transition to off-farm work, however, depends not only on direct time savings but on numerous individual, household and community factors that affect the ability and desire to work off-farm. A large literature emphasizes various factors that may impede women's off-farm market activities in the rural areas of developing countries (Mammen and Paxson, 2000; Feder and Lanjouw, 2001). Women's ability to participate in off-farm work may be affected by social norms and cultural restrictions on their time use and mobility (Kevane and Wydick 2001; Jayaraman and Lanjouw, 1998). The tradeoffs between farm and off-farm work are likely to depend on a household's economic situation, its access to land and labor, seasonality, local agro-climatic factors and exposure to risks, as well as work opportunities and markets in the community.[3] Studies also emphasize the effects of education and wages, the ability to control fertility, access to child care, access to credit, as well as household composition and interactions with men's occupational choices (Lokshin and Glinskaya, 2008, Matsche and Young, 2004; Khandker, 1998).

A limited but growing economic literature addresses the role of infrastructure and natural resource availability in women's labor supply (including Ilahi and Grimard, 2000, and Menon, 2009, for water; Dinkelman, 2009, and Grogan and Sadanand, 2009, for electricity; and Lokshin and Yemtsov, 2005, for various types of infrastructure). Part of

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[2] See, for example, World Bank (2005b); African Development Bank (2006).

[3] Community-level factors such as transportation costs and access to markets/information about jobs are also important (Schultz, 2001). Changes in agricultural technology may divert labor back from off-farm to farm activities, as was the case for women during India's Green Revolution (Mukhyopadhyay, 1994).

the difficulty in studying these effects beyond the local level is that women's market-based work often varies strongly with geography, with very low participation rates in some areas, and higher degrees of concentration in other localities (see de Janvry and Sadoulet, 2000; Fafchamps and Shilpi, 2003; Kuiper et. al., 2006; McCarthy and Sun, 2009). As a result, the effects of other variables on labor supply, including education and health, are often subsumed by geographic factors (Phillips, 1987; Fafchamps and Quisumbing, 1998).

Infrastructure investments are also typically guided by geographically-correlated community characteristics, including agro-climatic factors and potentially unobserved features such as local political influence. By way of offering access to markets and resources, poor infrastructure might fall among the potential economic constraints facing women's labor supply. Confirming this, however, requires untangling the geographic effects on women's labor supply from infrastructure placement. In addition, observed and unobserved factors at the individual and household level can affect both access to infrastructure and women's participation in market activities within communities.

The few studies that examine this question with respect to water use various approaches and find mixed effects on women's market-based activities. Ilahi and Grimard (2000) use 1991 data from Pakistan and a simultaneous-equation reduced form analysis to model women's choices over time spent on water collection, market-based activities, and leisure, as a function of household access to water.[4] They find that greater distance to a water source raises water-collection rates for women, and lowers their participation in income-generating activities; however, in households with private water technology (as opposed to poorer public infrastructure outside the home), women are more likely to spend time on leisure than on market-based work. Menon (2009) uses 1995-96 household data for Nepal to construct a logit model of occupational choice in the context of rainfall uncertainty, and finds that household members, including women, are less likely to work in agriculture when rainfall is less predictable, even if the head is self-employed in agriculture. Finally, Lokshin and Yemtsov (2005) find that women's wage employment is not significantly affected by rural water supply improvements in Georgia between 1998 and 2001. Creating a panel of villages across two rounds of data, they apply a double-

[4] Specifically, they use average distance to the nearest external water source in the community, and separately whether or not the household has access to water in the home.

difference with propensity score matching approach to address observed and time-invariant unobserved factors affecting program placement. The study finds a significant reduction in the incidence of waterborne diseases, but less clear effects on labor supply.

Other studies have also found positive impacts on women's employment of access to non-water types of infrastructure, such as electricity.[5] However, these studies rely on strong assumptions about how infrastructure projects or resources are placed, relative to factors that might be correlated with women's labor supply.

With respect to child outcomes, strong geographic effects on schooling and health have often been found in the literature, although their attribution to local infrastructure is often uncertain (Ginther et al., 2000). There is a small literature on the effects of improved water and sanitation on child health. Jalan and Ravallion (2003) find that child health outcomes (specifically the prevalence and severity of diarrhea) are better for Indian children living in villages with access to piped water than for those in observationally similar families in villages lacking such infrastructure. Using cross-country data, Fay et al. (2005) argue that access to basic infrastructure (piped water, sanitation, and electricity) reduces infant and under-five child mortality and the incidence of stunting in children. However, Ravallion (2007) questions the robustness of the Fay et al. findings based on a number of concerns with their methodology. An alternative approach for testing the Fay et al. hypotheses under weaker assumptions does not confirm their findings, though does point to a much more important role played by mother's schooling in reducing infant and child mortality. Mangyo (2008) uses individual-level panel data from China to show that access to water in the home has a positive effect on child health, but only when mothers are relatively more educated.

The above discussion suggests that in examining the impacts of water infrastructure, it is crucial not only to control for geographic and community effects, but also to account for a range of individual and household variables that can affect intra-

[5] Dinkelman (2009) examines the employment effects of an electricity roll-out program in South Africa, instrumenting for project placement with local variation in land slope. Women's employment rates are estimated to increase by about 9.5 percentage points in treated areas, and more so for women with fewer child care responsibilities. Men's employment is not significantly affected. Grogan and Sadanand (2009) also examine the effects of electrification on rural female employment and earnings in Guatemala; instrumenting for the program, they find that women's earnings improved substantially from better access to electricity (around 60%), and that women also spent more time in market-based work.

household and labor and time allocation decisions.

3. A model of time allocation and women's productivity

Improved access to water for household consumption can be interpreted as a gain in the productivity of domestic labor time. This section outlines a simple expository model of how such a productivity gain might be expected to affect female labor supply to market work. The model makes a number of simplifications, but even so it reveals the likely ambiguities in the impacts of improved access to water.

It is assumed that time can be allocated to either domestic labor (t_1), market wage work (t_2), or leisure (t_3), such that $t_1 + t_2 + t_3 = 1$. Domestic labor here is a composite good which includes activities such as fetching water, collecting firewood, cooking meals and child care, including attending to the health and educational needs of children, but also non-market unpaid work in the family such as own farm work. Utility is derived from consumption of a domestic good x_1, a market good x_2 and time in leisure; the utility function is $u(x_1, x_2, t_3)$, which is strictly increasing in all three, strictly quasi concave, and with diminishing marginal utility to all three activities. The domestic good is produced from time devoted to domestic labor $x_1 = \rho t_1$, where ρ >0 is an exogenous productivity parameter. The market good, which is also the numeraire, is purchased in amount $x_2 = wt_2 + \tau$ where w is the market wage rate and τ is other income. Time allocation between domestic labor and market work (t_1, t_2) maximizes $u(\rho t_1, wt_2 + \tau, 1 - t_1 - t_2)$, and the solutions equate both $\rho u_1(x_1, x_2, t_3)$ and $wu_2(x_1, x_2, t_3)$ with the marginal utility of leisure $u_3(x_1, x_2, t_3)$, where the subscripts on the function u denote partial derivatives.

The issue here is how changes in the productivity of domestic labor affect time allocation. The comparative statics are ambiguous under the assumptions so far, but one can re-write the model in a different form, which makes it easier to understand the source of the ambiguity and to derive sufficient conditions for the effects to go one way or the other. The key is to note that the above model is equivalent to the following problem:

$$\text{Max}\, u(x_1, x_2, t_3) \text{ s.t. } (w/\rho)x_1 + x_2 + wt_3 = w + \tau \qquad (1)$$

The relative price of the domestic good (relative to the market good) is w/ρ, the relative price of leisure is the market wage rate and $w+\tau$ is full-income (the value of the time endowment, valued at the market wage rate, plus other income). With this transformation of the problem, we can readily invoke the Slutsky decomposition:

$$\frac{\partial x_i}{\partial(w/\rho)} = \left(\frac{\partial x_i}{\partial(w/\rho)}\right)_{u=\bar{u}} - x_1 \frac{\partial x_i}{\partial(w+\tau)} \text{ for } i=1,2 \qquad (2)$$

The following proposition follows:

<u>Proposition</u>: If the only way that higher productivity of domestic labor affects time allocation is through the relative (implicit) price of the domestically produced good and both the domestic and the market goods are normal ($\partial x_i / \partial(w+\tau) > 0$ for i=1,2) then higher productivity of domestic labor will increase consumption of the domestic good. If, in addition, the domestic and market goods are (Hicks-Allen) complements ($\partial x_2 / \partial(w/\rho) < 0$ holding utility constant) then both the consumption of market goods and the time devoted to market production will increase.

Three remarks can be made. First, note that time devoted to domestic work may or may not increase with higher productivity of domestic labor time even though consumption of the domestic good increases. Stronger assumptions are required to determine the effect on domestic labor time. It can also be shown that if the utility function is additively separable between its three components then there will be a substitution of time from domestic work to market work when the productivity of the former increases. An increase in the productivity of time in domestic production is equivalent to a reduction in its price, which will result in a substitution towards the composite domestic good, including, potentially, increased time spent on child care and children's schooling.

Second, note that the assumption that market goods and domestic goods are complements is more plausible for some domestic goods than for others. If one purchases more un-cooked food, one will probably need to collect more firewood for cooking and more water. However, some domestic goods are likely to be substitutes for market goods. If the substitution effect is strong enough then a higher productivity of domestic labor could displace market work. This will happen when the higher productivity of domestic labor (lower relative price of the domestic good) leads to sufficient substitution of domestic goods for market goods.

Third, the assumption that higher productivity of domestic labor only affects time allocation through the implicit price of the domestically produced good can be relaxed to allow the possibility that changes in ρ also affect other income. This could happen if the other sources of income include a transfer made within the household, such as when there is a division of labor whereby one member of the household specializes in market labor (the main "breadwinner") while the other specializes in domestic labor, and (in return) receives a share of the market earnings of the main breadwinner. In such a model, one can expect that the terms of this exchange are affected by the productivity of domestic labor. In particular, if a higher ρ also lowers τ then there will be an extra direct income effect, attenuating the supply of labor to market production (by lowering the demand for market goods). There may also be an issue of simultaneity across household members' labor allocation decisions (including joint decision-making across children and women). This model is relevant to any one person in the household, but it is also possible that if ρ goes up due to easier access to water, other household members such as children may take over the water collection responsibility while the woman goes to work outside, creating an additional ambiguity about what happens to the domestic good.

On balance then, the impact on women's market work of a generalized increase in the productivity of their time in producing the composite domestic good is theoretically ambiguous. The rest of this paper investigates the issue empirically.

4. Empirical strategy

We see three possible ways of approaching these research questions empirically. With a large and detailed household cross section, it may be possible to use matching to create an appropriate control group and analyze how the allocation of women's time and other outcomes differ according to whether they have easy access to water.[6] Placement is then assumed to be exogenous conditional on the matching variables. Alternatively, an

[6] See for example Jalan and Ravallion (2003).

instrumental variable (IV) may be available in some cases. This requires a believable exclusion restriction (an alternative conditional independence assumption).

A second approach might rely on a household panel that includes the same detailed information as above, and exogenous changes in access to water for at least some households. Then the key assumption is that changes in access to infrastructure are exogenous (conditional on observables). This is more likely to hold if the panel was expressly collected to deal with the likely endogeneity of the changes in access to water, or the panel contains more than two waves or one has good data on the initial conditions jointly influencing infrastructure changes and subsequent outcome changes. A double difference (possibly with matching) can then be used to see the effect of access to water infrastructure on the outcomes of interest.

Here we propose a third approach that has not (to our knowledge) been used before. We have an outcome variable Y_{ij} for individual *i* in area *j*, an indicator of the individual's access to infrastructure Z_{ij}, a vector of exogenous individual and household characteristics X_{ij}, and exogenous community characteristics G_j (which can include community means of X_{ij}, denoted $\overline{X}_j$). The aim is to estimate the causal impact of Z_{ij} on Y_{ij}. The problem is that the observed variation in Z_{ij} reflects latent factors that also influence Y_{ij}. Within a given locality, some households will have latent preferences, knowledge or unobserved resources that lead them to have better access to infrastructure than other (observationally similar) households. This is particularly worrying when talking about certain kinds of basic infrastructure such as access to water. Thus there must be a strong presumption that the individual-specific differences in Z_{ij} are endogenous to outcomes. The standard solution is to find an IV that is correlated with Z_{ij} but uncorrelated with outcomes given Z_{ij}. However, this is a demanding requirement, as one can reasonably question whether any observed household characteristic that might influence whether that household has a higher level of access to household-specific infrastructure would not also be a relevant factor in determining the overall outcomes, independently of infrastructure.

We show below that we can address this problem without an instrumental variable by exploiting the geographic differences in infrastructure placement and outcomes.

However, this requires an identifying assumption, namely that we have adequately captured the relevant geographic characteristics jointly influencing outcomes and infrastructure through the vector G_j. In other words, by assuming that the geographic placement of infrastructure is exogenous conditional on G_j we will be able to address the endogeneity of placement at the micro level within geographic areas without an IV.

The model for outcomes is:

$$Y_{ij} = \pi Z_{ij} + \phi X_{ij} + \lambda G_j + \mu_j + \varepsilon_{ij} \tag{3}$$

where μ_j is a latent geographic effect and ε_{ij} is an idiosyncratic (individual-specific) error term. (Notice that the geographic effect in (3) has both observed (λG_j) and unobserved (μ_j) components). The reduced form model for infrastructure placement is:

$$Z_{ij} = \alpha X_{ij} + \gamma_j^Z + \upsilon_{ij} \tag{4}$$

Here

$$\gamma_j^Z = \beta G_j + \eta_j \tag{5}$$

is the geographic effect on infrastructure placement, containing both observable (βG_j) and latent components (η_j) and υ_{ij} in (4) is an idiosyncratic error term. The reduced form equation for outcomes is then:

$$Y_{ij} = (\pi\alpha + \phi)X_{ij} + \gamma_j^Y + \pi\upsilon_{ij} + \varepsilon_{ij} \tag{6}$$

where

$$\gamma_j^Y = \pi\gamma_j^Z + \lambda G_j + \mu_j \tag{7}$$

is the reduced-form geographic effect on outcomes.

Recall that the key parameter we want to identify is the impact parameter π in equation (3), which is the effect of Z_{ij} on Y_{ij}. While OLS applied to (3) will give a biased estimate given endogenous placement at the household level, equation (7) shows that π can also be identified by the regression coefficient of the geographic effect in Y_{ij} on the geographic effect in Z_{ij}. This can be estimated consistently by OLS under a weaker assumption than exogeneity of Z_{ij} in (3), namely that only the geographic placement is conditionally exogenous, meaning that $Cov(\eta_j, \mu_j | G_j) = 0$. In other words, we assume that we have sufficient geographic controls to make it plausible that the latent geographic effects on outcomes and placement can be treated as uncorrelated. Notice however that we still allow for endogenous individual placement within-areas, whereby there are latent idiosyncratic factors that jointly influence outcomes and individual infrastructure access, i.e. $Cov(\varepsilon_{ij}, \upsilon_{ij}) \neq 0$.

Under the assumption of conditionally exogenous geographic placement we can estimate π from the regression:

$$\hat{\gamma}_j^Y = \pi \hat{\gamma}_j^Z + \lambda G_j + \mu_j \tag{8}$$

where $\hat{\gamma}_j^Z$ and $\hat{\gamma}_j^Y$ are consistent estimates of the geographic effects on infrastructure and outcomes, obtained by estimating the reduced-form equations in (4) and (6) respectively, with geographic fixed effects and retrieving the estimates of the latter.

One worry with estimating equation (8) with OLS is that it will give standard errors that are not correct because of the generated regressor on the right hand side. An alternative method for estimating π that avoids this problem is the following estimator. On taking the mean of equation (4) we have:

$$\hat{\gamma}_j^Z = \overline{Z}_j - \hat{\alpha}\overline{X}_j \tag{9}$$

We can then rewrite (8) in the following form:

$$\hat{\gamma}_j^Y = \pi \overline{Z}_j + \lambda G_j + \delta \overline{X}_j + \mu_j \tag{10}$$

Where $\delta = -\pi\hat{\alpha}$ and as before, $\hat{\gamma}_j^Y$ is estimated with equation (6). The OLS standard errors from the model in (10) will be correct. This comes at the disadvantage that one loses identification of the geographic effects on outcomes for the G_j variables (since these can include the $\overline{X}_j$ vector), though this does not appear to be an important concern. The observed geographic controls now combine effects on outcomes and effects on infrastructure placement.[7] Also note that the estimated equation (10) is essentially unchanged if one adds geographic mean X_{ij} to (8) — all that changes is the interpretation of the parameters on the mean *X*s. This does not affect π, the parameter of interest.

[7] The only case where separation is possible with this estimator is for any variable in G_j that is not a community-level mean of X_{ij}.

We estimated the impact of access to water on our outcome indicators using both approaches (8) and (10) and got very similar results.[8] Given that the second approach based on (10) gives the correct standard errors, we report and focus on this estimation method and its results in what follows.

Whether one accepts the assumption of conditional exogeneity must depend on the data available and the setting. In principle it appears more likely that one could collect geographic data relevant to both outcomes and infrastructure placement, while one might be justifiably skeptical of any claim that one could collect data on all the relevant individual characteristics, which would include many latent preference and knowledge parameters at the individual level. So the ability of our estimation strategy to deal with endogenous placement across individuals within a given area is desirable.

5. Data and descriptive statistics

We use rural household and community data from national consumption surveys spanning Sub-Saharan Africa (Madagascar, Malawi, Rwanda and Uganda), South Asia (India, Nepal and Pakistan), North Africa (Morocco) and the Middle East (Yemen). Countries meeting three criteria are included. The first is the availability of a good quality and comprehensive household survey containing household level information on water access, and either distance or time to the nearest water source used; data on household members' time spent, or participation in, market and non-market productive activities; and a wide range of other household and individual socioeconomic characteristics. The surveys must also contain disaggregated and detailed community level data on access to facilities, commodity prices, presence of labor markets, and other characteristics not directly affected by water access for the communities where sample households reside. Finally, among the countries meeting these criteria, we select those where rural access to water is a concern for at least part of the rural population, and where rural households typically spend substantial amounts of time collecting water.

Table 1 gives an overview of the datasets used, including the survey period, and the number of sample households and rural communities (typically corresponding to the primary sampling units, or PSUs) covered. The latter form the basis of the rural

[8] Results based on both (8) and (10) are available from the authors.

community questionnaires that we use to identify geographic effects. Most surveys spanned a full year. All are nationally representative with the exception of the India REDS which is representative of rural areas only. As can be seen in column 3, some countries, particularly in Sub-Saharan Africa and South Asia, are markedly more rural than others.

Household access to water: As noted, water access in these countries is known to be limited. In Sub-Saharan Africa, Uganda, Madagascar, and Rwanda have among the highest shares of rural households that rely on a source of drinking water at least 30 minutes away (see WHO, 2008). Yemen and Morocco have among the lowest rates of per capita freshwater availability across the Middle East and North Africa (World Bank, 2005b). In South Asia, recent investments have vastly improved drinking water availability, yet large shares of the rural population continue to endure frequent water shortages and spend hours a day in water collection (Loughran and Pritchett, 1997; National Commission for Women, India, 2005).

In common with other studies (Whittington et al., 1990; Ilahi and Grimard, 2000; Kremer et. al., 2009), we define access to water by the household's reported time to walk one-way (in minutes) to the source of drinking water it typically uses. In the sole survey where time to water is not available (Rwanda), we use the distance in meters (converted to kilometers in the analysis). Time is preferred since it reflects potential difficulties in terrain. All households across the surveys were asked this question in a module on housing characteristics and infrastructure. Households with water inside the home or plot are considered to face zero walking time/distance.

This measure of access is particularly useful since it is continuous and directly related to the potential time constraints of rural individuals. In contrast to self-reported time spent on water collection from time use modules, this measure allows better comparability across households since it is not a function of the health and availability of household members, or reflective of other activities that may be combined with water collection.[9] As with other reported household variables, the time/distance variables are likely to suffer from measurement error. One mitigating factor is that households in the

[9] Alternative measures include the type of water source, used by the WHO (although Ilahi (2001) shows a weak association between type and time use), and household views about the quality of their access to water.

surveyed areas travel these routes on a daily basis which can be expected to improve recall and the accuracy of reporting.

Table 2 presents summary statistics for our measure of access to water across the surveys. The limited water access in these countries is confirmed. On average, few households have water in the home or plot, and most travel outside to collect water. However, there is considerable variance both across and within countries. Only 0.2% of rural Rwandan households have water in their home or plot versus 69% of Pakistani households. But even in Pakistan, about 20 percent of rural households had to walk at least 30 minutes round-trip to reach the nearest source of water.

Household water sources vary across countries. In Yemen, 19 percent of households report access to piped water (within a private or cooperative network); of those with access in the home or garden, about 50 percent have piped water. In Pakistan and Nepal, about 70 percent of households with water in the home use handpumps, 20 percent have piped water, and the rest have wells. In India and Morocco, households with private access to water most often use dug wells or handpumps. In the African countries in our sample, the majority of households access water from communal standpipes, wells, handpumps, or an open source such as a lake or river.

Women are also revealed to hold primary responsibility for collecting water in these rural areas (Table 2, last two columns). In time use data provided by some of the surveys, many report spending at least an hour each day collecting water.

Women's participation in market-based activities: A central interest in this paper concerns the impact of water infrastructure on women’s participation in market work. By ‘market work’ we mean market-based activities from which women either bring income into the household, or maintain control over some resources in line with arguments that this bolsters their status and bargaining power within the household with potential externalities for their children. In addition to their domestic work, the majority of rural women in poor countries work, many on the family farm. Yet, own-farm activities for women in these countries are typically not associated with much control over the use of inputs and the distribution of revenues (Ellis, 2000). Unless they are part of female headed households or live in the few countries where women control their own plots, they are unlikely to control any of the proceeds themselves. As we are unable to identify from the data the few cases where women control own farm revenues, we exclude farm self-employment from our measure of labor force participation. We focus instead on wage work (agricultural and non-agricultural) and off-farm self-employment.

The concern we have with own-farm work may also arise with respect to off-farm family businesses in which women labor as unpaid family workers. To avoid this as much as possible we define women who work in a household enterprise as participating in off-farm self-employment if the surveys identify them as specifically involved in the operation of the enterprise. This includes ownership or time spent in managing the day-to-day activities of the business, including finances or management of inputs. It should be noted that the surveys do not cover women who are not currently living in the household and may have migrated for work reasons, such as to pursue manufacturing jobs.

We compile our measure of women's participation in market based work based on detailed data on the main and secondary occupations in the past year of female household members aged 15 and older. We focus on a binary labor participation outcome as opposed to hours/days worked, since individuals often work multiple jobs in a given period, and accurate measurement of time worked is not always straightforward.[10]

Table 3 presents summary statistics for participation in off-farm work by women aged 15 and older and for the sake of comparison, for men's participation as well. Off-farm work includes off-farm self-employment activities as described above and any wage work. The cross-country differences for women are large, ranging from a low of 3 percent in rural Yemen to a high of 40 percent in Madagascar. The variance across countries is much lower for men ─ ranging from 33 percent in Rwanda to around 52 percent in India, Morocco and Pakistan. As expected, women participate far less in off-farm work activities than men. Furthermore, fewer of those not working are instead enrolled in school relative to men in the same age group. This difference is particularly pronounced in Yemen, Morocco, and Pakistan.

The type of work underlying these figures also differs widely across countries. The few women in off-farm activities in Yemen are primarily involved in off-farm self-employment activities. In Malawi and Madagascar, roughly equal shares of women were

[10] We obtain similar results when looking at days worked in off-farm activities over the last year; these results are available upon request.

involved in off-farm self-employment and wage work. In Morocco, Uganda, Rwanda, India and Nepal, wage work dominates; the surveys reveal that most of this work is agricultural, including work on other households' farms.[11]

Child schooling and health outcomes: Defining our child outcome variables is more straightforward. Schooling is measured as a dummy variable for whether boys and girls aged 5-19 attended school during the last year. For health outcomes, we use anthropometric indices of growth status (weight-for-height, a measure of wasting, and height-for-age, a longer-term measure of stunted growth). These are presented in terms of z-scores, or standard deviations from the WHO reference population. Ideally, we would like to measure women's time devoted to household nutrition and child rearing. Most surveys do not allow direct measures of such effects, but they do elicit the weight and height of young children.[12,13] Anthropometric outcomes are also a function of nutritional investments and other longer-term factors related to child care, and unlike other health indicators do not suffer from measurement error correlated with socioeconomic household characteristics (Alderman and Garcia, 1994; Strauss and Thomas, 1998). Table 4 presents summary statistics for the child schooling and health outcome variables by gender.

Explanatory variables: Table 5 provides the exact definitions of the dependent variables and summary lists of all explanatory variables by regression.[14] The aim in all regressions is to control for identical factors across countries but specific variable configurations may vary according to the data and peculiarities of each country. The outcome regressions (equation (6)) control for a large set of household and individual characteristics. The household variables are essentially the same across regressions while individual level variables differ according to whether the specific outcome refers to women or children. Individual-level variables include factors that may affect women's decisions to engage in off-farm work, such as age and age squared, years of schooling and years

[11] Exceptions include Uganda, where 60% of wage-earning women did non-agricultural work, including teaching, retail (shops/trade), handicrafts, and manufacturing/construction. In Morocco, about 45% of women in wage work were primarily in industrial occupations.
[12] Direct time use data on women's time spent with children was either not available or very limited across the surveys, and is in any case difficult to isolate in the context of household activities.
[13] The lower age cutoff for the anthropometric data is 6 months, while the upper age cutoff varies across the surveys (3, 4 or 5 years of age).
[14] A statistical addendum containing summary statistics for all variables and the regressions across the different surveys is available from the authors.

squared, marital status, and whether they have a chronic illness or disability. In the case of child outcomes, controls include the age of the child as well as of the mother and father if present, the child's birth order, whether the mother and father live in the home, their years of schooling, and whether the child had a sudden illness or accident in the last month.

The household determinants for eq. (6), presented in the last column of Table 5, include factors that may reflect preferences, resource and women's time use constraints. These include the years of schooling of the most educated male and female adults, ethnicity/caste and religion, whether the household owns land, receives remittances, and whether the head migrated to the current residence from outside the locality. We include a comprehensive set of demographic variables (log household size and the share of different age groups by gender), a dummy for whether any adults have a chronic illness or disability, as well as a dummy for having experienced a recent economic shock such as the death of a working family member.

Income or wealth may be important determinants of female labor force participation and child outcomes, yet they raise endogeneity concerns. We run regressions with and without wealth as proxied by household per capita expenditures and a dummy for the durability of the external material of the house. Finally, off-farm work, school attendance and child anthropometrics are likely to be highly seasonal. For this reason, all the regressions control for survey month dummies when these do not perfectly coincide across households in a given community.

All individual level regressions also contain a full set of community fixed effects. Table 6 ─ which presents the R^2 for regressions of each dependent variable on the geographic dummy variables only ─ provides evidence of the considerable role geography plays in explaining both access to water infrastructure and our outcome variables. The share of the total variance accounted for by location effects is highest for access to water ─ ranging from a low of 29% in Malawi to a high of 70% in Yemen. Location also explains around 15-20% of women's off-farm work and a little more of child enrollments, with a stronger explanatory power for girls' enrollments in many countries. It also accounts for around 30-40% of the total variance in anthropometric outcomes.

The last step in our approach consists of the community-level regressions of the geographic effects from the outcome regressions on the geographic effects on access to water given by equation (9). As discussed in Section 4, we present the estimation setup and results for equation (10). Here again, we control for a wide range of household characteristics similar to that included in the individual outcome regressions but expressed as means over all households in each community ($\overline{X}_j$). To ensure conditional exogeneity, the community regressions also include a range of non-water-related community characteristics (G_j), including access to roads, schools, banks, health centers and markets; price levels for food and other important commodities; male and female daily agricultural and non-agricultural wage rates; the profile of major ethnic or caste groups; when available, population or population density; and inequality (as measured by the mean log deviation of household per capita consumption). Finally, to account for seasonality, we include the month during which community households were surveyed.

6. Results

While a nonlinear binary response model (such as a probit) would have advantages, the drawback is that many communities and sample observations drop out of the regression due to perfect prediction; for example, it is quite common for no women to engage in market work or for all children to be enrolled in school in some communities. Excluding such geographic areas would clearly lead to the loss of key information and prevent us from estimating, and including in our second stage regressions, fixed effects for all communities. This leads us to use a linear probability model. It is also important that the outcome and final equations ((6) and (10) respectively) contain the same geographic effects estimated with respect to the same omitted reference community. We therefore ensure that the sample of communities and the reference community are identical across each outcome regression and its companion community level regression; for the community regression the reference is included and entered with a zero value. Standard errors in all estimated regressions are corrected for heteroscedasticity and clustering at the community level. We include wealth proxies (statistically significant) though recognizing the endogeneity concerns. However, our main results were quite robust to excluding them. In the following discussion, we therefore focus on the results based on the regressions that include the wealth variables.

Tables 7, 8 and 9 present our estimates of the impact of water infrastructure on women's participation in market based activities, child enrollments and anthropometrics, respectively, as well as the R^2 for each regression. We transform the estimates so that they are interpretable as impacts of a one hour reduction in the time to water.[15] In each table, column (a) presents the naive estimate of the impact parameter π, applying OLS directly to equation (3) and using community dummy variables to capture both observed and unobserved geographic effects. This provides a sense of what our methodology brings to the estimation. A priori, how significant within place endogeneity will be is unclear. In practice, individuals and households in the rural areas of poor countries may have little power to influence their access to infrastructure. However, the issue cannot be ignored since it is potentially a big source of concern.

Column (b) presents the key π parameter estimates from equation (10) — i.e., the community level regression of the geographic effect on an outcome variable against the geographic effect on water access — estimated controlling for a large set of community characteristics that includes seasonality effects as measured by the month of interview. We emphasize that controlling for seasonality is crucial. The interview month dummies are consistently highly significant in all regressions.

As a sensitivity test, column (c) presents estimates of π after the regressions are pruned of potentially endogenous community level variables (such as, in the child anthropometrics regressions, access to health care facilities). The specific excluded regressors are noted in the table footnotes. As can be seen in the tables, this step has relatively little effect on the magnitude of the coefficients or their significance.

For the most part, the estimates in columns (b) and (c), Table 7 indicate an ambiguous relationship between geographic effects on women's work and better access to water infrastructure. In some countries such as Yemen, Uganda, Madagascar, Nepal and Rwanda, the effect of a reduction in time/distance to water is positive. However, there are no statistically significant effects for these countries. A few of the equivalent estimates in column (a) are significant, but these are often of the opposite sign to what the literature posits. As discussed above, however, the estimates in (a) are potentially spurious correlations. One can readily imagine models that imply correlations of different signs.

[15] The exception is for Rwanda where the estimates represent the impact of a kilometer reduction in the distance to the closest water source.

Imagine, for example, that land is equally productive everywhere but is more densely populated closer to the water source. The further a household is from water, the more land there is per person and the more work there is on the farm. As long as there is not much effect on fertility, such a model predicts that the further a household is from water, the less likely its members will work off-farm. Alternatively, if the model allows for lower productivity of land further away from water, then even if landholdings are larger, land may be so unproductive that pressure to work off-farm is greater. Being further from the water source would therefore push people off-farm, since land is less productive and hence worse for agriculture. Once we purge the estimates of such within area endogeneity of placement and control for observable between area characteristics including seasonality, we find no impacts on women's off-farm work.[16]

We find more support for the hypothesis that a reduction in the time to water has positive impacts on child schooling (Table 8). For both girls and boys, sizeable impacts on enrollments are indicated for Yemen, Morocco, Nepal (1995-96) and Pakistan. For example, a one hour reduction in the time to water would increase girls' and boys' enrollment rates by about 8-9 percent in Yemen and by 18-19 percent in Pakistan.[17] These impacts are found exclusively for non-African countries.

An undoubtedly important characteristic of these countries is that they are also places where enrollments are low overall, and where the gender gap in those enrollments is particularly pronounced (Table 4). For Yemen, Nepal 1995-96, and Pakistan, the results in Table 8, columns (b) and (c) suggest that as the total time needed for household chores is reduced, the benefits spill over roughly equally to both girls and boys.[18] As we noted earlier, the geographic effects on girls' schooling are also among the strongest for these particular countries, and typically disproportionately stronger for girls than for boys (Table

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[16] In sensitivity checks, we do not find significant effects overall for participation in off-farm work by older women (aged 40 and over); one could surmise that older women, having completed their childbearing, would have more time to work outside the home if their domestic workload improved.

[17] This echoes anecdotal reports such as reflected in this quote by Dr. Mohamad Al-Hamdi, Deputy Minister of Water and Environment in the Yemen Times, 2009: "…water shortages keep children, especially girls, out of school because long, daily treks to collect water prevent them from attending classes. When girls grow up with little or no education, they generally have more children. And because groundwater in Yemen is a finite resource, the more the population grows, the harder it is to find water. The next generation of girls is thus even less likely to get an adequate education as they will be collecting water for their families to survive."

[18] This pattern can also be seen in the difference in schooling impacts across the two Nepal surveys. As the gap between girls' and boys' enrollments has closed between 1995-96 and 2003-04, and enrollment rates have risen, the effect on schooling also disappears for the Nepal 2003-04 survey.

6). Why, then, are the effects of access to water on enrollments similar for boys and girls in these countries? This finding appears to be due to a combination of having large gender gaps and substantial room for improvement in boys' enrollments as well as of girls'. Boys may well be benefitting from a spillover effect due to higher girls' schooling.

Finally, Table 9 examines impacts on anthropometric z-scores by gender. In Yemen, a one hour reduction in the time to water is found to increase girls' height-for-age by 0.82 standard deviations, with some signs of a smaller positive impact for boys, albeit not significant. There is also a significant effect on weight-for-height outcomes for girls in Malawi, but not for boys. We find no other significant effects. Given that weight-for-height represents wasting and reflects a short-run health outcome, and height-for-age represents stunting and a longer-term outcome (Alderman and Garcia, 1994), it is difficult to draw any systematic conclusions on the effects of improved water access on anthropometric indicators from our results.

7. Conclusions

Do the lack of basic water infrastructure and high time burdens of water collection prevent rural women in developing countries from participating in market-based income generating activities? There is little solid empirical evidence either to support or refute this often heard argument. This is due in no small way to the methodological difficulties in untangling decisions about female labor force participation from decisions on infrastructure placement, confounding a causal analysis of improved water access on women's time allocation.

This paper tests the proposition that reducing women's time in water collection will augment their participation in market based income earning activities. Our proposed method allows for endogenous individual placement within communities, while dealing with the endogeneity problem between areas by controlling for community observables influencing infrastructure placement.

We apply the method separately for several countries, spanning Sub-Saharan Africa, North Africa and the Middle East, and South Asia, where rural water access and women's time burdens for collecting water have been highlighted as important policy issues. Allowing for the possibility of intra-household responses and time re-allocations, we also examine whether impacts are felt at the level of child schooling and child health.

We do not find any evidence that improved access to water leads to greater off-farm work for women. However, we do find that in countries where substantial gender gaps in schooling exist, both boys' and girls' enrollments improve as a result of a reduction in the time needed to collect water. In addition we find some signs of impacts on child health as measured by anthropometric z-scores for Yemen and Malawi. A number of the significant correlations found between access to water and our outcome variables are not robust to allowing for endogenous placement.

The fact that our results are more suggestive of impacts of better access to water on children's health and schooling than on women's allocation of time to market work suggests that the latter is not the main channel linking this aspect of infrastructure to children's welfare. We find no support for the idea that induced effects on women's participation in work outside the home are affecting (positively or negatively) child welfare. The more direct channels linking access to water to child outcomes ─ such as through women's time for child care, child labor in the home and water quality ─ appear to be more relevant.

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Table 1: Country surveys used in the analysis

	Survey period	Rural household sample size	% of population in rural areas	Rural PSU sample size	Rural household sample/ PSU
Middle East and North Africa					
Yemen Household Budget Survey (YHBS)	Apr 2005- Mar 2006	4,847	72.5	431	11.2
Morocco Living Standards Survey (MLSS)	Feb 1998- Jan 1999	2,154	46.2	181	11.9
Sub-Saharan Africa					
Uganda National Household Survey (UNHS)	May 2005- Apr 2006	5,727	83.9	584	9.8
Malawi Integrated Household Survey (MIHS)	Mar 2004- Apr 2005	9,840	87.5	492	20
Madagascar Enquête Périodique Auprès Des Ménages (EPM)	Sep 2005- Nov 2005	5,922	77.8	277	21.4
Rwanda Enquête Intégrale sur les Conditions de Vie des Ménages (EICV)	July 2000- July 2001 (rural)	5,280	89.6	440	12
South and Southeast Asia					
India Rural Economic and Demographic Survey (REDS)	January 1998- July 1999	7,474	72.2 §	253	29.5
Nepal Living Standards Survey (NLSS 2003)	Apr 2003- Mar 2004	2,748	84.6	229	12
Nepal Living Standards Survey (NLSS 1995)	June 1995- May 1996	2,657	92.9	215	12.4
Pakistan Integrated Household Survey (PIHS)	Jan 1991- Dec 1991	2,386	70.0	150	15.9

Notes:
(1) In the MLSS, the community survey was conducted at the douar (village) level in rural areas. In some cases, 2-3 douars were surveyed within a particular PSU.
§ From the 2001 India Census, since the India REDS was representative only of rural areas.

Table 2: Rural access to water: one-way time/distance to nearest water source

	% households, by time to nearest water source (minutes (m), walking, one-way)							% aged 15+ reporting time spent in water collection	
								women	men
	$m=0$	$0< m <5$	$5\leq m \leq 10$	$10< m \leq 15$	$15< m \leq 30$	$30< m \leq 60$	$m >60$		
Yemen	34.1	3.0	19.3	17.6	16.5	8.4	1.0	58.4	7.8
Morocco	21.0	12.4	28.7	12.5	14.0	7.1	4.2	-	-
Uganda	5.0	4.6	13.3	12.4	29.5	22.8	12.4	67.7	39.9
Malawi	1.4	19.7	49.9	9.8	15.6	3.4	0.4	80.5	11.3
Madagascar	3.9	4.5	29.1	18.5	27.1	12.1	4.8	-	-
India	21.2	22.2	35.7	9.9	8.4	2.2	0.4	85.5	-
Nepal 2003-04	56.9	17.5	14.6	3.8	5.1	1.7	0.4	-	-
Nepal 1995-96	41.3	11.8	22.6	10.6	8.5	4.2	1.1	78.5	36.9
Pakistan	68.6	0.1	8.0	3.7	10.9	3.3	5.5	60.8	-
	% households, by distance to nearest water source (km (k))								
	$k=0$	$0< k \leq 0.1$	$0.1< k \leq 0.5$	$0.5< k \leq 1$	$1< k \leq 2$	$2< k \leq 3$	$k >3$		
Rwanda	0.2	5.9	49.8	27.6	9.9	3.6	2.9	56.0	36.3

Notes:
(1) Figures are population weighted.
(2) (-) indicates data not available in the survey.

Table 3: Men and women in rural areas participating in off-farm work (%)

	Women aged 15+ years				Men aged 15+ years			
	Any off-farm work	Any wage work	No off-farm work, but enrolled in school	Sample	Any off-farm work	Any wage work	No off-farm work, but enrolled in school	Sample
Yemen	3.3	0.6	4.7	10,277	50.5	38.0	14.7	10,137
Morocco	16.3	12.4	3.8	4,432	52.3	42.6	14.9	3,995
Uganda	31.5	29.3	15.1	8,087	48.3	45.7	18.8	7,588
Malawi	27.2	13.7	7.8	12,659	48.0	31.8	12.8	11,808
Madagascar	39.9	19.6	7.5	7,658	41.7	26.8	8.6	7,414
Rwanda	19.8	14.8	6.4	7,843	33.2	27.5	8.7	6,256
India	20.6	19.6	7.1	14,148	49.1	48.5	9.5	15,255
Nepal 2003-04	25.3	20.8	5.9	4,850	48.2	38.0	8.2	4,593
Nepal 1995-96	25.2	21.3	5.1	4,793	47.4	39.8	8.4	4,758
Pakistan	21.7	16.7	2.1	4,702	52.3	37.5	8.3	5,150

Notes:
(1) Figures are population weighted. Any off-farm work includes wage work (agricultural and non-agricultural), as well as work in non-farm self-employment activities.
(2) Individuals are coded as participating in non-farm self-employment if explicitly identified in the survey as owning/managing operations for their own business or family business. A few surveys (Uganda, Malawi) ask about household members' responsibility for operations, but also about unpaid family workers in the business. Unpaid family workers are excluded from our definition of nonfarm self-employment.

Table 4: Schooling and health outcomes for children in rural areas

	Child aged 5-19 enrolled in school (Y=1, N=0)		Anthropometric outcomes: weight-for-height z-scores [2]		Anthropometric outcomes: height-for-age z-scores [2]	
	Girls	Boys	Girls	Boys	Girls	Boys
Yemen	0.36	0.63	-0.52	-0.68	-2.64	-2.83
	[0.48]	[0.48]	[1.60]	[1.61]	[2.16]	[2.21]
	8,120	8,669	2,217	2,312	2,393	2,518
Morocco	0.30	0.58	0.17	0.21	-0.51	-0.41
	[0.46]	[0.49]	[1.54]	[1.71]	[2.11]	[2.39]
	2,577	2,648	276	342	458	534
Uganda	0.76	0.78	-	-	-	-
	[0.43]	[0.41]	-	-	-	-
	7,080	7,096	-	-	-	-
Malawi	0.68	0.71	0.26	0.27	-1.64	-1.69
	[0.47]	[0.45]	[1.22]	[1.24]	[1.42]	[1.45]
	9,127	9,136	3,011	2,852	3,011	2,884
Madagascar	0.68	0.69	-	-	-	-
	[0.47]	[0.46]	-	-	-	-
	5,911	6,028	-	-	-	-
Rwanda	0.45	0.46	0.09	0.20	-2.04	-2.11
	[0.50]	[0.50]	[1.29]	[1.32]	[1.43]	[1.40]
	5,963	5,579	1,478	1,449	1,446	1,430
India	0.60	0.69	-	-	-1.42	-1.38
	[0.49]	[0.46]	-	-	[1.87]	[1.92]
	7,123	7,898	-	-	1,142	1,292
Nepal 2003-04	0.57	0.68	-	-	-	-
	[0.50]	[0.47]	-	-	-	-
	2,937	3,019	-	-	-	-
Nepal 1995-96	0.41	0.59	-1.01	-1.09	-2.15	-2.22
	[0.49]	[0.49]	[1.45]	[1.41]	[1.39]	[1.37]
	3,011	3,121	552	619	533	599
Pakistan	0.28	0.56	-	-	-1.92	-1.96
	[0.45]	[0.50]	-	-	[1.64]	[1.68]
	3,497	3,809	-	-	891	887

Notes:
(1) Population-weighted estimates are presented. Standard deviations are presented in brackets, followed by sample sizes.
(2) z-scores are for children at least 6 months old with upper age cutoffs at 5 years for Yemen, Malawi, India, and Pakistan; 4 years for Nepal 1996, and 3 years for Morocco.
(3) (-) indicates data not available in the survey. There are problems with the weight variable in the Pakistan data.

Table 5: Regression Variables

Individual regressions: women's off-farm work

Equation (6)

Dependent variable
Woman aged 15+ participates in any off-farm work or in wage work alone (Y=1 N=0)

Explanatory variables

Individual characteristics:

- Age, age squared
- Currently married (Y=1 N=0)
- Divorced/widowed (Y=1 N=0)
- Age at first marriage (years)
- Has chronic illness/disability (Y=1 N=0)
- Years of schooling, years of schooling squared

Additional country-specific individual characteristics:

- Woman is in polygamous marriage (*Uganda*)
- Lives in a joint family (*Morocco*)
- Number of living brothers and sisters (*India*)

HH characteristics:

- HH variables (X) listed in eq. (10)
- Community fixed effects

Individual regressions: child schooling/health

Equation (6)

Dependent variable
Schooling: Child aged 5-19 enrolled in school during last year (Y=1 N=0)
Health: Weight-for-height and height-for-age z-scores for children aged 6 months to 3, 4 or 5 years old.

Explanatory variables

Individual characteristics:

- Age dummies
- Birth order of child
- Mother in home (Y=1 N=0) [3]
- Father in home (Y=1 N=0) [3]
- Mother's and father's years of schooling [3]
- Had sudden illness/accident in last month (Y=1 N=0)

Additional country-specific individual characteristics:

- One or both parents has passed away (*Pakistan, Morocco, Yemen, Malawi*)

HH characteristics:

- Distance to nearest primary school (km)
- Distance to nearest secondary school (km)
- HH variables (X) listed in eq. (10)
- Community fixed effects

Community-level regressions of geographic effects

Equation (10)

Dependent variable
Geographic effect on outcomes estimated from eq. (6)

Explanatory variables

- Mean household time to nearest water source ($\overline{Z}$) (minutes, walking, one-way)

Community variables (G):

- Market prices of various agricultural staples/commodities
- Men's daily agricultural wage
- Men's daily non-agricultural wage
- Women's daily agricultural wage
- Women's daily non-agricultural wage
- Factories/industries in or near community
- Access to markets/shops
- Access to paved roads
- Access to credit institutions/ banks
- Access to primary school(s) [4]
- Access to secondary school(s) [4]
- Access to health facilities and antenatal care in community
- Share of households with electricity
- Access to government/local governing institutions
- Presence of land markets/ characteristics of land ownership
- Presence of agricultural cooperatives and agricultural extension services
- Natural or economic shock in last year
- Mean log deviation of per capita consumption expenditures
- Migration of community members for work
- Population/population density of community
- Interview date dummies

Community-level means of household variables ($\overline{X}$):

- HH head born/moved from outside locality (Y=1 N=0)
- HH head from outside locality*years since move
- Age and age squared of HH head
- HH head is divorced/widow (Y=1 N=0)
- Adult has chronic disability/illness (Y=1 N=0) [2]
- Maximum years of schooling among adult men
- Maximum years of schooling among adult women
- Log HH size
- Share of adult women 16-55
- Share of adult men 16-55
- Share of girls 7-15
- Share of boys 7-15
- Share of girls 0-6
- Share of boys 0-6
- Indicator of ethnicity/language
- Indicator of religious status
- Owns land (Y=1 N=0)
- Receives remittances from outside area (Y=1 N=0)
- Log annual HH per capita expenditure
- External walls of dwelling made from solid material (e.g., stone/concrete) (Y=1 N=0)

Community-level mean of additional country-specific HH characteristics ($\overline{X}$):

- Suffered economic shock in last 12 months (Y=1 N=0) (*Malawi, Uganda*)
- Whether HH head inherited residence (*Morocco*)
- Inherited land of HH head and spouse at the time of marriage (*India*)

Notes:
(1) Exact country specific variable definitions are in a statistical addendum available from the authors.
(2) In the women's off farm work equation (6), this variable takes the form: "other adult has a chronic illness."
(3) When information on a child's parents is not available (for example when a parent is not in the household), the enrollment regressions instead control for the maximum years of schooling among adult women/men in the household.
(4) When available, additional information was included on teachers (number, sex, schooling levels), quality of school construction, highest class offered, presence of religious schools, girls'/coeducational schools, and primary school enrollment rates of boys and girls.

Table 6: Share of total variance explained by geographic dummies

	Woman aged 15+ in off-farm work (Y=1, N=0)	Woman aged 15+ in wage work (Y=1, N=0)	Girl aged 5-19 enrolled in school (Y=1, N=0)	Boy aged 5-19 enrolled in school (Y=1, N=0)	Girls' weight for height z-score	Boys' weight for height z-score	Girls' height for age z-score	Boys' height for age z-score	Access to water (time/ distance to nearest source)
Yemen	0.18	0.10	0.24	0.16	0.45	0.45	0.33	0.40	0.70
Morocco	0.19	0.18	0.22	0.21	0.59	0.48	0.39	0.33	0.49
Uganda	0.17	0.16	0.17	0.15	-	-	-	-	0.32
Malawi	0.13	0.12	0.12	0.13	0.23	0.28	0.24	0.29	0.29
Madagascar	0.31	0.26	0.15	0.16	-	-	-	-	0.51
Rwanda	0.15	0.16	0.12	0.12	0.36	0.36	0.37	0.39	0.44
India	0.17	0.18	0.17	0.13	-	-	0.34	0.30	0.38
Nepal 2003-04	0.15	0.15	0.26	0.19	-	-	-	-	0.42
Nepal 1995-96	0.20	0.19	0.28	0.16	0.44	0.46	0.40	0.40	0.48
Pakistan	0.23	0.27	0.21	0.12	-	-	0.29	0.28	0.48

Notes:
(1) Numbers represent the R-squared obtained from regressing each dependent variable on geographic dummy variables.

Table 7: Impact of a 1 hour/1 km reduction in time/distance to water on the share of rural women engaging in off-farm work

	(a)		(b)		(c): dropping potentially endogenous variables	
	Coeff.	R^2	Coeff.	R^2	Coeff.	R^2
Woman aged 15+ in off-farm work (Y=1, N=0)						
Yemen	0.005	0.19	0.026	0.18	0.022	0.17
	[0.33]		[1.30]		[1.23]	
Morocco	-0.028*	0.22	-0.032	0.80	-0.029	0.77
	[-1.80]		[-0.61]		[-0.63]	
Uganda	-0.017	0.26	0.029	0.37	0.002	0.34
	[-0.98]		[1.02]		[0.08]	
Madagascar	-0.007	0.34	0.014	0.51	0.014	0.50
	[-0.26]		[0.28]		[0.31]	
Malawi	-0.002	0.19	-0.104	0.35	-0.106	0.34
	[-0.19]		[-1.50]		[-1.55]	
India	-0.088***	0.27	-0.108	0.64	-0.114	0.61
	[-3.02]		[-0.96]		[-1.05]	
Nepal 2003-04	0.014	0.28	0.137	0.66	0.129	0.62
	[0.28]		[1.22]		[1.17]	
Nepal 1995-96	-0.113***	0.32	0.161	0.90	0.168	0.89
	[-3.03]		[1.27]		[1.39]	
Pakistan	-0.014	0.30	-0.081	0.97	-0.081	0.97
	[-0.73]		[-0.95]		[-0.87]	
Rwanda	-0.002	0.18	-9.5E-05	0.69	0.001	0.68
	[-0.24]		[-0.010]		[0.11]	
Woman aged 15+ in wage work (Y=1, N=0)						
Yemen	0.003	0.12	0.004	0.21	0.005	0.20
	[0.56]		[0.63]		[0.88]	
Morocco	-0.013	0.22	-7.8E-05	0.87	-0.006	0.85
	[-0.80]		[-0.002]		[-0.14]	
Uganda	-0.016	0.25	0.035	0.33	0.042	0.31
	[-1.14]		[1.27]		[1.53]	
Madagascar	0.021	0.30	0.003	0.51	0.007	0.50
	[0.908]		[0.08]		[0.21]	
Malawi	0.004	0.16	-0.047	0.63	-0.051	0.63
	[0.40]		[-1.00]		[-1.09]	
India	-0.091***	0.28	-0.109	0.65	-0.109	0.62
	[-3.60]		[-0.94]		[-0.92]	
Nepal 2003-04	-0.024	0.29	0.156	0.74	0.172	0.71
	[-0.48]		[1.39]		[1.55]	
Nepal 1995-96	-0.110***	0.31	0.095	0.93	0.099	0.91
	[-2.98]		[0.91]		[0.98]	
Pakistan	-0.021	0.34	-0.072	0.97	-0.073	0.97
	[-1.14]		[-0.83]		[-0.81]	
Rwanda	0.002	0.20	-0.007	0.48	-0.007	0.46
	[0.48]		[-0.69]		[-0.70]	
Level of regression	Individual		Community		Community	

Notes:
(1) t-statistics in brackets. *** p<0.01, ** p<0.05, * p<0.1. Estimates reflect the change in the share of women participating in off-farm work from a one-hour decline in time to the nearest water source (or, for Rwanda, a 1 km reduction in distance).
(2) Parameter estimates in: (a) are from simple regressions of off-farm work on time to water and community fixed effects; (b) are based on equation (10); (c) are also estimated from equation (10), and exclude mean years of women's schooling, mean women's wages, community access to primary schools and to electricity, and average community per capita expenditures.
(3) The results for Pakistan are based on a subset of the sample without six outlier communities.

Table 8: Impact of a 1 hour/1 km reduction in time/distance to water on the share of rural children that are enrolled in school

	(a)		(b)		(c): dropping potentially endogenous variables	
	Coeff.	R^2	Coeff.	R^2	Coeff.	R^2
Girls 5-19 enrolled in school (Y=1, N=0)						
Yemen	0.076**	0.44	0.087*	0.53	0.088*	0.53
	[2.21]		[1.76]		[1.78]	
Morocco	0.023	0.41	0.117*	0.88	0.114*	0.88
	[0.66]		[1.72]		[1.71]	
Uganda	0.002	0.41	-0.017	0.30	-0.018	0.29
	[0.14]		[-0.75]		[-0.78]	
Madagascar	-0.001	0.42	-0.034	0.59	-0.040	0.56
	[-0.04]		[-1.11]		[-1.28]	
Malawi	0.018	0.43	-0.073	0.61	-0.070	0.61
	[1.30]		[-0.82]		[-0.79]	
India	0.052	0.41	0.023	0.64	-0.01	0.62
	[0.94]		[0.23]		[-0.12]	
Nepal 2003-04	-0.031	0.48	0.010	0.83	-0.015	0.81
	[-0.56]		[0.07]		[-0.11]	
Nepal 1995-96	0.013	0.46	0.323**	0.73	0.386**	0.71
	[0.26]		[2.02]		[2.41]	
Pakistan	0.039*	0.37	0.172**	0.84	0.182**	0.84
	[1.77]		[2.08]		[2.14]	
Rwanda	0.016***	0.48	0.001	0.87	0.003	0.87
	[2.60]		[0.15]		[0.28]	
Boys 5-19 enrolled in school (Y=1, N=0)						
Yemen	0.107***	0.46	0.086**	0.46	0.089**	0.43
	[3.35]		[2.13]		[2.17]	
Morocco	0.007	0.39	0.192***	0.81	0.177***	0.79
	[0.20]		[3.92]		[3.25]	
Uganda	0.014	0.34	-0.017	0.36	-0.020	0.35
	[1.02]		[-0.75]		[-0.87]	
Madagascar	0.001	0.41	0.008	0.49	0.008	0.49
	[0.03]		[0.29]		[0.29]	
Malawi	-0.020	0.34	-0.127	0.42	-0.126	0.42
	[-1.47]		[-1.53]		[-1.52]	
India	0.023	0.35	-0.049	0.55	-0.039	0.53
	[0.55]		[-0.56]		[-0.44]	
Nepal 2003-04	0.047	0.41	-0.027	0.86	-0.047	0.86
	[0.70]		[-0.17]		[-0.30]	
Nepal 1995-96	0.035	0.36	0.329***	0.71	0.334***	0.69
	[0.74]		[2.88]		[2.82]	
Pakistan	0.077*	0.30	0.188**	0.92	0.193**	0.91
	[1.73]		[2.39]		[2.37]	
Rwanda	-0.006	0.45	0.008	0.35	0.008	0.34
	[-0.75]		[0.84]		[0.86]	
Level of regression	Individual		Community		Community	

Notes:
(1) t-statistics in brackets. *** p<0.01, ** p<0.05, * p<0.1. Estimates reflect the change in the share of children enrolled in school from a one-hour decline in time to the nearest water source (or, for Rwanda, a 1km reduction in distance).
(2) Parameter estimates in: (a) are from simple regressions of school enrollments on time to water and community fixed effects; (b) are based on equation (10); (c) are also estimated from equation (10), and exclude mean years of schooling and wages for women (in the girls' schooling equation), as well as mean years of schooling and wages for men (in the boys' schooling equation).
(3) The results for Pakistan are based on a subset of the sample without six outlier communities.

Table 9: Impact of a 1 hour/1 km reduction in time/distance to water on rural children's anthropometric z-scores

	(a)				(b)				(c): dropping potentially endogenous variables			
	Weight for height		Height for age		Weight for height		Height for age		Weight for height		Height for age	
	Coeff.	R^2	Coeff.	R^2	Coeff.	R^2	Coeff.	R^2	Coeff.	R^2	Coeff.	R^2
Girls												
Yemen	0.51*	0.47	0.10	0.36	0.07	0.27	0.84**	0.23	0.04	0.27	0.82**	0.20
	[1.91]		[0.23]		[0.25]		[2.38]		[0.15]		[2.37]	
Morocco	-0.51	0.67	0.46	0.55	-0.73	0.77	0.74	0.74	-0.41	0.75	0.47	0.71
	[-0.65]		[0.86]		[-0.94]		[1.38]		[-0.58]		[0.96]	
Malawi	-0.02	0.29	0.06	0.35	0.68**	0.75	-0.38	0.70	0.68**	0.75	-0.35	0.70
	[-0.22]		[0.75]		[2.36]		[-0.98]		[2.39]		[-0.94]	
India	-		0.20	0.40	-		0.81	0.74	-		0.88	0.46
	-		[0.48]		-		[0.66]		-		[0.69]	
Nepal 1996	-0.40	0.50	-0.26	0.45	-0.87	0.74	0.40	0.79	-0.83	0.73	0.52	0.79
	[-1.13]		[-0.52]		[-1.46]		[0.72]		[-1.41]		[0.94]	
Pakistan	-		0.21	0.38	-		-0.12	0.80	-		-0.07	0.79
	-		[0.82]		-		[-0.20]		-		[-0.11]	
Rwanda	0.01	0.41	0.01	0.41	0.04	0.23	0.05	0.29	0.04	0.23	0.05	0.29
	[0.27]		[0.32]		[0.58]		[0.85]		[0.60]		[0.87]	
Boys												
Yemen	0.15	0.47	-0.04	0.43	0.18	0.26	0.84*	0.24	0.22	0.26	0.76	0.22
	[0.57]		[-0.12]		[0.71]		[1.71]		[0.88]		[1.52]	
Morocco	0.34	0.57	0.24	0.54	-0.61	0.71	0.28	0.66	-0.56	0.71	0.46	0.64
	[0.40]		[0.61]		[-1.15]		[0.54]		[-1.09]		[0.91]	
Malawi	-0.05	0.29	-0.09	0.37	-0.16	0.42	0.05	0.55	-0.17	0.42	0.12	0.54
	[-0.78]		[-1.06]		[-0.53]		[0.12]		[-0.56]		[0.33]	
India	-		-0.24	0.35	-		1.38	0.50	-		1.31	0.50
	-		[-0.46]		-		[1.10]		-		[1.06]	
Nepal 1996	-0.15	0.53	-0.44	0.46	-1.02	0.79	-0.28	0.67	-1.04	0.79	-0.16	0.66
	[-0.25]		[-0.92]		[-1.47]		[-0.37]		[-1.49]		[-0.21]	
Pakistan	-		-0.09	0.35	-		0.04	0.67	-		0.07	0.66
	-		[-0.31]		-		[0.05]		-		[0.09]	
Rwanda	0.03	0.42	0.07	0.44	0.03	0.26	-0.06	0.34	0.03	0.26	-0.06	0.33
	[0.48]		[1.05]		[0.51]		[-0.90]		[0.52]		[-0.96]	
Level of regression	Individual				Community				Community			

Notes:
(1) t-statistics in brackets. *** p<0.01, ** p<0.05, * p<0.1. Estimates reflect the change in the z-score from a one-hour decline in time to the nearest water source (or, for Rwanda, a 1km reduction in distance).
(2) Parameter estimates in: (a) are from simple regressions of the z-scores on time to water and community fixed effects; (b) are based on equation (10); (c) are also estimated from equation (10), and exclude community access to health facilities.
(3) The relevant age sample for boys and girls is 6-59 months for Yemen, Malawi, Rwanda, India, and Pakistan; for Morocco, 6-36 months, and for Nepal 1996, 6-48 months.
(4) The results for Pakistan are based on a subset of the sample without six outlier communities.