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IFPRI Discussion Paper 01269

May 2013

The Child Health Implications of Privatizing Africa's Urban Water Supply

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IFPRI gratefully acknowledges the generous unrestricted funding from Australia, Canada, China, Denmark, Finland, France, Germany, India, Ireland, Italy, Japan, the Netherlands, Norway, the Philippines, South Africa, Sweden, Switzerland, the United Kingdom, the United States, and the World Bank.

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ABSTRACT

Identifying policies which can improve water sector management is critically important given the global burden of water-related disease. Each year, 1 in 10 child deaths—roughly 800,000 in total—is the direct result of diarrhea. Can private-sector participation (PSP) in the urban piped water sector improve child health? The author uses child-level data from 39 African countries during 1986–2010 to show that introducing PSP decreases diarrhea among urban dwelling children under five years of age by 5.6 percentage points, or 35 percent of its mean prevalence. PSP also leads to greater reliance on piped water. To attribute causality, the author exploits time variation in the private water market share controlled by African countries' former colonizers. A placebo analysis reveals that PSP does not affect symptoms of respiratory illness in the same children, nor does it affect a rural control group unaffected by PSP.

Keywords: privatization, public health, water utilities, government policy

ACKNOWLEDGMENTS

This research was supported by a National Science Foundation Graduate Research Fellowship and a Stanford Institute for Economic Policy Research Dissertation Fellowship. I thank George R.G. Clarke, Sebastián Galiani, Giacomo De Giorgi, Caroline Hoxby, Seema Jayachandran, Saumitra Jha, Phil Keefer, Masa Kudamatsu, John Nye, Rohini Pande, Mary Shirley, Alberto Simpser, Fabián Valencia, Romain Wacziarg, and Scott Wallsten for helpful comments. I gratefully acknowledge the research assistance of Nicole Anchondo, Alison Bonelli, and Stephanie Hausladen, and the generous help of David Lloyd Owen of Envisager Limited. All remaining errors are my own.

1. INTRODUCTION

Can private-sector participation (PSP) in the urban piped water sector improve child health? This question is critically important given the global burden of water-related disease. Each year, 1 in 10 child deaths—roughly 800,000 in total—is the direct result of diarrhea (UNICEF and WHO 2009). An estimated 88 percent of deaths from diarrhea could be prevented by ensuring access to safe, improved water and sanitation supplies (Black, Morris, and Bryce 2003). In 2000, the United Nations issued the Millennium Development Goals (MDGs). Among the goals set were: (1) "to halve, by 2015, the 1990 proportion of the population without sustainable access to safe drinking water and basic sanitation" and (2) "to reduce by two thirds, between 1990 and 2015, the under-five mortality rate." Most African countries will not reach these goals if current trends persist (United Nations 2011). As of 2010, 39 percent of people living in Africa south of the Sahara lacked safe drinking water, and only 19 of 50 countries in the region were on track to meet the drinking water target (UNICEF and WHO 2012).[1] Today, Africa accounts for about 15 percent of the world's population but for more than half of child deaths (You, Jones, and Wardlaw 2010). One potential solution is more extensive use of PSP in the water sector, but little is known about how it would affect child health and progress on the MDGs.

Allowing the private sector to provide basic infrastructure such as piped water is controversial. Theory suggests that PSP can increase utility efficiency if it is accompanied by direct competition (Shapiro and Willig, 1990; Schmidt, 1996), or by competition for the market, through a competitive bidding process (Demsetz 1968). However, water provision is a natural monopoly in which firms are not subject to direct competition. Furthermore, there have been fewer bidders in the water sector than in others including energy, telecommunications, and roads (Iimi 2008). In developing countries, competition may be further encumbered by corruption, collusion, a lack of transparency, and regulatory capture (Beato and Laffont 2002). This raises the question of whether efficiency gains can translate into greater access to water, or better health outcomes, in the developing world. Galiani et al. (2005) find that child mortality from water-related diseases in Argentina (an upper-middle income country) fell following PSP in water, but it is unclear whether this would apply in a developing country context. Institutional and governance challenges abound in developing countries, which could lead to poorer performance by public *or* private firms. Also, in developing countries it may be relatively more costly if a private firm fails to internalize the positive externalities of using piped drinking water, since many people may realistically turn to unsafe alternatives.

This paper uses child-level data from 39 African countries during 1986–2010 to test whether PSP affects the prevalence of diarrhea in urban-dwelling children under age five. This is the period during which nearly all African countries with PSP in water implemented those arrangements. Results show that PSP decreases diarrhea by about 5.6 percentage points, which implies a 35 percent decrease in its mean prevalence. Also, the prevalence of diarrhea is decreasing in years under PSP. Importantly, PSP reduces diarrhea most among children from the poorest households. Children from households with more educated mothers and more assets see the smallest reductions. PSP is also associated with greater reliance on piped water (either in the home or from a public tap) as the primary drinking water source, which is a likely causal channel explaining health improvements. Those with piped water have higher-quality water at the source, use larger quantities of water, and are less likely to store water in containers, all of which help reduce the prevalence of diarrhea (see Blum and Feachem 1983; Esrey et al. 1991; Black, Morris, and Bryce 2003; Fewtrell et al. 2005; Kremer and Zwane 2007). PSP is also associated with less time spent collecting water.

The analysis faces a significant challenge to identification: the possibility of time-varying, unobserved covariates correlated with both PSP in water and child health. The strength of my analysis stems from an instrumental variables framework that takes into account non-random selection into PSP. Specifically, I exploit variation over time in the share of privately-run water taps worldwide (but excluding Africa) run by an African country's former colonizer (France, the UK, Belgium, Portugal, Germany, or Italy). This

[1] The world as a whole met the Millennium Development Goal drinking water target in 2010—five years early. Nonetheless, more than 780 million people—1 in 10—still lacked safe drinking water.

time-varying measure of relative water market expertise of a country's former colonizer serves as a supply-side shock to PSP in Africa. I show that when a former colonizer gains an additional 10 percent of the non-African water market, this increases the probability of PSP in the African country by 4.4 percentage points.

Importantly, OLS estimates which ignore selection into PSP underestimate its health benefits. PSP would appear to decrease diarrhea by only 2.2–2.6 percentage points (14–16 percent of the mean prevalence), which is about half as large as the IV estimates. The difference between the OLS and the IV results is consistent with the timing of PSP coinciding with declines in child health driven by time-varying, unobserved covariates.

A possible concern is that the excluded instrument is correlated with some time-varying factor that improves health. In that case, PSP might spuriously appear to reduce diarrhea. I explore this possibility with two placebo tests. First, I test whether PSP affects symptoms of acute respiratory illness in the same children. I find that PSP affects neither the prevalence of coughing, nor coughing with short, rapid breaths. Health improvements seem to be driven by changes in the water sector. Second, I test whether PSP affects child diarrhea in rural areas, which are not directly impacted by PSP policies. I indeed find no significant effect of PSP on this natural control group.

The paper is organized as follows: Section 2 offers background information on water and human health, and their importance to the piped water PSP debate. Section 3 describes the empirical strategy. Section 4 presents the main empirical results. Section 5 discusses potential causal channels through which PSP affects diarrhea. Finally, Section 6 concludes.

2. BACKGROUND

Water and Child Health

Health has a profound impact on individual well-being and productivity. Poor health in childhood lowers school enrollment (Alderman et al. 2001), reduces learning productivity (Glewwe, Jacoby, and King 2001), increases absenteeism (Miguel and Kremer 2004), and lowers test scores (Paxson and Schady 2007), all of which have lasting impacts. Yet young children have both the least knowledge of how to avoid exposure to disease and the least resistance to disease (Burstrom et al. 2005; Kremer and Zwane 2007). This is especially problematic in Africa—a continent that accounts for 15 percent of the world's population but over half of child deaths (You, Jones, and Wardlaw 2010).

The health indicator on which I focus is the prevalence of diarrhea in children under age five. Each year, about 800,000 child deaths are the direct result of diarrhea (UNICEF and WHO 2009). Diarrhea accounts for more under five deaths than malaria and HIV combined (WHO 2007). Diarrhea also contributes to morbidity and delayed development; it reduces growth, fitness, and cognitive function by reducing appetite, altering feeding patterns, and decreasing absorption of nutrients.[2]

Unsafe water is the major cause of diarrhea. An estimated 88 percent of deaths from diarrhea could be prevented by ensuring access to safe, improved water and sanitation supplies (Black, Morris, and Bryce 2003). However, 39 percent of Africans who live south of the Sahara lack access to improved drinking water (UNICEF and WHO 2012).[3]

Piped water is the premier improved water source, and ensuring access to it can help combat diarrhea for several reasons. First, alternative sources of water are relatively more exposed to disease-causing contamination (Tonglet et al. 1992; Fewtrell et al. 2005). Second, piped water is relatively easy to collect; it comes from a tap in the home or yard, or from a (usually) nearby public standpipe. Having piped water can contribute to the use of larger quantities of water, and reduces the need to store water in containers. Households that use more water tend to practice better hygiene. Also, storage of water in containers has itself been linked to contamination and diarrhea (see Blum and Feachem (1983), Esrey et al. (1991), Black et al. (2003), Fewtrell et al. (2005), and Kremer and Zwane (2007)).

In addition to diarrhea, environmental (tropical) enteropathy is another condition associated with contaminated water. It occurs when ingested fecal bacteria infect the small intestine, reducing its capacity to absorb nutrients. It may be a leading factor in the persistence of malnutrition despite interventions targeting diarrhea and supplementing nutrition (Humphrey 2009; McKay et al. 2010). Thus, improving water quality could have wider-ranging impacts on nutrition beyond any effects on diarrhea morbidity and mortality.

The empirical evidence on whether increased access to piped water improves health is mixed. Gamper-Rabindran et al. (2010) show that increasing access to piped water in Brazil decreases infant mortality. However, Bennett (2012) finds that access to cleaner, piped water in the Philippines is correlated with decreased sanitation in the community as a whole. People substitute clean, piped water for sanitary behavior (which has large health externalities). Devoto et al. (2012) do not find reductions in waterborne diseases, including child diarrhea, as a result of a program in urban Morocco providing subsidized credit to obtain an individual water tap over a free communal one.

[2] Diarrheal diseases include cholera, colitis, gastritis, gastroenteritis, enteritis, intestinal inflammation, and typhoid fever, among others. These originate from pathogens such as rotavirus, adenovirus, and Norwalk virus (Burstrom et al. 2005).

[3] Improved means protected from excreta, contaminants, and insects. Water sources likely to be improved are piped water into the dwelling, piped water to a yard/plot, a public tap/standpipe, a tube well/borehole, a protected dug well, a protected spring, and rainwater. Unimproved sources include an unprotected dug well, an unprotected spring, a cart with a tank/drum, a water tanker-truck, and surface water (UNICEF and WHO 2006).

The Effects of PSP on Consumers

PSP includes concessions, leases, affermage contracts, build-operate-transfer contracts, and management and service contracts. It has been motivated by theoretical efficiency gains, fiscal crises, and the requirements of lenders.

The water industry has several features that make PSP less common than it is in other industries. First, a clean and reliable water supply generates large, positive health externalities. Second, allowing a private firm to profit from something necessary for life is politically controversial. This makes PSP risky for governments as well as for private firms that fear contract cancellation.[4] Third, governments can often profit heavily from public control by delaying investments (usually longer than they can in other industries) and earning quasi-rents (Noll 2002). They often use quasi-rents to reduce water tariffs, thus intensifying public resistance to PSP as it would likely end the subsidies. Finally, provision of piped water is a natural monopoly. It is not desirable to duplicate the water provision network, and fragmentation can limit economies of scale. This generates ambiguity about the benefits of PSP.

Theory suggests that PSP can increase utility efficiency if accompanied by competition.[5] Shapiro and Willig (1990) use the distortions in the objectives of public managers (a malevolent government) to show the benefits of private ownership under incomplete contracting. Schmidt (1996) eliminates the assumption of a malevolent government and shows that the real threat of bankruptcy faced by private-sector firms, combined with competitive conditions, generates gains from PSP. However, direct competition is difficult with natural monopolies. Demsetz (1968) proposes a possible solution: competition for the market via a bidding process. However, Goldberg (1976) and Williamson (1976) identify problems with this approach: collusion, asymmetric information, problems in the pricing of assets, and other incumbent advantages may make it anti-competitive. Moreover, any resulting contracts are incomplete in practice (Williamson 1976). As a result, competition for the market cannot fully substitute direct competition. Empirically, there have been fewer bidders in the water sector than in other sectors including energy, telecommunications, and roads—possibly due to relatively high market concentration and technical complexity in this industry (Iimi 2008).[6]

Empirical evidence of the consumer impacts of PSP in water is mixed. Although some studies find that PSP can improve efficiency and consumer outcomes (see Galiani and Petrecolla 1996; Menard and Saussier 2000; Noll, Shirley, and Cowan 2000; Kirkpatrick, Parker, and Zhang 2004; Galiani, Gertler, and Schargrodsky 2005; Nellis 2005; Galiani, Gonzalez-Rozada, and Schargrodsky 2009; and Barrera-Osorio, Olivera, and Ospino 2009), others are less optimistic or find null results (see Byrnes, Grosskopf, and Hayes 1986; Houscamp and Tynan 2000; Saal and Parker 2001; Estache and Rossi 2002; Wallsten and Kosec 2008; Clarke, Kosec, and Wallsten 2009; Kremer et al. 2011). Most econometric studies focus on utility efficiency or access to piped water rather than health. Existing studies have also tended to focus on single countries given data limitations, raising questions of external validity.

Galiani, Gertler, and Schargrodsky (2005) uniquely examine the health implications of PSP. They find that child mortality from water-related diseases in Argentina (an upper-middle-income country) fell following PSP and that poor municipalities benefited more than richer ones. However, it is unclear whether this would apply in a developing country context. Institutional and governance challenges abound in developing countries, which could lead to poorer performance by public or private firms. Also, in developing countries it may be relatively more costly if a private firm fails to internalize the positive externalities of using piped water since many people may realistically turn to unsafe alternatives. And PSP may be relatively more likely to be a response to public-sector mismanagement of the water sector (endogenizing it in any health regression).

[4] An AfroBarometer survey of 12 African countries undertaking economic reforms between 1999 and 2001 revealed that only 35 percent of people preferred private to state ownership.

[5] For a nice discussion of the role of competition, see Kessides (2004).

[6] On average, there are 3.6 bidders for water and sewerage contracts, 3.8 for energy, 4.7 for roads, and 5.4 for telecommunications (Iimi 2008).

Where Does PSP in Water Come About and Why?

Why does PSP in the water sector come about in some areas and not in others? Kosec (2012) sheds light on this question using a database of all major PSP contracts in the water sector, worldwide, during 1990 through 2010 (from Envisager Limited 2011). Contracts are defined by the firm name and the country in which the firm is headquartered, the market country (where the PSP is carried out), and the number of water customers (taps) served. Two factors that are strongly positively associated with a firm's signing a new contract in a country are (1) its existing share of the global market for private, piped water (a measure of relative global experience) and (2) whether the country in which it is headquartered has a colonial relationship with the market country (a measure of interconnectedness). Also, although experience is always a helpful tool in gaining new contracts and customers, it is especially helpful in politically unstable market countries. It may be that in such contexts politicians are more easily persuaded by a firm's experience into signing a PSP contract (possibly owing to fewer checks and balances on this large decision) or that only relatively experienced firms can be profitable there. Kosec (2012) also shows that the headquarters country's gross domestic product, foreign direct investment (FDI), and payment of remittances are not significant predictors of the number of water contracts a firm signs.

This suggests that, for example, a French water company is more likely to sign a contract with the government of a former colony than with a non-colony's government. Such a contract is especially likely to be signed when the firm's global-water market share is growing because it is expanding more aggressively than firms in other countries. Also, the contract is more likely to be signed if the former colony is relatively unstable politically. Finally, a booming French economy or greater economic interdependence between France and the rest of the world does not increase French firms' chances of securing a water contract.

3. EMPIRICAL STRATEGY

In this section, I present an empirical model capturing the possibility that PSP in water affects child health. Ideally, I would randomly assign PSP to some subnational regions and not to others, and estimate the following equation:

$$d_{ijkt} = \delta p_{jt} + \gamma \mathbf{X_{ijkt}} + \lambda_j + \alpha_k + \beta_t + u_{ijkt} \tag{1}$$

where an observation is a child indexed by i, j indexes the subnational region of residence,[7] k indexes the month he is surveyed, and t indexes the year. p_{jt} is a dummy for PSP in the water sector in subnational region j in year t. d_{ijkt} is a dummy for whether a child experienced diarrhea at some point during the last two weeks. $\mathbf{X_{ijkt}}$ is a vector of child characteristics that may affect susceptibility to disease, including dummies for the child's age and gender, the mother's age, the mother's education level, the martial status of the child's parents, the number of household members, and whether the child's house has a natural (earth/ clay/ dung, etc) floor, electricity, a refrigerator, a radio, a television, a bicycle, a motorcycle, and a car. λ_j are subnational region fixed effects, α_k are month fixed effects, and β_t are year fixed effects.

Subnational region fixed effects control for time-invariant heterogeneity. They capture the unique geographic, institutional, and social context of each region.[8] My analysis thus leverages off of variation in PSP and the prevalence of diarrhea within regions, over time. Year fixed effects account for the global state of access to medicine, vaccines, and finance, for the strength of the global economy, and for the state of global experience with private water provision.[9]

The prediction that PSP in water reduces diarrhea implies $\delta < 0$. I test this prediction in the next section. I also examine whether PSP has heterogenous effects on children at different levels of poverty. I then explore potential causal channels by examining the effects of PSP on access to piped water, a flush toilet, and minutes it takes to collect water. Finally, I present two placebo analyses: one examining PSP's effect on illnesses it should not affect (coughing and coughing with short, rapid breaths) and one examining PSP's effect on a group of children it should not affect (those in rural areas).

Identification

The main threat to identification is the existence of time-varying, unobserved covariates correlated with both PSP in water and child health. PSP is the result of factors affecting both the potential for (or the ability to undergo) PSP as well as the government's (and population's) demand for PSP. I want to exploit supply-side variation in PSP. Factors affecting demand for PSP may directly affect child health, which would bias OLS estimates of δ.

There are several possible sources of omitted variable bias. First, governments are more likely to privatize a public water utility when years of under-investment in infrastructure mean that large investments will soon be required. This decline in infrastructure quality, however, may trigger an increase in diarrhea. δ might be biased in either direction. Places with poor water infrastructure quality may languish in this condition for years if the investments required are time-consuming and challenging to implement, keeping health poor for the duration. However, it may be relatively easy for places with poor health to catch up (that is, to reduce diarrhea by a given number of percentage points) precisely because they are starting at such a low base.

Second, people may be more likely to accept or even demand PSP in water when their government has revealed incompetence in handling the water sector. The government's incompetence, however, may also coincide with a deterioration in public health care and early childhood development policies. While it

[7] A subnational region is a province, state, or region within a country; terminology varies.

[8] Some regions have deserts while others have lush forests, which can affect water sources and human health. Different regions also have very different colonial histories, which have affected modern-day institutions (Acemoglu and Robinson, 2006).

[9] On average, we have four years of data on each locality. Given the unbalanced nature of the panel, year fixed effects index the three-year period in which the observation falls.

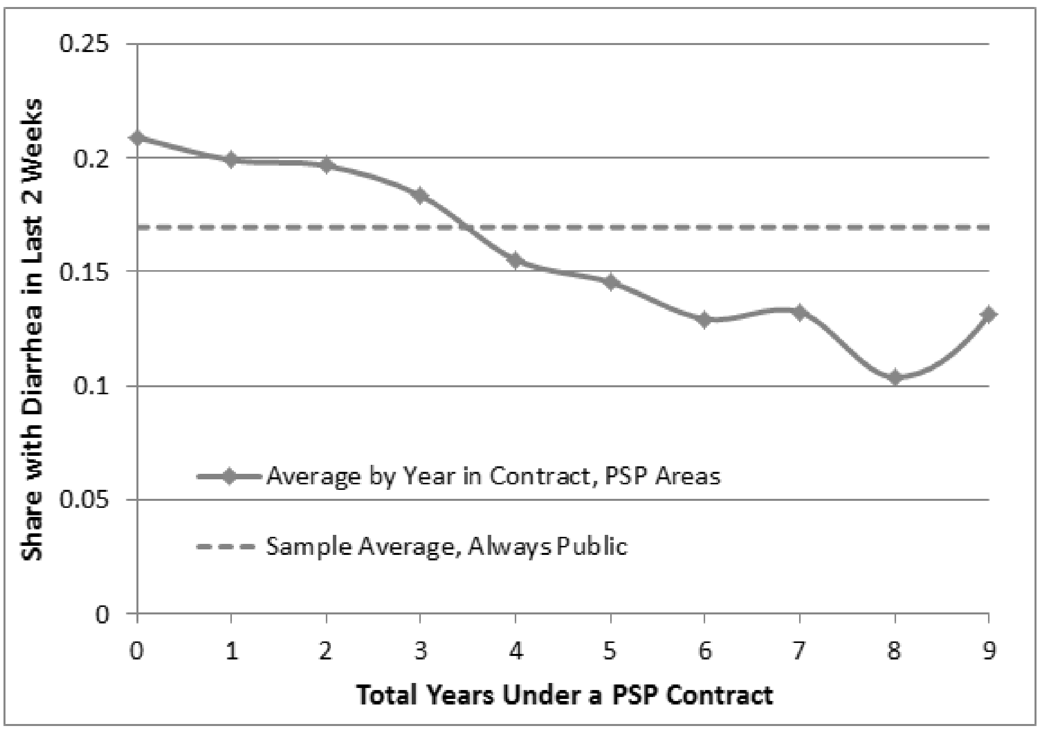
is again impossible to sign the bias in estimates of δ, this would seem to bias them toward 0. PSP would be initiated at a time when public institutions are unequipped to improve child health.

Third, PSP might be part of a larger set of "good governance" reforms that themselves improve public health. Again, δ might be biased in either direction. If countries choosing to undertake such reforms already have relatively good child health, and further improvements are difficult, then this might bias δ toward 0. However, if such such reforms occur when health improvements are relatively easy to make (perhaps because the new institutions equip the public and private sectors to improve health), then δ might be biased away from 0.

The possibility of simultaneity is also a potentially large concern. Even a competent government that has invested heavily in its water infrastructure may get a bad draw which causes child health to suffer (for example, an outbreak of cholera). Addressing this negative shock might require a private investor with more experience. Donors and lenders observing water sector mismanagement or health problems might also demand PSP in water.

Figure 3.1 shows the average prevalence of diarrhea (across all sample years) for several subgroups of subnational regions: those that will never undergo PSP, those that undergo PSP but have not yet done so, and those that have been under PSP arrangements for one, two, three, four, five, six, seven, eight, or nine years.

Figure 3.1—Average prevalence of diarrhea among water utilities that will undergo private-sector participation, by years private



Source: Author's calculations based on data from DHS (1986–2010), Pinsent Masons (1999–2011), Envisager Limited (2011), World Bank WDI (2011), and World Bank WGI (2011).

Note: The prevalence of diarrhea is the average prevalence (share of children experiencing diarrhea in a two-week period). The horizontal line shows the average prevalence of diarrhea among water utilities that are always public. PSP areas are places that undergo PSP at some point; The prevalence of diarrhea is shown in places that have not yet undergone PSP (zero years under a contract) and for different numbers of years under a PSP contract. Nine years is the 95th percentile of years under a PSP contract.

The average prevalence of diarrhea among localities that are always public is about 17 percent (meaning 17 out of 100 children experienced diarrhea sometime during the last two weeks). In contrast, the average prevalence of diarrhea is about 21 percent in localities that will eventually undergo PSP but have not yet done so. In the first and second years of a PSP contract, the prevalence of diarrhea lowers to 20 percent. In years 4, 5, 6, 7, and 8, it drops further to 18 percent, 16 percent, 15 percent, 13 percent, 13 percent, and 10 percent, respectively.[10] While diarrhea is decreasing in years under PSP,[11] it is not until the fourth year that a locality with PSP finally has lower diarrhea than does a locality that is always public. This figure presents suggestive evidence that PSP in water is correlated with other factors driving child health.

Instruments for Private-Sector Participation

To address these threats to identification, I construct an instrumental variable that captures supply-side variation in PSP. To do so, I first identify the European country that most recently colonized each African country. Appendix Table A.1 presents a list of colonizers. There are six colonizers of the 39 African countries in the sample: France (16), the United Kingdom (UK) (15), Belgium (3), Portugal (2), Germany (1), Italy (1), and never colonized (1).[12] I then use the former colonizer's time-varying share of the world market for private, piped water (ignoring contracts covering African countries) as an instrument for PSP in the African country.

Some brief words on African colonization are in order. By the mid-1870s, Europe had only established a few coastal trading posts in Africa, and the colonies of Algeria and South Africa. However, as Pakenham describes: "Suddenly, in half a generation, the Scramble gave Europeans virtually the whole continent: including thirty new colonies and protectorates, 10 million square miles of new territory, and 110 million dazed new subjects, acquired by one method or another. Africa was sliced up like a cake, the pieces swallowed by five rival nations—Germany, Italy, Portugal, France, and Britain" (1991 xxi). Under colonial rule, legal systems were imposed and Africans were taxed to fuel the colonizer's empire. Africans were also exposed to the languages and religions of their colonizers. By the mid 1960's, the majority of African countries had declared independence. However, many African countries still share a special relationship with their former colonizer, as they are linked by language, legal customs, and conventions. Piped water PSP arrangements in Africa typically involve large multinational firms, and frequently involve a company from the former colonizer country—likely because of advantages conferred by these commonalities, which make former colonies relatively receptive customers.

The number of customers a multinational water firm serves can expand merely due to population growth in the countries in which it has PSP arrangements. However, growth in its market share indicates expansion relative to other firms and relative to the global prevalence of PSP in water (which is itself captured by year fixed effects). As a former colonizer's non-African water market share grows, its firms are actively expanding their capacity outside of Africa, and are thus more likely to aggressively pursue new contracts in Africa.

The market share of each colonizer changes over time, as shown in Figure 3.2. The UK's share has declined over the last 20 years, France's share has increased, and the shares held by countries other than the UK, France, Germany, Italy, and Portugal have also increased markedly. The decline in the UK's share is not due to a reduction in the number of private water customers of UK firms; indeed, these increased by 15 percent during 1990–2010. Instead, it is due to UK companies' failure to keep pace with expansions in France and other countries. For example, France added 21 times more private water customers during 1990–2010 than did the UK, primarily through contracts signed by its largest three firms: Suez, Veolia, and SAUR. Italy and Germany's shares are both relatively small, and peaked in the early 2000s. Portugal and Belgium have been largely absent from this market.

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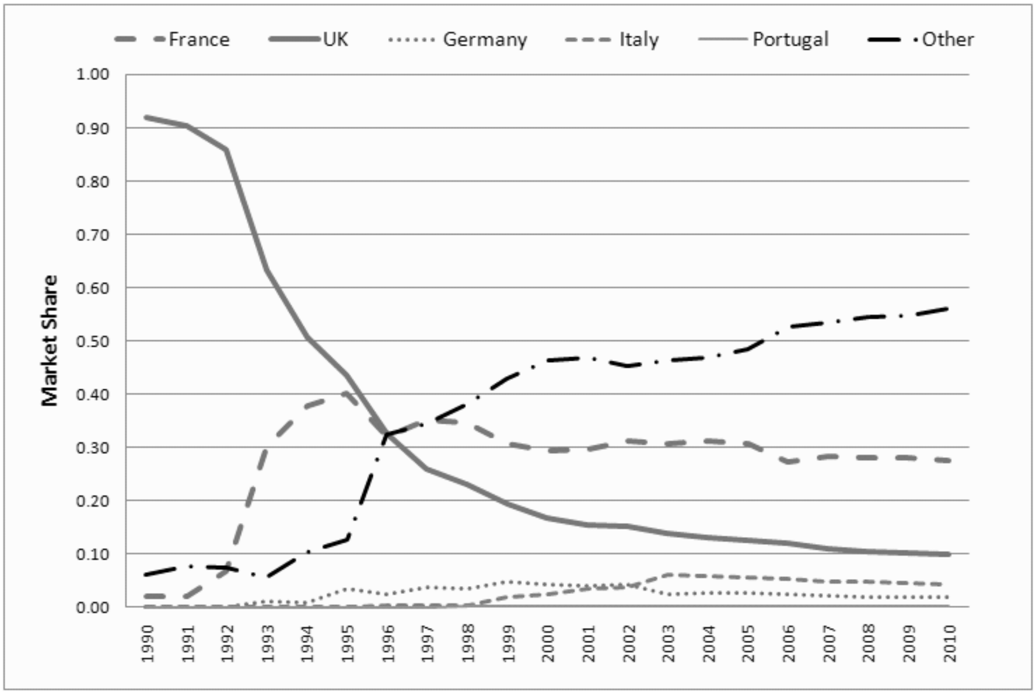
[10] In year 9, it increases slightly. 9 years is the 95th percentile of years under PSP.

[11] It is decreasing monotonically for the first six years.

[12] Liberia is classified as never colonized.

Figure 3.2—Market shares of selected countries in the private, non-African world water market, 1990–2010



Source: Pinsent Masons (1999–2011) and Envisager Limited (2011). Envisager Limited is an independent water and wastewater market analysis firm.

Note: Market shares are based on the country's share of total private water connections (taps) located in countries outside of the African continent. The connections (taps) of all companies headquartered in a given country are said to pertain to that country. The category "Other" includes any country other than these five European countries (even African countries) whose companies have contracts outside of Africa.

Naturally, we might expect the effects of the former colonizer's water market share to have heterogenous impacts in different African country contexts. A number of studies describe how privatization is influenced by the local socio-political context. For example, Kaufmann and Siegelbaum (1996) show that "spontaneous privatization" occurred in especially corrupt environments during the transition in Eastern European, with private firms successfully diverting state assets. Clarke and Cull (1998) show that bank privatizations in Argentina are more likely in times of fiscal and economic crisis, when the costs of raising money through taxes are relatively high. And Galiani et al. (2005) show that larger and poorer municipalities were more likely to privatize water in Argentina, as were those run by Peronists rather than by the Radical Opposition. As such, I explicitly allow the former colonizer's market share to have differential impacts in different county contexts by including a second instrument: the interaction of the former colonizer's water market share with the (time-invariant) average level of political stability in the African country.

I estimate the following first stage equation, where p_{jt} is a dummy for PSP in subnational region j, in year t:

$$p_{jt} = \theta m_{jt} + \pi m_{jt} \times s_j + \eta \mathbf{X_{ijkt}} + \rho_j + \tau_k + \mu_t + \varepsilon_{ijkt} \qquad (2)$$

m_{jt} is the water market share of the European colonizer of subnational region j in year t and s_j is the 1996 level of political stability of the country in which subnational region j is situated. ρ_j are subnational region fixed effects, τ_k are month fixed effects, and μ_t are year fixed effects. $\mathbf{X_{ijkt}}$ is a vector of child characteristics, as previously defined.

To further ensure that the results are not driven by a correlation of PSP or colonizer water market shares with foreign aid or investment, I control for several African country-level variables: (i) net inflows of foreign direct investment (FDI), (ii) net official flows from all UN agencies, (iii) official development assistance (ODA) from the former colonizer country—all in 1000s of constant 2000 USD per capita—and (iv) the average annual amount of World Bank water and sewerage sector loans and grants over the previous five years (in constant 2000 USD per capita). Shortly, I show that their inclusion has little effect on the sign, magnitude, or significance of δ in Equation 1.

Data

The analysis uses an unbalanced, pseudo-panel dataset that spans 1986–2010 and includes samples of under-five children from 39 African countries. An observation is a child, described by his country and subnational region of residence, and the month and year he is surveyed. Children are not followed over time. There are between one and seven years of data from each subnational region. Data come from several sources, matched at the subnational or national level.

The primary data source is a set of 99 Demographic and Health Surveys (DHS) conducted in Africa during 1986–2010. This is the universe of publicly-available and useable, standard DHS surveys from Africa.[13] They cover 39 countries—33 of which have data from multiple years.[14] I combined the data into a single, child-level dataset. These children come from 372 different subnational regions. Throughout the paper, I cluster standard errors at the subnational region level, as PSP varies at this level.

DHS datasets are a leading source of information about health and nutrition. They collect data on household member characteristics (age, education level, marital status, household size, minutes to get to a water source and return, and whether children under age five experienced diarrhea, a cough, or a cough with short and rapid breaths in the last two weeks),[15] household characteristics (whether there is a natural floor, electricity, a flush toilet, and piped water being used as the primary water source), and assets owned (including a refrigerator, radio, television, bicycle, motorcycle, and car). A household is coded as having piped water if the primary source of drinking water comes from a pipe—whether in the home or a public standpipe.[16] Appendix Table A.2 shows the countries, subnational regions, and years for which data are available.[17]

[13] I drop only two publicly available standard DHS surveys from Africa: the 1988 Egypt survey, as there was not a variable describing whether children experienced diarrhea in the previous two weeks, and the 1999 Senegal survey, as only raw data were available.

[14] The six countries for which I have one year of data are: Burundi, Comoros, Democratic Republic of the Congo, Republic of the Congo, Sierra Leone, South Africa, and Tunisia.

[15] Data on other symptoms of acute respiratory illness were not available consistently across DHS.

[16] Since Jalan and Ravallion (2003) find that the impact of piped water on the prevalence of diarrhea is largely unaffected by whether a household obtains piped water from an in-home tap versus a public tap (standpipe), I do not differentiate between the two.

[17] In a few countries, the subnational regions identified in the DHS vary over time. To address such inconsistencies, I aimed to maximize the length of the panel and still ensure that the same code never refers to two different (even if quite similar) entities in different years. When two subnational regions are given separate codes in one year, but are lumped together (that is, identified by a single code) in another year, I recoded the data to lump them together in all years. For the vast majority of countries with inconsistent subnational region coding over time, this was sufficient to create a harmonized set of subnational region identifiers. When a simple recoding could not be used to construct comparable subnational regions over time, I simply allowed each region to carry a unique code, which resulted in fewer observations for each region. All coding is available on request.

PSP arrangements in water usually affect only urban areas, so I exclude rural-dwelling children from the sample. Among urban-dwelling children under age five in the 99 DHS datasets, about 35 percent live in capitals or large cities, 35 percent live in small cities, and 30 percent live in towns.

The health outcome studied is a dummy for a child's experiencing diarrhea at some point during the previous two weeks.[18] This variable captures, in some sense, both the extensive and the intensive margins of diarrhea. When diarrhea is more intensive, it is present longer. This makes a child more likely to show symptoms of diarrhea on the day he or she is surveyed.

Several sources were cross-referenced to construct a subnational database on locations of PSP in water: Pinsent Masons World Water Year Books (1999–2011), Envisager Limited (2011), World Bank's (2010) Private Participation in Infrastructure (PPI) Database (2010), Hall, Bayliss, and Lobina (2002), and Lexis Nexis Academic (2011). Appendix Table A.4 summarizes these PSP arrangements. In many cases, a subnational region's water sector has always been publicly operated. In several cases, PSP occurred at the national level, affecting all urban water networks. In other cases, PSP affects only select subnational regions or occasionally only select cities in a region. This information is used to code a dummy for PSP in each subnational region year.[19]

Envisager Limited (2011) also provided a database of all PSP contracts in the water sector, worldwide, from 1985–2010.[20] It reports the country of the company awarded the contract, the country in which the project took place, and the number of customers (water taps) served by each contract. These data were used to compute the annual market shares of each European colonizer in the world (non-African) private water market from 1986–2010.

Data also come from several World Bank databases. First, from the World Development Indicators (WDI) databank, I gathered data on per capita net inflows of FDI, net official flows from all UN agencies, and ODA (World Bank 2011a). Second, from a listing of all World Bank water and sewerage sector grants and loans, I computed the average annual amount of sector funding given to each African country over the previous five years (World Bank 2011b).[21] Finally, I gathered data on political stability by country, collected by Kauffmann, Kraay, and Mastuzzi for the Worldwide Governance Indicators (WGI) Project (World Bank 2011c). They have a global index of political stability covering 1996–2009. I use the 1996 value of this index as an indicator of average political stability in each African country.

Table 3.1 summarizes the means and standard deviations of key variables. The average urban household has electricity, a non-natural floor, piped water, and a radio, but no flush toilet, television, bicycle, motorcycle, or car. About 16 percent of under-five children experienced diarrhea in the last two weeks. Diarrhea is most common among the children of less-educated mothers and those with fewer assets and amenities. Among children whose mothers have no education, 18 percent experienced diarrhea in the last two weeks; among those whose mothers have secondary or more education, only 13 percent experienced diarrhea (almost 30 percent less diarrhea). About 29 percent of under-five children experienced a cough in the last two weeks, and 12 percent experienced a cough with short, rapid breaths. Of the regions and years covered by the DHS, about 29 percent are marked by a PSP arrangement, and the average length of time under PSP is 2.7 years.

[18]This is the outcome studied by Gunther and Fink (2010). This measure was used because the causes and consequences of diarrhea are well known and because data on the prevalence of water-borne diseases and on mortality from them are nonexistent for most African countries.

[19]A subnational region is coded as being under PSP if its largest city is under PSP. In most cases, all cities in a subnational region either are or are not under PSP.

[20]Only contracts serving 10,000 or more, with at least five years' duration, are included.

[21]I used aid listed under major sector: General Water, Sanitation, & Flood Protection.

Table 3.1—Summary statistics

Variable	Mean	S.D.
Dummy - child experienced diarrhea during last two weeks	0.160	0.367
Dummy - diarrhea last two weeks (mom - no education)	0.180	0.384
Dummy - diarrhea last two weeks (mom - primary educ or less)	0.178	0.383
Dummy - diarrhea last two weeks (mom - primary educ)	0.177	0.381
Dummy - diarrhea last two weeks (mom - primary + educ)	0.151	0.358
Dummy - diarrhea last two weeks (mom - secondary + educ)	0.128	0.334
Dummy - diarrhea last two weeks (1st quartile - poverty index)	0.199	0.399
Dummy - diarrhea last two weeks (2nd quartile - poverty index)	0.174	0.379
Dummy - diarrhea last two weeks (3rd quartile - poverty index)	0.145	0.352
Dummy - diarrhea last two weeks (top quartile - poverty index)	0.121	0.326
Dummy - child had a cough during the last two weeks	0.287	0.452
Dummy - child had cough w/ short, rapid breaths, last two weeks	0.123	0.329
Dummy - PSP in water	0.289	0.453
Years under a PSP contract	2.666	7.369
Non-African water market share of final colonizer	0.282	0.247
Non-African water market share of original colonizer	0.264	0.248
1996 World Governance Indicators political stability score	-0.606	0.815
Dummy - child is a boy	0.504	0.500
Number of household members	7.470	4.671
Dummy - parents are married	0.767	0.423
Mother's age	28.571	6.590
Dummy - mother has no education	0.311	0.463
Dummy - mother has primary education	0.324	0.468
Dummy - secondary or more education	0.365	0.481
Dummy - HH has electricity	0.544	0.498
Dummy - HH has a radio	0.762	0.426
Dummy - HH has a television	0.463	0.499
Dummy - HH has a refrigerator	0.298	0.458
Dummy - HH has a bicycle	0.212	0.409
Dummy - HH has a motorcycle	0.131	0.337
Dummy - HH has a car	0.102	0.302
Dummy - HH has a natural floor	0.225	0.418
Dummy - HH has piped water	0.701	0.458
Dummy - HH has a flush toilet	0.315	0.464
Minutes spent collecting water	5.277	17.830
World Bank water grants/ loans per capita (constant 2000 US dollars)	0.100	0.108
Net United Nations aid per capita	0.022	0.026
Foreign direct investment (net inflows) per capita	0.192	0.327
Official development assistance from final colonizer per capita	0.129	0.361

Source: DHS (1986–2010), Pinsent Masons (1999–2011), Envisager Limited (2011), World Bank WDI (2011), and World Bank (2011a, 2011b, and 2011c).

Note: Data are summarized for all urban households from 1986-2010 (N=165,543). PSP is private sector participation. Unless otherwise indicated, all per capita values are in 100s of constant 2000 U.S. dollars.

4. RESULTS

OLS Results

Table 4.1 presents OLS estimates of the effect of PSP in water on diarrhea in under-five children. The results suggest that PSP has a robust, negative effect on diarrhea ($\delta < 0$). All specifications include both subnational region and year fixed effects, and other controls are introduced sequentially. The coefficient on PSP, δ, varies little with the inclusion of controls. PSP is always associated with a prevalence of diarrhea that is between 2.2 and 2.6 percentage points lower, which implies a 14–16 percent drop in its mean prevalence. The findings on the effects of PSP are always significant at the 5 percent level or higher.

That the coefficient on PSP varies little when I add child, mother, household, and country level controls offers initial evidence that omitted variables alone do not drive the results. Altonji, Elder, and Taber (2005) and Bellows and Miguel (2009) propose—for a nonlinear and for a linear model, respectively—a way of assessing omitted variable bias by measuring the ratio of selection on unobservables to selection on observables that would be required if the entire effect of the endogenous regressor were due to omitted variable bias. Following Bellows and Miguel (2009), I use the change in the coefficient on PSP following the addition of controls to estimate the relative importance of the omitted variables required to explain away the entire effect of PSP. Comparing specifications 1 and 4 in Table 4.1, I find that selection on unobservables would have to be 8.67 times greater than selection on observables to itself account for the entire effect of PSP.[22] The addition of other controls is thus unlikely to eliminate the relationship between PSP and child diarrhea.

The signs on the control variables are generally intuitive. Having more assets and amenities is associated with significantly less diarrhea, as is having a mother with secondary education or more. Girls and children of married parents experience less diarrhea. World Bank water and sewerage sector grants and loans, inflows of FDI, and ODA from the former colonizer do not have a statistically significant impact on the prevalence of diarrhea.

[22]Following Bellows and Miguel (2009), the ratio is computed as follows (where C denotes "controls," and NC denotes "no controls"):

$$\frac{\hat{\delta}_{OLS,C}}{\hat{\delta}_{OLS,NC} - \hat{\delta}_{OLS,C}} = \frac{-0.026}{-0.023 + 0.026} = 8.67$$

Table 4.1—Ordinary least squares results, showing the effect of private sector participation (PSP) in water on the prevalence of diarrhea in under-five children

Dependent Variable: Dummy - child experienced diarrhea during last two weeks	(1)	(2)	(3)	(4)
Dummy - PSP in water	-0.023	-0.022	-0.022	-0.026
	[0.010]**	[0.010]**	[0.010]**	[0.010]***
Dummy - child is a boy		0.010	0.010	0.010
		[0.002]***	[0.002]***	[0.002]***
Dummy - parents are married		-0.015	-0.010	-0.010
		[0.004]***	[0.004]***	[0.004]***
Dummy - mother has primary education			0.007	0.007
			[0.004]*	[0.004]*
Dummy - secondary or more education			-0.014	-0.014
			[0.004]***	[0.004]***
Dummy - HH has electricity			-0.012	-0.012
			[0.004]***	[0.004]***
Dummy - HH has a radio			-0.013	-0.013
			[0.003]***	[0.003]***
Dummy - HH has a television			-0.011	-0.011
			[0.003]***	[0.003]***
Dummy - HH has a refrigerator			-0.010	-0.010
			[0.004]***	[0.004]***
Dummy - HH has a bicycle			-0.002	-0.002
			[0.003]	[0.003]
Dummy - HH has a motorcycle			0.001	0.001
			[0.004]	[0.004]
Dummy - HH has a car			-0.004	-0.004
			[0.004]	[0.004]
Dummy - HH has a natural floor			0.015	0.015
			[0.004]***	[0.004]***
World Bank water grants/ loans per capita				0.044
				[0.028]
Net United Nations aid per capita				0.266
				[0.096]***
FDI (net inflows) per capita				0.022
				[0.018]
ODA from former colonizer per capita				0.008
				[0.030]
Observations	160,342	160,342	160,342	160,342
R-squared	0.03	0.06	0.07	0.07
Mother's age and HH size dummies?	No	Yes	Yes	Yes

Source: Author's calculations based on data from Demographic and Health Surveys (1986–2010), Pinsent Masons (1999–2011), Envisager Limited (2011), World Bank (2011a, 2011b, and 2011c).

Note: Robust standard errors are in brackets and are clustered at the subnational region level. All specifications include subnational region, month, and year fixed effects. Age dummies are for both mother and child. World Bank water and sewerage sector loans and grants is the total over the previous five years in constant 2000 US dollars per capita. Net United Nations aid is total received from any United Nations agency, in 100s of constant 2000 US dollars per capita. FDI (net inflows) is foreign direct investment in 100s of constant 2000 US dollars per capita. ODA is official development assistance from the country's final colonizer, in 100s of constant 2000 US dollars per capita. *** indicates p<.01; ** indicates p<.05; * indicates p<.10.

IV First-Stage Results

Table 4.2 presents estimates of the first stage regression using a linear probability model. All specifications include subnational region, month, and year fixed effects. The market share of a country's former colonizer in the non-African water market is robustly positively correlated with PSP in the water sector of the former colony, and this relationship is especially strong in African countries with low levels of average political stability (using the 1996 value).

Column 4 uses only one excluded instrument (the market share), and indicates that a former colonizer having an additional 10 percent of the non-African water market increases the probability of PSP in the African country by 4.4 percentage points. The F-statistic on the excluded instrument is 12.93, which is not low but may nonetheless signal a weak instrument (Stock and Yogo 2002). Column 8 flexibly allows the former colonizer's market share to have heterogenous impacts in different African country contexts (specifically, at different levels of political stability). It indicates that if political stability is at the 25th percentile (relatively unstable),[23] then having an additional 10 percent of the market increases the probability of PSP by 5.9 percentage points. However, if political stability is at the 75th percentile (relatively stable),[24] then having an additional 10 percent of the market increases the probability of PSP by only 1.5 percentage points.[25] The F-statistic on the excluded instruments in this specification is 40.93, making weak instruments very unlikely. That the first stage is much stronger when taking into account political stability in the African country suggests that the market share instrument has a truly heterogenous impact on PSP in different country contexts.

While an African country's level of political stability may directly affect the prevalence of diarrhea, its 1996 level is swept up in the subnational region fixed effects. As such, it only appears in the regression in interaction. One can think of political stability as a slow-moving characteristic of an African country whose 'average' value is captured in some sense by the 1996 value.[26]

[23] Countries in the sample at the bottom quartile of political stability in 1996 include: Burundi, Cameroon, Democratic Republic of the Congo, Guinea, Liberia, Nigeria, Rwanda, Sierra Leone, South Africa, and Sudan.

[24] Countries at the top quartile of political stability are: Benin, Comoros, Ivory Coast, Lesotho, Madagascar, Mali, Namibia, Sao Tome and Principe, Swaziland, and Tunisia.

[25] The 25th percentile of political stability is -0.962 and the 75th percentile is -0.031. $0.59 = 0.131 + -0.477 \times -0.962$, and $0.15 = 0.131 + -0.477 \times -0.031$

[26] Using different WGI indices other than political stability that also describe the quality of governance in a country—including voice and accountability, government effectiveness, regulatory quality, rule of law, and control of corruption—leads to similar first stage results.

Table 4.2—Instrumental variables first stage results, showing the effect of the non-African world water market share of the former colonizer country on private sector participation (PSP) in the African country

Dependent Variable: Dummy - PSP in water	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Market share of former colonizer	0.486	0.486	0.485	0.444	0.159	0.159	0.159	0.131
	[0.111]***	[0.111]***	[0.111]***	[0.123]***	[0.138]	[0.138]	[0.138]	[0.146]
Market share × 1996 political stability (African country)					-0.497	-0.497	-0.498	-0.477
					[0.096]***	[0.096]***	[0.096]***	[0.097]***
Dummy - mother has primary education			0.001	-0.000			0.001	0.001
			[0.004]	[0.003]			[0.003]	[0.003]
Dummy - secondary or more education			0.003	0.003			0.004	0.004
			[0.005]	[0.004]			[0.004]	[0.004]
Dummy - HH has electricity			0.003	0.009			-0.004	0.002
			[0.008]	[0.008]			[0.007]	[0.007]
Dummy - HH has a radio			0.002	0.003			0.003	0.004
			[0.003]	[0.003]			[0.003]	[0.003]
Dummy - HH has a television			0.009	0.004			0.008	0.004
			[0.005]*	[0.005]			[0.005]*	[0.005]
Dummy - HH has a refrigerator			-0.002	0.001			-0.003	0.001
			[0.004]	[0.004]			[0.004]	[0.004]
Dummy - HH has a bicycle			-0.001	-0.001			-0.004	-0.004
			[0.004]	[0.004]			[0.004]	[0.004]
Dummy - HH has a motorcycle			-0.007	-0.008			-0.004	-0.005
			[0.004]*	[0.003]**			[0.004]	[0.003]
Dummy - HH has a car			0.001	0.002			0.006	0.006
			[0.004]	[0.004]			[0.004]	[0.004]*
Dummy - HH has a natural floor			0.015	0.015			0.014	0.014
			[0.006]**	[0.006]**			[0.006]**	[0.005]**
World Bank water grants/ loans per capita				0.918				0.854
				[0.306]***				[0.283]***
Net United Nations aid per capita				0.856				1.393
				[0.680]				[0.703]**
FDI (net inflows) per capita				-0.148				-0.148
				[0.079]*				[0.076]*
ODA from former colonizer per capita				0.046				0.121
				[0.209]				[0.185]
Observations	160,342	160,342	160,342	160,342	160,342	160,342	160,342	160,342
R-squared	0.37	0.37	0.37	0.43	0.40	0.40	0.40	0.46
F Stat, excluded instrument(s)	19.04	19.02	18.98	12.93	55.72	55.65	56.19	40.93
Dummies - age, marital status, # HH members	No	Yes	Yes	Yes	No	Yes	Yes	Yes

Source: Author's calculations based on data from Demographic and Health Surveys (1986–2010), Pinsent Masons (1999–2011), Envisager Limited (2011), World Bank (2011a, 2011b, and 2011c).

Note: Robust standard errors are in brackets and are clustered at the subnational region level. All specifications include subnational region, month, and year fixed effects. Age dummies are a vector of mother and child age, and marital status pertains to the child's parents. World Bank water and sewerage sector loans and grants is the total over the previous five years in constant 2000 US dollars per capita. Net United Nations aid is total received from any United Nations agency, in 100s of USD per capita. FDI (net inflows) is foreign direct investment in 100s of USD per capita. ODA is official development assistance from the country's final colonizer, in 100s of constant 2000 US dollars per capita. *** indicates p<.01; ** indicates p<.05; * indicates p<.10.

IV Second-Stage Results

Table 4.3 presents IV estimates of the effect of PSP in water on diarrhea in under-five children. All specifications include subnational region, month, and year fixed effects. Columns 1-4 show results that use only one excluded instrument—the market share of the former colonizer—and Columns 5-8 show results that use the two excluded instruments (the market share and its interaction with political stability). In all specifications, the IV results suggest that PSP has a negative, statistically significant effect on diarrhea. In the baseline specification of Column 8—which includes all controls and is least likely to suffer from problems of weak instruments—PSP reduces the prevalence of diarrhea by 5.6 percentage points, or 35 percent of its mean value. I interpret this as the local average treatment effect of PSP on child diarrhea. This effect is twice as large as that implied by the OLS estimates and is statistically significant at the 1 percent level. The coefficients on the other regressors are similar in sign, magnitude, and statistical significance to their OLS counterparts.

The OLS estimates of δ are sufficiently different from the IV estimates to suggest bias. That the OLS estimates are smaller in magnitude than the IV estimates is consistent with the timing of PSP coinciding with declines in child health driven by time-varying, unobserved covariates.

Among localities under PSP, the prevalence of diarrhea is also decreasing in total years under PSP, as shown in Table A.5. Column 1 presents an IV estimate of the effect of logged years under a PSP contract on the prevalence of diarrhea. The F-Statistic on the excluded instruments from the first stage regression is 24.59, revealing that the instruments strongly predict not only whether PSP occurs, but also the number of years it has been in place. I find that doubling the number of years under a PSP contract (such as in going from 1 to 2 years, or 2 to 4 years) is associated with a 7.2 percentage point reduction in the prevalence of diarrhea. This result is significant at the 5 percent level. It suggests that not all of the diarrhea-reducing benefits of PSP are conferred immediately, but instead they intensify over time.

A natural question is whether the results are largely driven by a few capital cities to whom the benefits of PSP disproportionately accrue. To explore this, I excluded the 35 percent of urban-dwelling children who live in capital and large cities and present the IV estimates in Column 2 of Table A.5. In smaller cities as in larger cities, PSP is associated with a reduction in diarrhea that is statistically significant at the 1 percent level. It is also within the 95 percent confident interval around the baseline estimate of Table 4.3, Column 8.[27]

Another question is whether France and the UK—the two most active countries in the private water market—are driving the results. Column 3 of Table A.5 presents an IV estimate using only data on France and the UK. The point estimate is now smaller in magnitude (PSP leads to a 4.7 percentage point reduction in diarrhea, which is 29 percent of its mean prevalence), though it is not statistically significantly different from the baseline estimate.

[27]The average prevalence of child diarrhea is the same (16 percent) in both types of cities.

Table 4.3—Instrumental variables results, showing the effect of private sector participation (PSP) in water on the prevalence of diarrhea in under-five children

Dependent Variable: Dummy - child experienced diarrhea during last two weeks	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV: Water market share of former colonizer				IVs: Market share, Share × political stability			
Dummy - PSP in water	-0.071	-0.063	-0.069	-0.085	-0.057	-0.050	-0.051	-0.056
	[0.035]**	[0.032]**	[0.033]**	[0.036]**	[0.021]***	[0.021]**	[0.021]**	[0.021]***
Dummy - mother has primary education			0.007	0.007			0.007	0.007
			[0.004]*	[0.004]*			[0.004]*	[0.004]*
Dummy - secondary or more education			-0.014	-0.014			-0.014	-0.014
			[0.004]***	[0.004]***			[0.004]***	[0.004]***
Dummy - HH has electricity			-0.012	-0.012			-0.012	-0.012
			[0.004]***	[0.004]***			[0.004]***	[0.004]***
Dummy - HH has a radio			-0.014	-0.013			-0.014	-0.013
			[0.003]***	[0.003]***			[0.003]***	[0.003]***
Dummy - HH has a television			-0.011	-0.011			-0.011	-0.011
			[0.003]***	[0.003]***			[0.003]***	[0.003]***
Dummy - HH has a refrigerator			-0.010	-0.010			-0.010	-0.010
			[0.004]***	[0.004]***			[0.004]***	[0.004]***
Dummy - HH has a bicycle			-0.002	-0.002			-0.002	-0.002
			[0.003]	[0.003]			[0.003]	[0.003]
Dummy - HH has a motorcycle			0.000	0.000			0.000	0.000
			[0.004]	[0.004]			[0.004]	[0.004]
Dummy - HH has a car			-0.004	-0.004			-0.004	-0.004
			[0.004]	[0.004]			[0.004]	[0.004]
Dummy - HH has a natural floor			0.016	0.016			0.016	0.016
			[0.004]***	[0.004]***			[0.004]***	[0.004]***
World Bank water grants/ loans per capita				0.104				0.075
				[0.045]**				[0.034]**
Net United Nations aid per capita				0.346				0.307
				[0.120]***				[0.106]***
FDI (net inflows) per capita				0.012				0.017
				[0.020]				[0.018]
ODA from former colonizer per capita				-0.001				0.004
				[0.033]				[0.031]
Observations	160,342	160,342	160,342	160,342	160,342	160,342	160,342	160,342
Dummies - age, marital status, # HH members	No	Yes	Yes	Yes	No	Yes	Yes	Yes

Source: Author's calculations based on data from Demographic and Health Surveys (1986–2010), Pinsent Masons (1999–2011), Envisager Limited (2011), World Bank (2011a, 2011b, and 2011c).

Note: Robust standard errors are in brackets and are clustered at the subnational region level. All specifications include subnational region, month, and year fixed effects. Age dummies are a vector of mother and child age, and marital status pertains to the child's parents. World Bank water and sewerage sector loans and grants is the total over the previous five years in constant 2000 US dollars per capita. Net United Nations aid is total received from any United Nations agency, in 100s of constant 2000 US dollars per capita. FDI (net inflows) is foreign direct investment in 100s of constant 2000 US dollars per capita. Excluded instruments used are indicated above the column. ODA is official development assistance from the country's final colonizer, in 100s of constant 2000 US dollars per capita. *** indicates p<.01; ** indicates p<.05; * indicates p<.10.

Robustness

A potential concern is that the colonizer's non-African water market share is correlated with unobserved, time-varying features of business activity in the African country that tend to promote child health. This would violate the exclusion restriction. If it were driving the results, we might expect PSP to have a smaller effect on diarrhea when we consider the country's *initial* colonizer instead of its final colonizer. In African countries for which the initial and final colonizers differ (see Table A.1 for a listing), linkages of any kind between the two countries are likely to be weaker for the initial colonizer than for the final colonizer. Table A.5, Column 4 presents IV results using the initial colonizer. Now, the point estimate indicates a slightly larger, 6.0 percentage point reduction in diarrhea (though this is not statistically significantly different from the 5.6 percentage point reduction in the baseline). This is evidence against this particular form of violation of the exclusion restriction.

Another concern is that African countries in different regions (that is, West, East, South, North, and Central Africa), or at different initial levels of access to piped water, are on different time trends with respect to child health. Columns 5 and 6 of Table A.5 estimate variants of the baseline specification that include region- and initial piped water access-specific time trends, respectively. In both cases, PSP in water continues to reduce diarrhea, and this finding remains significant at the 1 percent level. Inclusion of region-specific time trends suggests that PSP is associated with a larger, 9.3 percentage point reduction in the prevalence of diarrhea. Inclusion of a time trend interacted with initial access to piped water suggests that PSP is associated with a smaller, 5.1 percentage point reduction in the prevalence of diarrhea. Neither estimate is statistically significantly different from the baseline estimate.

As a final set of robustness checks, I estimate specifications with: a) month-by-year dummies, b) standard errors clustered at the country level, and c) standard errors clustered at the colonizer level. These appear in Columns 7, 8, and 9 of Table A.5, respectively. Each of these specifications presents some concerns of weak instruments (first stage F-Statistics on the excluded instruments are 17, 13, and 16, respectively). However, PSP is always associated with a reduction in diarrhea within the 95 percent confidence interval of the baseline estimate, and which is statistically significant at the 5 percent level or higher.

Results by Family's Poverty Level

Table 4.4, panel A, shows how the IV results vary according to the education level of the child's mother. Panel B shows how they vary according to the quartile in which the family falls on a poverty index. Each specification includes subnational region, month, and year fixed effects and the full set of control variables included in previous specifications (except the asset and amenity controls). The poverty index is the first principal component of a principal components analysis involving 10 variables: dummies for having electricity, a radio, a television, a refrigerator, a bicycle, a motorcycle, a car, and a non-natural floor as well as dummies for the mother's having at least primary education and at least secondary education. The first principal component explains 31 percent of the variation in these variables, with an eigenvalue of 3.1.

Table 4.4—Instrumental variables results, showing how the effect of private sector participation (PSP) in water on the prevalence of diarrhea in under-five children varies with the mother's education and a household poverty index

Dependent Variable: Dummy - child experienced diarrhea during last two weeks

	(1)	(2)	(3)	(4)	(5)
Panel A: Mother's education level					
	none (47%)	primary or less (81%)	primary (34%)	primary or more (53%)	secondary or more (19%)
Dummy - PSP in water	-0.048	-0.074	-0.083	-0.053	-0.017
	[0.040]	[0.025]***	[0.027]***	[0.023]**	[0.022]
Observations	50,221	101,880	51,648	110,110	58,457
Number of subnational regions	352	372	372	372	367
F Stat, excluded instruments	16.41	40.87	39.98	32.40	29.84
Panel B: Quartile of poverty index					
	Bottom	2nd	3rd	Top	
Dummy - PSP in water	-0.146	-0.054	-0.035	-0.015	
	[0.041]***	[0.033]*	[0.024]	[0.024]	
Observations	42,458	38,443	39,190	40,222	
Number of subnational regions	357	367	357	333	
F Stat, excluded instruments	25.48	62.42	56.28	43.04	

Source: Author's calculations based on data from Demographic and Health Surveys (1986–2010), Pinsent Masons (1999–2011), Envisager Limited (2011), World Bank (2011a, 2011b, and 2011c).

Note: Robust standard errors are in brackets and are clustered at the subnational region level. All specifications include subnational region, month, and year fixed effects, as well as dummies for the mother's age, the child's age, and the # of household members, and controls for the parents' marital status, child's gender, World Bank water and sewerage sector loans and grants, total United Nations aid received, and FDI (net inflows), and official development assistance from the African country's former colonizer. Poverty Index is the first principal component of a principal components analysis that takes into account a dummy for the mother having primary or more education, a dummy for the mother having secondary or more education, and dummies for having electricity, a radio, a television, a refrigerator, a bicycle, a motorcycle, a car, and a non-natural floor. In all specifications, the market share of the African country's former colonizer in the non-African world water market, and its interaction with the African country's 1996 political stability index, are the excluded instruments. *** indicates p<.01; ** indicates p<.05; * indicates p<.10.

PSP reduces diarrhea most among children whose mothers have primary education (as opposed to no education or secondary and higher education). For these children, the introduction of PSP lowers the prevalence of diarrhea by 8.3 percentage points, and the effect is significant at the 1 percent level. This is a 47 percent drop in this group's mean prevalence of diarrhea. For the group with no education, diarrhea drops by only 4.8 percentage points (27 percent of the group's mean prevalence), and the effect is insignificant at conventional levels. Similarly, for the group with secondary and more education, diarrhea drops by only 1.7 percentage points (13 percent of the group's mean prevalence), and the effect is also insignificant. The IV results appear to be driven largely by benefits accruing to families of moderately educated (primary school only) mothers. Also, PSP offers the smallest health benefits to children of the most-educated mothers. It may be that highly educated mothers are always sufficiently rich and aware of health risks that they can protect children and provide them clean water. Also, uneducated mothers may have income constraints that prevent them from taking advantage of new or better infrastructure.

PSP reduces diarrhea most among children from the poorest households on the poverty index.[28] The diarrhea-reducing benefits of PSP decline monotonically in quartile of poverty. At the bottom, second, third, and top quartiles of poverty, PSP reduces diarrhea by 14.6, 5.4, 3.5, and 1.5 percentage points, respectively. Given each quartile's mean prevalence of diarrhea, this implies a drop of 73 percent, 31 percent, 24 percent, and 12 percent, respectively.[29] However, although the results for the bottom quartile are significant at the 1 percent level, the results decline in statistical significance for higher quartiles of poverty. For the second and third quartiles, they are significant at the 10 percent and 15 percent levels, respectively, and for the top poverty quintile, they are not statistically significant at conventional levels. PSP in water thus improves health the most for the poor.

Placebo Tests: Respiratory Illness and Rural Areas

A possible concern is that the excluded instrument is correlated with some time-varying factor (such as development assistance or foreign direct investment in the former colony) that itself improves health. Then, PSP might spuriously appear to reduce diarrhea. I explore this possibility in two ways.

As a first placebo test, I consider the health of the same set of children. However, I replace the dummy for experiencing diarrhea with a dummy that captures symptoms consistent with acute respiratory illness during the same two-week reference period: a) First, I use a dummy for experiencing an illness with a cough (28 percent of children experienced this); b) Next, I use a dummy for experiencing a cough as well as short, rapid breaths (12 percent of children experienced this). If the excluded instrument only affects child health by affecting the likelihood of PSP in water, then PSP should not affect these variables.

Table 4.5, Panel A presents results with the dummy for coughing, and Panel B presents results with the dummy for coughing with short, rapid breaths. In none of the IV specifications does PSP have a statistically significant effect on coughing. Additionally, the coefficient on PSP is generally positive and small; that is, if anything, PSP in water leads to a very slightly *higher* prevalence of coughing. These IV results are suggestive that the reduction in diarrhea associated with PSP is driven by changes in the water sector rather than by a correlation of PSP with other investments in health.

[28] Ideally, whether PSP has heterogeneous treatment effects on households at different income levels would be explored. However, the DHS generally does not include income data.

[29] The average of 73 percent, 31 percent, 24 percent, and 12 percent is 35 percent, which equals the baseline estimate.

Table 4.5—Instrumental variables results, showing the effect of private sector participation (PSP) in water on the prevalence of illness with a cough in under-five children

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS		IV: Colonizer market share		IVs: Share and Share × stability	
Panel A: Dummy - child experienced illness with a cough during last two weeks (mean=0.29)						
Dummy - PSP in water	0.041	0.026	0.003	-0.025	0.066	0.051
	[0.017]**	[0.019]	[0.070]	[0.087]	[0.042]	[0.044]
R-squared	0.06	0.07				
Panel B: Dummy - child experienced illness with a cough and short, rapid breaths during last two weeks (mean=0.12)						
Dummy - PSP in water	0.025	0.026	-0.003	-0.013	0.013	0.007
	[0.009]***	[0.009]***	[0.041]	[0.051]	[0.020]	[0.023]
R-squared	0.03	0.03				
Observations	151,926	151,926	151,926	151,926	151,926	151,926
Number of subnational regions	358	358	358	358	358	358
First Stage F-Statistic			17.77	11.18	58.69	37.19
Full set of child, HH, and country controls	No	Yes	No	Yes	No	Yes

Source: Author's calculations based on data from Demographic and Health Surveys (1986–2010), Pinsent Masons (1999–2011), Envisager Limited (2011), World Bank (2011a, 2011b, and 2011c).

Note: Robust standard errors are in brackets and are clustered at the subnational region level. All specifications include subnational region, month, and year fixed effects. The full set of child, household, and country controls includes the following: child age dummies, mother age dummies, marital status dummy for child's parents, World Bank water and sewerage sector loans and grants ver the previous five years, total aid received from any United Nations agency, FDI (net inflows), and official development assistance from the country's final colonizer. The excluded instruments used are indicated at the top of each column. *** indicates p<.01; ** indicates p<.05; * indicates p<.10. OLS = ordinary least squares and IV = instrumental variables. Colonizer market share is the African country's former colonizer's time-varying share of the world market for private, piped water (ignoring contracts covering African countries). Stability is the 1996 political stability score of the African country in the World Governance Indicators database.

Although always insignificant in the IV results, the coefficient on PSP is always positive and in some cases statistically significant in the OLS results. PSP would appear to increase coughing by up to 4.1 percentage points (a 14 percent increase over the mean rate) and to increase coughing with short, rapid breaths by up to 2.6 percentage points (a 21 percent increase over the mean rate). This is consistent with PSP's being correlated with time-varying, unobserved factors that harm child health, which would tend to downward bias OLS estimates of the health benefits of PSP. That this statistical significance disappears in the IV results that address endogeneity is encouraging.

As a second placebo test, I examine whether PSP has an impact on child diarrhea in rural areas. The PSP contracts (detailed in Appendix Table A.4) considered typically apply only to urban areas. For this reason I eliminated rural-dwelling children in each subnational region from the sample. If PSP had an apparent effect on diarrhea in rural children, this may be due to a correlation of PSP or the colonizer's water market share with other time-varying factors influencing child health.

Table A.5 presents estimates of the effect of PSP in water on the prevalence of diarrhea for rural children without piped water (Column 10) and all rural children (Column 11). In neither case does PSP have a statistically significant effect on the prevalence of diarrhea. Children in the same subnational regions who are not exposed to PSP do not see reductions in diarrhea.

5. POTENTIAL CAUSAL CHANNELS

A number of causal channels might explain the results. A private water provider can change the ease of getting a new connection (for example, waiting lists and hurdles), the price of water (and the tariff structure), water quality (for example, the presence of contaminants, the frequency of outages, and hours of water/day), and service quality (for example, the response time to correct outages or problems, and distributional fairness), among other factors. In this section, I show that PSP leads to higher rates of reliance on piped water as the primary water source, and less time spent collecting water. Also, PSP may be associated with greater access to flush toilets, though this finding is less robust.

Access to Piped Water

Access to piped water is defined as using piped water as the primary drinking water source. A household that always had a piped water tap in the home or a nearby public standpipe, but only recently started using it, is counted as gaining access to piped water. If consumers switch to piped water, revealed preference would suggest that the benefits outweigh the costs.

Table 5.1 reveals that PSP is associated with a 29.5 percentage point increase in access to piped water. This is a 42 percent increase over the mean rate of access. The result is significant at the 1 percent level and is a sizeable impact. It suggests that PSP lowers the prevalence of diarrhea at least in part by expanding usage of piped water. Separate estimates for children with mothers at different levels of education suggest that PSP leads to the greatest expansions among the most and the least educated mothers. PSP leads to a 32 percentage point increase in access to piped water among children whose mothers have no education, which is a 55 percent increase over the mean rate of access for this group. For children whose mothers have secondary or more education, PSP leads to a 34 percentage point increase in access to piped water, which is a 42 percent increase over this group's mean rate of access. Among children whose mothers have primary education, PSP leads to a 27 percentage point increase in access to piped water, which is a 40 percent increase over the group's mean.

Table 5.1—Instrumental variables results, showing the effect of private sector participation (PSP) in water on access to piped water, access to a flush toilet, and minutes spent collecting water

	Sub-sample mean of Dummy - PSP in water	Coefficient on Dummy - PSP in water	S.E. on Dummy - PSP in water	N	F Stat, excluded instruments
Panel A - Dependent Variable: Dummy - piped water in home					
OLS, full sample	0.701	0.097	[0.030]***	160,199	
IV, full sample	0.701	0.295	[0.068]***	160,199	40.84
IV, Mother has no education	0.587	0.320	[0.153]**	52,611	17.05
IV, Mother has primary or less education	0.638	0.302	[0.086]***	106,532	41.31
IV, Mother has primary education	0.686	0.274	[0.076]***	53,911	40.59
IV, Mother has primary or more education	0.752	0.329	[0.081]***	114,996	32.32
IV, Mother has secondary or more education	0.811	0.337	[0.090]***	61,081	29.86
Panel B - Dependent Variable: Dummy - flush toilet in home					
OLS, full sample	0.315	0.045	[0.015]***	160,236	
IV, full sample	0.315	0.063	[0.036]*	160,236	40.97
IV, Mother has no education	0.190	-0.010	[0.054]	52,625	17.12
IV, Mother has primary or less education	0.203	0.101	[0.037]***	106,553	41.47
IV, Mother has primary education	0.215	0.141	[0.043]***	53,918	40.70
IV, Mother has primary or more education	0.371	0.148	[0.051]***	115,004	32.42
IV, Mother has secondary or more education	0.510	0.113	[0.059]*	61,082	29.88
Panel C - Dependent Variable: Minutes (round trip) to collect water					
OLS, full sample	5.277	-1.375	[0.657]**	142,052	
IV, full sample	5.277	-6.683	[1.700]***	142,052	31.56
IV, Mother has no education	6.538	-8.417	[4.033]**	41,993	15.86
IV, Mother has primary or less education	6.542	-8.948	[2.652]***	89,802	30.86
IV, Mother has primary education	6.546	-7.800	[2.475]***	47,797	31.26
IV, Mother has primary or more education	4.777	-6.513	[1.761]***	103,461	26.16
IV, Mother has secondary or more education	3.262	-5.599	[1.958]***	55,658	27.21

Source: Author's calculations based on data from Demographic and Health Surveys (1986–2010), Pinsent Masons (1999–2011), Envisager Limited (2011), World Bank (2011a, 2011b, and 2011c).

Note: Robust standard errors are in brackets and are clustered at the subnational region level. All specifications include subnational region, month, and year fixed effects, as well as dummies for the mother's age and marital status, the child's age and gender, and the # of household members, and controls for World Bank water and sewerage sector loans and grants, net United Nations aid, foreign direct investment (net inflows), and official development assistance from the country's final colonizer. In all specifications, the market share of the African country's former colonizer in the non-African world water market, and its interaction with the African country's 1996 political stability index, are the excluded instruments. *** indicates p<.01; ** indicates p<.05; * indicates p<.10.

Access to a Flush Toilet

Flush toilets are a form of improved sanitation, which refers to excreta disposal facilities that can effectively prevent human, animal, and insect contact with excreta (World Bank WDI 2011). Improved facilities range from a simple but protected pit latrine to a flush toilet. I define access to a flush toilet as having a flush or pour flush toilet in one's home—whether it flushes to a piped sewer system, a septic tank, a pit latrine, or somewhere else.

Improved access to a piped water might be accompanied by improved access to flush toilets, as piped water may be integral to the flushing mechanism. Table 5.1 shows that a household is 6.3 percentage points more likely to have a flush toilet following PSP, though this result is only significant at the 10 percent level. This provides some evidence that PSP reduces the prevalence of diarrhea through access to improved sanitation, through it is not conclusive. Most of this positive effects seems to come from mothers with primary education; PSP does not have a statistically significant effect on access to flush toilets for children whose mothers have no education. This may reflect that money was the constraint for the poorest households, whereas the availability of water infrastructure was the constraint for more well-off households.

Time Spent Collecting Water

Households that gain access to piped water need not make long trips to collect water from a non-piped source. Those without piped water spend, on average, 25.2 minutes per trip to get water. If these individuals get an in-home tap, they could see this trip reduced to 0. Table 5.1 verifies that PSP indeed reduces travel time to a water source—by about 6.7 minutes per trip. This finding is significant at the 1 percent level. The time savings is largest for children of uneducated mothers (8.4 minutes), lower for children of mothers with primary education (7.8 minutes), and lowest for children of mothers with secondary or more education (5.6 minutes).

6. CONCLUSION

I shed light on a possible, partial solution to the global burden or diarrheal disease, which kills 800,000 young children each year. My findings suggest that private sector participation (PSP) in the urban piped water sector substantially improves the health of young children by reducing the prevalence of diarrhea. The analysis is innovative in two respects. First, I compile and use a novel, subnational database of experiences with PSP in water in 39 African countries during 1986-2010. By matching this with child-level data on the prevalence of diarrhea and coughing in the same areas, I am able to rigorously study linkages between PSP in water and health over time where the existing literature has been limited to case studies or analysis of a single country. Second, my analysis addresses a major threat to identification: the fact that PSP is a non-random policy choice often undertaken to address severe water sector problems. I ensure that my results are credibly causal by exploiting variation over time in the share of the non-African, private water market controlled by African countries' former colonizers. I show that the water market share of a country's former colonizer is robustly positively correlated with PSP in the water sector of the former colony, but argue that it should only affect the prevalence of diarrhea in Africa by increasing the likelihood of PSP in water.

My OLS analysis suggests that the introduction of PSP decreases diarrhea among urban-dwelling, under-five children by 2.2–2.6 percentage points, or 14–16 percent of its mean prevalence. My IV analysis suggests that the effects are twice as large; PSP in water reduces diarrhea by 5.6 percentage points, or 35 percent. The difference between the OLS and the IV results is consistent with the timing of PSP coinciding with declines in child health driven by time-varying, unobserved covariates. Without taking into account the selection mechanism behind PSP in water, one would tend to underestimate its child benefits, at least as evidenced by diarrhea. This adds some insight into why PSP in water is so politically controversial despite literature suggesting that privatization can be beneficial for consumers. Also, I find evidence that the health benefits of PSP are not all conferred immediately; diarrhea is decreasing in the number of years a water utility is under a PSP contract. Once again, this lends insight into why PSP often lacks immediate support from the public; its benefits take time to materialize.

PSP in water also leads to higher rates of reliance on piped water as the primary water source, which is a likely causal channel explaining child health improvements. Importantly, PSP appears to benefit the health of children from the poorest households the most. A placebo analysis reveals that PSP does not significantly affect respiratory illness in the same set children. A second placebo analysis reveals that PSP does not affect a control group of children from rural areas not directly affected by the PSP. This suggests that health improvements are driven by changes in the water sector rather than by a correlation of PSP with other health investments. More research is needed on any costs imposed by PSP in water, and on the particular contexts in which PSP is more or less effective.

APPENDIX: SUPPLEMENTARY TABLES

Table A.1—Colonizers of African countries in the dataset

Country	First Colonizer	Final Colonizer
Benin	France	France
Burkina Faso	France	France
Burundi	Germany	Belgium
Cameroon	Germany	France
Central African Rep.	France	France
Chad	France	France
Comoros	France	France
Dem. Rep. of Congo	Belgium	Belgium
Egypt	UK	UK
Ethiopia	Italy	Italy
Gabon	France	France
Ghana	UK	UK
Guinea	France	France
Ivory Coast	France	France
Kenya	UK	UK
Lesotho	UK	UK
Liberia	None	None
Madagascar	France	France
Malawi	UK	UK
Mali	France	France
Morocco	France	France
Mozambique	Portugal	Portugal
Namibia	Germany	Germany
Niger	UK	UK
Nigeria	UK	UK
Rep. of the Congo	France	France
Rwanda	Germany	Belgium
Sao Tome & Principe	Portugal	Portugal
Senegal	France	France
Sierra Leone	UK	UK
South Africa	UK	UK
Sudan	UK	UK
Swaziland	UK	UK
Tanzania	Germany	UK
Togo	Germany	France
Tunisia	France	France
Uganda	UK	UK
Zambia	UK	UK
Zimbabwe	UK	UK

Source: (a) Cannon (2004), (b) www.zonu.com (last accessed May 2012).

Note: In the case of multiple colonizers, this table identifies the first colonizer (at 1885) and the final colonizer (at 1930).

Table A.2—List of demographic and health surveys included

Country	Subnational Regions	Survey Years
Benin	Alibori, Atacora, Atlantique, Borgou, Collines, Couffo, Donga, Littoral, Mono, Oueme, Plateau, Zou	1996, 2001, 2006
Burkina Faso	Central/South, Centre (Sans Ouagadougou), Centre-Nord, East, North, Ouagadougou, West	1992-93, 1998-99, 2003
Burundi	Depressions, Imbo, Mugamba, Mumirwa, Plateaux Centraux	1987
Cameroon	Central/South/East, North/Extreme North/Adamaoua, Northwest/Southwest, West/Littoral, Yaounde/Douala	1991, 1998, 2004
Central African Rep.	Bangui, R.S. I, R.S. II, R.S. III, R.S. IV, R.S. V	1994-95
Chad	Bar Azoum, Batha, Biltine, Centre Est, Chari Baguirmi, Guéra, Kanem, Lac, Logone Occidental, Logone Oriental, Mayo Kebbi, Moyen Chari, N'Djaména, Ouaddai, Salamat, Tandjilé	1996-97, 2004-05
Comoros	Anjouan, Grande Comore, Moheli	1996
Dem. Rep. of Congo	Bandundu, Bas-Congo, Equateur, Kasa Occident, Kasa Oriental, Katanga, Kinshasa, Maniema, Nord-Kivu, Orientale, Sud-Kivu	2007
Egypt	Alexandria, Assuit, Aswan, Behera, Beni Suef, Cairo, Dakahlia, Damietta, Fayoum, Gharbia, Giza, Ismailia, Kafr El Sheikh, Kayubia, Luxor, Matroh, Menoufia, Menya, New Valley, North Sainai, Port Said, Qena, Red Sea, Sharkia, Souhag, South Sainai, Suez	1992-93, 1995-96, 2000, 2005, 2008
Ethiopia	Addis Abeba, Afar, Amhara, Ben-Gumz, Dire Dawa, Gambela, Harari, Oromiya, Snnp, Somali, Tigray	2000, 2005
Gabon	East (Haut-Ogooué/ Ogooué-Lolo), Libreville, Port-Gentil, North (Ogooué-Ivindo/ Woleu-Ntem), South (Ngounié/ Nyanga), West (Estuaire/ Moyen-Ogooué/ Ogooué-Maritime)	2000-01
Ghana	Ashanti, Brong Ahafo, Central, Eastern, Greater Accra, Northern Region, Upper East Region, Upper West Region, Upper West Upper East And Northern, Volta, Western	1988, 1993-94, 1998-99, 2003, 2008
Guinea	Conakry, Rest of Country	1999, 2005
Ivory Coast	Abidjan, Center, Center East, Center North, Center West, North, North East, North West, Small City, South, South West, West	1994, 1998-99
Kenya	Central, Coast, Eastern, Nairobi, Northeastern, Nyanza, Rift Valley, Western	1988-89, 1993, 1998, 2003, 2008-09
Lesotho	Berea, Butha-Buthe, Leribe, Mafeteng, Maseru, Mohale'S Hoek, Mokhotlong, Qacha'S-Nek, Qasha'S Nek, Quthing, Thaba-Tseka	2004-05, 2009-10
Liberia	Grand Gedeh, Monrovia, Montserrado, North Central, North Western, Rest Of Country, Sinoe, South Central, South Eastern A, South Eastern B	1986, 2006-07
Madagascar	Alaotra Mangoro, Analamanga, Analanjirofo, Anamoroni'I Mania, Androy, Anosy, Antananarivo, Antsiranana, Atsimo Andrefana, Atsimo Atsinanana, Atsinanana, Betsiboka, Boeny, Bongolava, Diana, Fianarantsoa, Haute Matsiatra, Ihorombe, Itasy, Mahajanga, Melaky, Menabe, Sava, Sofia, Toamasina, Toliary, Vakinankaratra, Vatovavy Fitovinany	1992, 1997, 2003-04, 2008-09
Malawi	Central, North, South	1992, 2000, 2004-05
Mali	Bamako, Kayes/Koulikoro, Kidal, Mopti Gao/Tomboucto, Sikasso And Segou	1987, 1995-96, 2001, 2006
Morocco	Casablanca/Rabat, Centre, Centre Nord, Centre Sud, Chaouia-Ouardigha, Doukkala-Abda, Fes-Boulemane, Gharb-Chrarda-Bni Hssen, Grand-Casablanca, Guelmim-Es-Smara, Laayoune-Boujdou-Sakia Al Hamra, Marrakech-Tensift-Al Haouz, Meknes-Tafilalet, Nord Ouest, Oriental, Rabat-Sale-Zemmour-Zaer, Souss-Massa-Draa, Sud, Tadla-Azilal, Tanger-Tetouan, Taza-Al Hoceima-Taounate, Tensift	1987, 1992, 2003-04

Table A.2—Continued

Country	Subnational Regions	Survey Years
Mozambique	Cabo Delgado, Gaza, Inhambane, Manica, Maputo, Nampula, Niassa, Sofala, Tete, Zambezia	1997, 2003
Namibia	Caprivi, Central, Erongo, Hardap, Karas, Kavango, Khomas, Kunene, Northeast, Northwest, Ohangwena, Omaheke, Omusati, Oshana, Oshikoto, Otjozondjupa, South	1992, 2000, 2006-07
Niger	Dosso, Maradi, Niamey, Tahoua And Agadez, Tillaberi, Zinda And Diffa	1992, 1998, 2006
Nigeria	Central, North Central, Northeast, Northwest, South South, Southeast, Southwest	1990, 1999, 2003, 2008
Rep. of Congo	Brazzaville, Nord, Pointe Noire, Sud	2005
Rwanda	Butare, Byumba, Cyangugu, Gikongoro, Gisenyi, Gitarama, Kibungo, Kibuye, Kigali Ngali, Kigaliville, Ruhengeri, Rural Kigali, Umutara	1992, 2000, 2005
Sao Tome & Principe	Região Centro, Região Do Principe, Região Norte, Região Sul	2008-09
Senegal	Center, Dakar, Diourbel, Fatick, Kaolack, Kolda, Louga, Matam, Northwest, Saint-Louis, South, Tambacounda, Thies, West, Zuguinchor	1986, 1992-93, 1997, 2005
Sierra Leone	Eastern, Northern, Southern, Western	2008
South Africa	Eastern Cape, Free State, Gauteng, Kwazulu Natal, Mpumalanga, North West, Northern Cape, Northern Province, Western Cape	1998
Sudan	Central, Darfur, Eastern, Khartoum, Kordofan, Northern	1989-90
Swaziland	Hhohho, Lubombo, Manzini, Shiselweni	2006-07
Tanzania	Arusha, Coast, Dar Es Salam, Dodoma, Iringa, Kagera, Kigoma, Kilimanjaro, Lindi, Manyara, Mara, Mbeya, Morogoro, Mtwara, Mwanza, Pemba, Pwani, Rukwa, Ruvuma, Shinyanga, Singida, Tabora, Tanga, Town West, Zanzibar	1991-92, 1996, 1999, 2004-05
Togo	Centrale, De La Kara, Des Plateaux, Des Savanes, Kara, Lomè, Maritimes, Maritime, Plateaux, Savanes	1988, 1998
Tunisia	Center, North-East, North-West, Sahel, South, Tunis	1988
Uganda	Central, East Central, Eastern, Kampala, Northern, Southwest, West Nile, Western	1988-89, 1995, 2000-01, 2006
Zambia	Central, Copperbelt, Eastern, Luapula, Lusaka, Northern, Northwestern, Southern, Western	1992, 1996-97, 2001-02, 2007
Zimbabwe	Bulawayo, Harare Chitungwiza, Manicaland, Mashonaland Central, Mashonaland East, Mashonaland West, Masvingo, Matabeleland North, Matabeleland South, Midlands	1988-89, 1994, 1999, 2005-06

Source: Demographic and Health Surveys (1986–2010).

Table A.3—Access to piped water and flush toilets by urbanization status in country

Country of Survey	Survey Dates	Share of Population w/ Piped Water		Share of Population w/ Flush Toilet	
		Urban	Rural	Urban	Rural
Benin	06/1996–08/1996	58.7	15.1		
Benin	08/2001–11/2001	67.5	30.1	6.3	0.4
Benin	08/2006–11/2006	66.4	28.6	8.1	0.4
Burkina Faso	12/1992–03/1993	66.3	4.8	4.7	0.0
Burkina Faso	11/1998–03/1999	72.7	2.0	3.9	0.0
Burkina Faso	06/2003–11/2003	88.5	4.0	8.9	0.3
Burundi	04/1987–08/1987	98.7	8.9	12.8	0.4
Cameroon	04/1991–09/1991	68.7	12.6	14.0	0.8
Cameroon	02/1998–06/1998	74.6	18.2	18.1	1.3
Cameroon	02/2004–08/2004	69.3	12.6	14.1	0.8
Central African Rep.	09/1994–03/1995	43.1	1.5	2.4	0.1
Chad	12/1996–07/1997	23.3	4.3	1.0	0.0
Chad	07/2004–12/2005	41.9	2.6	5.8	0.4
Comoros	03/1996–05/1996	73.7	40.9	7.6	1.6
Dem. Rep. of Congo	01/2007–08/2007	58.8	2.9	13.2	0.1
Egypt	11/1992–02/1993	97.2	64.2	94.7	57.3
Egypt	11/1995–01/1996	96.6	69.4	97.3	70.9
Egypt	02/2000–04/2000	99.0	75.9	99.2	89.7
Egypt	04/2005–06/2005	98.8	88.3	99.7	96.0
Egypt	03/2008–06/2008	98.8	91.0	99.8	98.6
Ethiopia	02/2000–05/2000	80.8	5.3	1.9	0.0
Ethiopia	04/2005–08/2005	90.1	12.5	7.4	1.2
Gabon	07/2000–01/2001	93.1	19.1	30.2	3.6
Ghana	02/1988–06/1988	66.1	10.3	10.9	0.9
Ghana	09/1993–02/1994	75.8	12.8	15.6	0.9
Ghana	11/1998–02/1999	84.0	15.7	18.4	2.1
Ghana	07/2003–10/2003	72.4	10.8	21.2	1.7
Ghana	09/2008–11/2008	66.2	22.2	29.3	3.5
Guinea	05/1999–07/1999	63.7	4.1	7.7	0.2
Guinea	02/2005–06/2005	68.0	3.3	7.0	0.4
Ivory Coast	06/1994–11/1994	78.2	24.7	29.3	2.3
Ivory Coast	09/1998–03/1999	79.1	30.4	24.7	2.1
Kenya	12/1988–05/1989	89.9	16.8	36.9	1.6
Kenya	02/1993–08/1993	87.3	19.6	44.8	1.6
Kenya	02/1998–07/1998	84.1	18.6	43.1	2.1
Kenya	04/2003–09/2003	71.2	18.5	39.0	1.7
Kenya	11/2008–02/2009	75.7	19.8	52.6	1.7
Lesotho	09/2004–01/2005	90.4	53.1	7.7	0.2
Lesotho	10/2009–01/2010	77.3	48.4	5.2	0.2
Liberia	02/1986–07/1986	18.1	0.3	31.1	2.7
Liberia	12/2006–04/2007	19.2	0.3	25.5	0.7
Madagascar	05/1992–11/1992	76.9	5.2	16.7	0.2
Madagascar	09/1997–12/1997	56.0	4.6	7.4	0.7
Madagascar	11/2003–03/2004	64.5	13.9	7.4	0.7
Madagascar	11/2008–07/2009	73.2	16.3	15.7	1.7
Malawi	09/1992–11/1992	82.1	18.0	13.9	0.6
Malawi	07/2000–11/2000	83.5	13.8	16.4	0.7
Malawi	10/2004–01/2005	74.4	9.1	16.2	0.8
Mali	11/1995–05/1996	49.3	2.7	2.9	0.1
Mali	01/2001–05/2001	58.9	17.1	13.9	2.8
Mali	05/2006–12/2006	69.0	7.0	6.1	0.8
Morocco	05/1987–07/1987	77.9	22.5	4.1	0.1

Table A.3—Continued

Country of Survey	Survey Dates	Share of Population w/ Piped Water		Share of Population w/ Flush Toilet	
		Urban	Rural	Urban	Rural
Morocco	10/2003–02/2004	94.1	17.5	90.3	18.4
Mozambique	03/1997–07/1997	96.0	30.8	97.8	56.4
Mozambique	08/2003–12/2003	70.5	8.6	12.2	0.1
Namibia	07/1992–11/1992	59.1	5.0	7.5	0.2
Namibia	09/2000–12/2000	96.4	34.7	82.8	5.7
Namibia	10/2006–03/2007	97.9	40.3	77.5	9.3
Niger	03/1992–06/1992	96.9	57.4	78.3	10.0
Niger	03/1998–07/1998	61.3	6.5	5.9	0.2
Niger	01/2006–05/2006	63.9	7.9	4.2	0.2
Nigeria	04/1990–10/1990	90.8	8.3	6.1	0.0
Nigeria	03/2003–08/2003	49.8	13.2	30.6	4.2
Nigeria	06/2008–10/2008	33.0	8.5	28.7	6.7
Rep. of Congo	07/2005–11/2005	19.9	5.5	39.4	7.1
Rwanda	06/1992–10/1992	86.8	8.0	9.1	0.3
Rwanda	06/2000–08/2000	69.4	19.7	10.6	0.2
Rwanda	02/2005–07/2005	76.0	27.9	6.9	0.2
Sao Tome & Principe	09/2008–01/2009	55.4	22.6	5.4	0.2
Senegal	04/1986–07/1986	84.1	19.7	25.4	1.7
Senegal	11/1992–08/1993	84.4	24.4	26.7	0.8
Senegal	01/1997–04/1997	89.2	40.3	65.5	12.7
Senegal	02/2005–05/2005	85.7	20.4	82.9	29.9
Sierra Leone	04/2008–06/2008	47.0	8.2	13.2	0.2
South Africa	01/1998–09/1998	97.9	57.7	79.6	7.7
Sudan	11/1989–05/1990	78.9	38.1	13.3	0.4
Swaziland	07/2006–03/2007	87.8	41.2	49.7	7.4
Tanzania	10/1991–03/1992	77.8	19.2	4.5	0.3
Tanzania	07/1996–11/1996	77.8	25.1	5.0	0.8
Tanzania	09/1999–11/1999	80.1	22.3	4.1	0.6
Tanzania	10/2004–02/2005	67.7	23.6	9.1	0.4
Togo	06/1988–11/1988	70.2	11.5	11.8	0.0
Togo	02/1998–05/1998	74.9	20.2		
Tunisia	06/1988–10/1988	87.3	32.3	84.4	29.2
Uganda	09/1988–02/1989	56.1	1.9	24.6	0.5
Uganda	03/1995–08/1995	44.6	1.1	9.2	0.3
Uganda	09/2000–03/2001	63.3	1.6	9.1	0.5
Uganda	04/2006–10/2006	59.4	7.2	8.6	0.1
Zambia	01/1992–05/1992	89.2	10.5	47.9	1.8
Zambia	07/1996–01/1997	80.6	7.0	45.6	1.2
Zambia	11/2001–05/2002	81.7	6.5	42.3	1.9
Zambia	04/2007–10/2007	76.6	3.3	34.2	1.1
Zimbabwe	09/1988–01/1989	95.9	19.5	94.5	4.9
Zimbabwe	07/1994–11/1994	97.4	17.6	94.6	2.5
Zimbabwe	09/1999–12/1999	98.4	17.4	93.7	2.2
Zimbabwe	08/2005–02/2006	97.2	11.8	93.9	3.4
AVERAGE	02/1986–01/2010	74.0	19.9	30.7	7.4

Source: Demographic and Health Surveys (1986–2010).

Table A.4—Description of private sector participation (PSP) in water arrangements in sample countries, 1986-2010, if any

Country	Description
Benin	Publicly owned and operated.
Burkina Faso	The national operator, ONEA, provides water and sanitation services to 41 urban centers in Burkina Faso. In 2001, ONEA signed a 5-year management contract with the private French firms Veolia and Mazars & Guerard in order to improve its commercial and financial management of the urban water systems of Burkina Faso.
Burundi	Publicly owned and operated. In 2000, the government of Burundi considered privatizing the state-run water utility to overcome inefficiency, but the project stalled.
Cameroon	In 1997, nation-wide PSP began in Cameroon. In 2000, French firm Suez was awarded a 20-year concession. In September 2004, Suez announced that this concession was being revoked. The government subsequently announced that it is seeking a new contract for managing SNEC, probably through a lease.
Central African Rep.	The government of the Central Africa Republic entered into a 15-year lease contract with French company Saur in 1991. By 1996, the company had moved from near-bankruptcy in 1988 into a viable entity providing funds to the central government.
Chad	Public utility Societ Tchadienne d'Eau et d'Electricite (STEE) is responsible for water and electricity supplies in Chad. In 2001, Veolia started a two year management contract with STEE. STEE was renationalized after Veolia Water pulled out in August 2004. This was mainly due to profitability problems. STEE is currently owned by the government (81.2%) and the French Development Agency (AFD, 18.8%).
Comoros	Publicly owned and operated.
Dem. Rep. of Congo	Publicly owned and operated.
Egypt	In 1992, several management contracts were initiated in the Egyptian water sector. Under a project funded by the United States Agency for International Development (USAID) and a local NGO, a private firm was engaged to inspect water and wastewater networks, reduce leakage, and install water meters in homes and government buildings in Cairo. By 1994, there were additional contracts in Suez and Ismailia.
Ethiopia	Publicly owned and operated.
Gabon	In 1997, the French company Vivendi began a 20 year lease/ concession contract.
Ghana	In 2005, the national water firm, Ghana Water Company Limited (GWCL), signed a 5-year management contract with Aqua Vitens Rand Ltd. (AVRL) covering urban Ghana. AVRL is a joint venture of the public Dutch company Vitens Rand water services BV and Aqua Vitra Ltd. The aim of the contract is to improve sector performance and rehabilitate and extend the infrastructure.
Guinea	In 1989, the government introduced PSP into the water system in Conakry via a 10-year lease to Saur. The government retained ownership of the assets, but a private firm began paying a leasing fee in return for "rental" of the infrastructure assets and was responsible for operating the system and billing and collecting revenue. According to Bayliss (2002), between 1989 and 1996, the connection rate to piped water rose from 38% to 47%, the number of employees per 1,000 connections was more than halved, metering of consumers' water usage increased from 5% to 98% of customers, and water and service quality reportedly increased.
Ivory Coast	In 1960, the government entered into a management contract with French firm Saur. In 1987, the contract was renegotiated for 20 years.
Kenya	In 1999, the government signed a 10-year management contract with Vivendi to offer water billing and revenue management services to the water system serving Nairobi.
Lesotho	Publicly owned and operated.
Liberia	Publicly owned and operated.
Madagascar	Publicly owned and operated.
Malawi	Publicly owned and operated.
Mali	In 1994, national operator EDM was in critical shape, with poor service, low coverage rates, and a troubled financial position. The government entered into a management contract in 1995, but it was terminated early (in 1998). Saur won a 20-year national concession contract in January 2001 to distribute water in Mali.
Morocco	In 1997, the government signed a 30 year concession contract with LYDEC (Suez) covering Casablanca. In 1999, the government signed a 30-year concession contract with Redal (Veolia) covering Rabat.

Table A.4—Continued

Country	Description
Mozambique	Between 2000 and 2004, the World Bank gave a 115 million dollar loan to Mozambique. The loan required that PSP occurr in all major cities. Consequently, all areas except Niassa, Tete, Manica, Inhambane, and Gaza came under a private management contract in 1999 with the company Saur. These excluded systems have yet to introduce PSP. Following the withdrawal of Saur, Aguas de Portugal was left with a 73% stake in the water system.
Namibia	In 2001, the government signed a 20-year management and lease contract with Vivendi.
Niger	In 2001, the government granted a 10-year lease contract to the French Multinational Veolia. Despite PSP, the government continued to make investments in extension of the network, with the use of development bank loans. Several consumer organizations have claimed water was cheaper and more readily available before PSP.
Nigeria	Publicly owned and operated.
Rep. of the Congo	In 2002, the UK firm Biwater took over the Congo's national water distribution company, the Societe Nationale de Distribution d'Eau (SNDE). The company signed a lease/ concession contract, after beating competition from Saur and Vivendi.
Rwanda	In 2003, the government of Rwanda awarded a 5-year contract to Lahmeyer International, the German management consultants, to take over management of Electrogaz, the national electricity and water utility.
Sao Tome & Principe	Publicly owned and operated.
Senegal	In 1996, the government undertook nation-wide PSP via a 10-year affermage contract with limited investment obligations. The companies involved were the international firm Saur and local private investors. The objective of the PSP was to improve overall management, with a particular focus on reducing unaccounted-for-water (leakage) and collection rates from customers. The PSP affected only urban areas of the country.
Sierra Leone	Publicly owned and operated.
South Africa	Publicly owned and operated expect for two contracts: In 1992, Suez - Ondeo / WSSA (Northumbrian Water) UWR was awarded a 25-year lease contract covering Queenstown. In 1993, the same company was awarded a 10-year lease covering Stutterheim. Both are in the Eastern Cape region.
Sudan	Publicly owned and operated.
Swaziland	Publicly owned and operated.
Tanzania	In 2003, the government of Tanzania signed a 10 year lease contract with the firms Biwater and Gauff to take control of the water sector in Dar es Salam. The government terminated the contract in May 2005, and the operator took the decision to court.
Togo	Publicly owned and operated.
Tunisia	Publicly owned and operated.
Uganda	During 1997-2001, the government of Uganda had a management contract called the Kampala Revenue Improvement Project (KRIP) with Germany firm JBG Gaulf. During 2002-2004, it had a management contract with ONDEO Services Uganda Limited (OSUL), a French water firm registered in Uganda. The contracts covered distribution and billing of water in the capital city of Kampala (but not production).
Zambia	In January 2001, the government entered into a 4-year management contract in Copperbelt Province with Saur that ended in 2005. The government turned down subsequent proposals by World Bank consultants to implement a deeper PSP arrangement (via a 10-year lease contract for this province).
Zimbabwe	Publicly owned and operated.

Source: Pinsent Masons (1999–2011), Envisager Limited (2011), World Bank Private Participation in Infrastructure (PPI) Database (2010), Hall et al. (2002), and Lexis Nexis Academic (2011).

Table A.5—Specification checks

Dependent Variable: Dummy - child experienced diarrhea during last two weeks

	Use logged years under PSP (1)	Remove capital cities (2)	Only France and UK (3)	Use data on first colonizer for IVs (4)	Time × African region FE (5)	Time × initial share water piped (6)	Month-year dummies (7)	Cluster at the country level (8)	Cluster at the colonizer level (9)	Rural HHs w/o piped water (10)	All rural HHs (11)
Dummy - PSP in water		-0.093	-0.047	-0.060	-0.093	-0.051	-0.107	-0.056	-0.056	-0.019	-0.066
		[0.033]***	[0.020]**	[0.026]**	[0.034]***	[0.019]***	[0.042]**	[0.027]**	[0.012]***	[0.065]	[0.066]
Log years under PSP	-0.072										
	[0.031]**										
Dummy - primary education	0.003	0.006	0.008	0.007	0.007	0.007	0.006	0.007	0.007	0.003	0.005
	[0.007]	[0.004]	[0.004]*	[0.004]*	[0.004]*	[0.004]*	[0.004]	[0.004]*	[0.001]***	[0.003]	[0.003]*
Dummy - secondary or more	-0.014	-0.015	-0.013	-0.014	-0.014	-0.015	-0.015	-0.014	-0.014	-0.024	-0.02
	[0.007]*	[0.005]***	[0.005]***	[0.004]***	[0.004]***	[0.004]***	[0.004]***	[0.005]***	[0.004]***	[0.005]***	[0.004]***
Dummy - HH has electricity	-0.008	-0.012	-0.012	-0.012	-0.012	-0.012	-0.014	-0.012	-0.012	-0.014	-0.011
	[0.006]	[0.005]**	[0.005]**	[0.004]***	[0.004]***	[0.004]***	[0.004]***	[0.004]***	[0.005]**	[0.007]**	[0.006]*
Dummy - HH has a radio	-0.008	-0.012	-0.014	-0.013	-0.013	-0.013	-0.012	-0.013	-0.013	-0.008	-0.009
	[0.006]	[0.003]***	[0.003]***	[0.003]***	[0.003]***	[0.003]***	[0.003]***	[0.003]***	[0.002]***	[0.002]***	[0.002]***
Dummy - HH has a television	-0.015	-0.013	-0.012	-0.011	-0.01	-0.011	-0.01	-0.011	-0.011	0.003	0.004
	[0.008]*	[0.003]***	[0.004]***	[0.003]***	[0.003]***	[0.003]***	[0.003]***	[0.003]***	[0.004]***	[0.007]	[0.005]
Dummy - HH has a refrigerator	-0.012	-0.013	-0.011	-0.01	-0.01	-0.011	-0.011	-0.01	-0.01	0.005	0.004
	[0.008]	[0.005]***	[0.004]***	[0.004]***	[0.004]***	[0.004]***	[0.004]***	[0.004]***	[0.001]***	[0.008]	[0.005]
Dummy - HH has a bicycle	-0.015	-0.004	-0.002	-0.002	-0.002	-0.001	-0.001	-0.002	-0.002	-0.009	-0.006
	[0.005]***	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]***	[0.003]**
Dummy - HH has a motorcycle	-0.003	0.001	0.002	0.0004	0.0000	0.001	0.001	0.0004	0.0004	-0.011	-0.01
	[0.006]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.002]	[0.005]**	[0.005]**
Dummy - HH has a car	0.009	-0.00003	-0.002	-0.004	-0.004	-0.004	-0.002	-0.004	-0.004	-0.0005	-0.011
	[0.007]	[0.005]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.002]**	[0.011]	[0.007]
Dummy - HH has a natural floor	0.013	0.013	0.015	0.016	0.016	0.016	0.016	0.016	0.016	0.004	0.002
	[0.007]*	[0.005]***	[0.005]***	[0.004]***	[0.004]***	[0.004]***	[0.004]***	[0.005]***	[0.003]***	[0.003]	[0.003]
W. Bank water grants/ loans pc	0.869	0.128	0.073	0.079	0.114	0.072	0.088	0.075	0.075	0.086	0.091
	[0.278]***	[0.048]***	[0.034]**	[0.037]**	[0.050]**	[0.031]**	[0.069]	[0.045]*	[0.024]***	[0.064]	[0.060]
Net United Nations aid per capita	15.38	0.407	0.368	0.313	0.382	0.234	0.093	0.307	0.307	0.118	0.184
	[5.059]***	[0.132]***	[0.106]***	[0.108]***	[0.125]***	[0.096]**	[0.133]	[0.134]**	[0.127]**	[0.201]	[0.213]
FDI (net inflows) per capita	0.081	0.0002	0.031	0.016	0.022	0.007	-0.004	0.017	0.017	-0.044	0.005
	[0.068]	[0.020]	[0.022]	[0.018]	[0.022]	[0.017]	[0.019]	[0.032]	[0.016]	[0.031]	[0.029]
ODA from former colonizer pc	0.083	-0.018	0.015	0.003	0.021	0.002	-0.023	0.004	0.004	-0.I371	-0.001
	[0.046]*	[0.031]	[0.031]	[0.032]	[0.033]	[0.031]	[0.049]	[0.029]	[0.013]	[0.000]**	[0.000]***
Observations	49,287	114,121	140,366	160,342	160,342	160,342	160,342	160,342	160,342	234,016	295,184
Number of subnational regions	153	355	298	372	372	372	372	372	372	281	284
F Stat, excluded instruments	21.99	14.69	50.75	23.10	24.59	44.5	17.22	13.41	15.54	7.51	7.61

Source: Author's calculations based on data from DHS (1986–2010), Pinsent Masons (1999–2011), Envisager Limited (2011), World Bank WDI (2011), and World Bank WGI (2011).

Note: Robust standard errors are in brackets, and are clustered at the subnational region level. All specifications include subnational region, month, and year fixed effects, as well as dummies for the mother's age, the child's age, and the # of household members, and controls for the parents' marital status, child gender, World Bank water and sewerage sector loans and grants, total United Nations aid received, and FDI (net inflows). In all specifications, the market share of the African country's former colonizer in the non-African world water market, and its interaction with the African country's 1996 political stability index, are the excluded instruments. *** indicates p<.01; ** indicates p<.05; * indicates p<.10.

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