Constraints on Foreign Aid Effectiveness in the Water, Sanitation, and Hygiene (WASH) Sector

Joshua Wayland

Department of Geographical Sciences
University of Maryland, College Park

Abstract

Numerous studies have sought to empirically test the effectiveness of foreign aid as a tool for international development, with often inconsistent or contradictory results. New sources of disaggregated aid data now allow researchers to test the impact of individuals sectors of aid on sector-specific outcomes. The paper investigates the effectiveness of foreign aid in the water, sanitation, and hygiene (WASH) sector and seeks to identify constraints on WASH aid effectiveness in recipient countries. Multilevel latent growth and dynamic panel regression models were estimated on a panel dataset comprising 100 developing countries over 25 years. Results indicate that WASH aid had a statistically significant effect on health in recipient countries, as measured by infant mortality, child mortality, and life expectancy at birth. Potential constraints on the effectiveness of WASH aid—including political, economic, institutional, and technical constraints—were examined using subgroup analysis. No evidence was found that WASH aid was more effective in democratic countries, those with more open economies, or those with lower levels of corruption, as has been proposed in the literature. The impact of WASH aid on health indicators was, however, affected by the population density and the availability of water in recipient counties.

1. Introduction

This study examines the effectiveness of aid in the water, sanitation, and hygiene (WASH) sector. Specifically, it tests for the existence of a statistical relationship between the amount of aid per capita committed for projects in the WASH sector and a subsequent increase in the proportion of the population in recipient countries with access to improved sources of drinking water and sanitation and reduction in the disease burden, as measured by the under-five mortality rate, in recipient and the conditions under which the effect of WASH aid on those outcomes can be observed. A wide variety of panel data models are applied to a dataset comprising 125 low and middle income countries over the twenty year period from 1994 through 2013. The results suggest that WASH aid has been effective in terms of expanding access to improved WASH facilities and in reducing the child mortality rate in middle-income recipient countries. The effectiveness of WASH aid appears to be constrained by institutional and demographic conditions in some recipient countries, including especially ineffective governance, poor regulatory quality, and high rural populations.

The study contributes to a broad literature assessing the effectiveness of foreign aid as a tool for development. Historically, quantitative analyses of aid effectiveness were interested primarily in the impact of foreign aid on economic growth, fueling a decades-long debate that has repeatedly spilled from academic and professional circles into the public sphere (see Friedman, 1958; Bauer 1971, Hicks et al., 2008; Asra, 2005; Miller, 2011; Doucouliagos & Paldam, 2009, 2010, 2011). Despite countless regressions and oceans of ink spilled, the answer remains elusive; most observers agree that the empirical literature to date has failed to produce conclusive evidence one way or the other regarding the relationship between foreign aid and GDP growth (Doucouliagos & Paldam, 2009; Mavrotas, 2009; Bourguignon & Sundberg, 2007; Arndt et al., 2009; Roodman, 2007).

The recent availability of data on commitments and disbursements of foreign aid disaggregated to the sector or project level has breathed new life into the old aid effectiveness debate by enabling the development of a new literature examining not only the net effect of aid on economic growth, but also on the more specific objectives of individual sectors of aid (see Tierney et al., 2011; Findley et al., 2010;

Hicks et al., 2008; Clemens et al., 2004). In one early example, Clemens et al. (2004), compare aid intended to promote short-term growth—such as agriculture, infrastructure, and industry—with aid for humanitarian and other long-term goals—including aid for education and environmental conservation—and conclude that, when aid with explicit short-term economic objectives is evaluated separately, aid appears to have a statistically significant impact on growth. In the education sector, Birchler & Michaeolowa (2015) and Michaelowa & Weber (2007) find evidence of a statistically significant impact of aid for education projects on school enrollment and educational attainment. Gualberti et al. (2014) present evidence that aid in the energy sector has increased access to electricity by expanding infrastructure. Wilson (2011) applies a wide variety of statistical models and finds no significant relationship between aid in the health sector and improved health in recipient countries. In the WASH sector, recent studies by Anand (2006) and Gopalan & Rajan (2016) have come to differing conclusions regarding the impact of WASH sector aid on the reported use of improved sources of drinking water and sanitation in recipient countries, with the former reporting no significant effect and the latter reporting a strong effect, but one that appears to be limited to lower middle income countries. The results presented below support the findings of Gopalan & Rajan (2016) with respect to the effectiveness of WASH aid and the conditions under which it is effective.

2. Aid Effectiveness in the WASH Sector

(a) Objectives of WASH aid

The WASH sector offers a useful case for the evaluation of aid effectiveness, for two reasons. First, the sector represents a strong test of the proposition that aid can be delivered and implemented effectively. Among the criticisms of foreign aid—leakage and waste due to corruption, poor planning, and insufficient monitoring; the crowding out of government spending; the undermining of domestic markets; and the moral hazard of dependency—each is as applicable to the WASH sector as any other (Verhoeven et al., 2011; WHO, 2012). Because the management of water resources is a necessarily integrative process, this sector may be at heightened risk for ineffective implementation. The spatially disparate and indefinite nature of water resources makes it difficult for small, localized projects to

succeed in isolation, while national water management and large-scale infrastructure projects are notoriously prone to mismanagement, inefficiency, and rent-seeking (Salzman, 2012; Conca, 2006; Verhoeven et al., 2011). Among the sectors most at risk for failure, WASH surely ranks among the foremost.

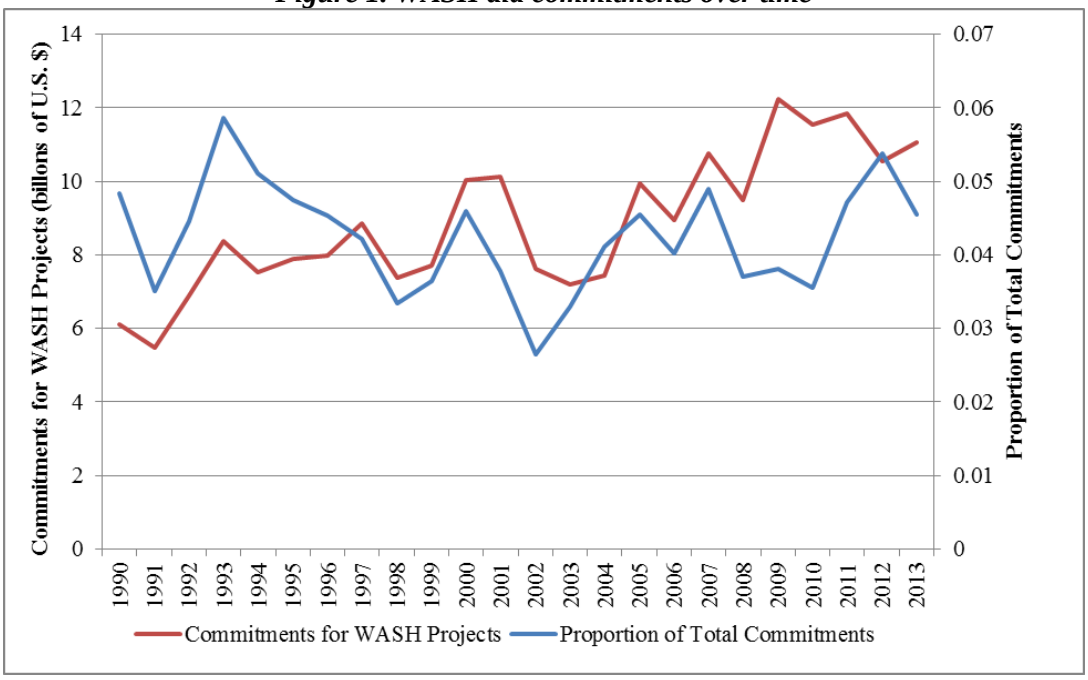
The WASH sector also serves well as a proxy for development writ large. From the aqueducts of ancient Rome, China, and Mesoamerica to the sewers of nineteenth century Paris and London, water and sanitation infrastructure has historically been among the hallmarks of what we think of as advanced civilizations (see Salzman, 2012; Lofrano & Brown, 2010). Today, access to clean drinking water and to adequate sanitation remain the indicators that most intuitively and comprehensively capture the distinction between wealth and poverty at the international scale. Simply put, rich people need not worry where their next drink of water will come from, or that it will prove toxic to them or their children. This is a luxury denied to many residents of the developing world, among whom an estimated 748 million lack access to an improved source of drinking water and some 2.5 billion to a source of improved sanitation (UNICEF & WHO, 2014; see also Verhoeven et al., 2011; UNICEF & WHO, 2012; WHO, 2012; UN, 2012; Glieck, 2002). WHO has estimated that more than 3.5 million people, the majority of whom are children, die each year in developing countries as a result of preventable water-related diseases, far more than in all of the world's wars and other violent conflict combined (Prüss-Üstün et al., 2008; see also Gleick, 2002). In addition to death and disease, inadequate drinking water and sanitation have also been linked to a myriad of other social ills, from educational non-attainment and gender inequality to poor economic productivity and outbreaks of violent conflict (UNDP, 2006; WHO, 2012; UNICEF & WHO, 2012), making the WASH sector a critical component of aid's broader objective of promoting development.

To distinguish WASH aid from other sectors of foreign aid, this study relies on the coding system of the AidData dataset. Is a collaborative effort between the College of William and Mary, Brigham Young University, and Development Gateway that compiles, codes, and makes available to researchers project-level development finance data from 95 donor agencies, including historical data dating back to

1945. AidData assigns sector codes to individual aid-funded projects based on the description of the project in the donor's records. For the purposes of this study, WASH aid is defined as the funding allocated to projects falling under AidData's Water Supply and Sanitation Purpose Code Group. These projects include a number of water-related development activities, including the construction of wells and other drinking-water infrastructure, desalination projects, water conservation initiatives, water management capacity building, water pollution control, sewage construction, dam and reservoir construction, municipal waste management, and water assessment studies, among others. Excluded are those projects that are primarily for irrigation or large hydroelectric dams, although such project may have WASH sector components (see Tierney et al., 2011).

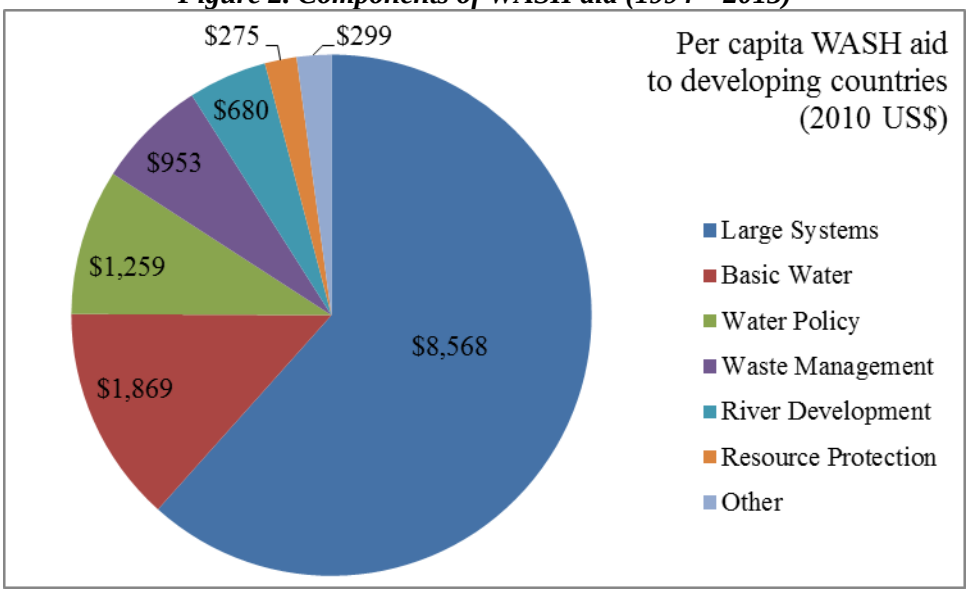
Aid for WASH projects grew steadily from approximately $700 million in 1960 to well over 6 billion by 2000, in constant (2009) U.S. dollars. Since the turn of the millennium, and following the call of the Millennium Development Goals to "halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation," commitments increased an average of 5 percent annually, reaching a high of nearly 12 billion dollars by 2009. In all, nearly one-quarter of a trillion dollars has been allocated as aid for the WASH sector over the past fifty years (see Figure 1).

Figure 1. WASH aid commitments over time



The WASH sector includes projects that fund, among other activities, water assessment studies, capacity building for water management, water conservation initiatives, municipal waste management, desalination projects, and the construction of wells, reservoirs, sewerage, and other infrastructure. As shown in Figure 2, the majority of WASH aid is devoted to large drinking water delivery and sewerage systems; between 1994 and 2013, recipient countries received more than $8,500 per person in aid for large systems, measured in 2009 U.S. dollars. Other major activities include aid for basic water supply, water policy development, and waste management.

Figure 2. Components of WASH aid (1994 – 2013)



Generally, the effectiveness of WASH sector aid has been assessed with respect to access to 'improved' sources of drinking water and sanitation in recipient countries, as defined by the JMP. The Millennium Development Goals (MDGs) that deal specifically with water and sanitation, for instance, set specific standards for the proportion of the population of developing countries using improved sources. Improved sources of drinking water include water piped into the dwelling or yard; public taps and standpipes; tube-wells and borehole wells; protected dug wells; protected springs; rainwater collection; and bottled water. Nonimproved sources are unprotected dugs wells; unprotected springs; vendor provided water; carted water; tanker truck water; and surface water from rivers, ponds, lakes, and streams. Improved sanitation includes flush toilets; piped sewer systems; septic systems; flush or pour-flush toilets

to a pit latrine; ventilated improved pit (VIP) latrines; pit latrines protected by a slab; composting toilets; and some special cases. Non-improved sanitation are public or shared latrines; flush or flush-pour toilets not connected to a pit, septic tank, or sewer; unprotected pit latrines; open pit latrines; bucket latrines; hanging toilets and latrines; and the absence of any facility.

Using access to improve WASH facilities as the benchmark, studies of WASH aid effectiveness present mixed evidence. Botting et al. (2010) find evidence that foreign aid has played a role in increasing access to improved sources of drinking water, but has been less effective at expanding access to improved sanitation. Anand (2006) finds no evidence for a correlation between the volume of WASH aid received and subsequent expanded access to improved sources of drinking water and sanitation. Gopalan & Rajan (2016), however, find that WASH aid does increase access to both improved sources of drinking water and improved sources of sanitation, though they conclude that the effect is limited to lower-middle-income countries.

Ultimately, the objective of WASH aid is to improve human health by expanding access to safe drinking water and adequate sanitation, thus reducing the spread of water-related illnesses. The analysis described below builds on those existing studies by test for an effect of WASH aid directly on health indicators. Along with access to improved sources of drinking water and sanitation, therefore, the impact of WASH aid on the under-five mortality rates (per 1000 births) is also tested. The under-five mortality rate (also called the child mortality rate) is an appropriate measure of effectiveness here because water-related illnesses, such as diarrheal diseases, disproportionally affect children.

(b) Allocation of WASH aid

Table 5 below shows the top donors of WASH aid during the years 1960 through 2009. The World Bank has historically been, and continues to be, by far the largest source of WASH aid, accounting for nearly 30 percent of total commitments to the sector. Among the bilaterals, Japan heads the pack, followed by Germany and the U.S. Altogether, 68 donors have been involved in the sector, with the majority accounting for less than one percent each of the total.

Table 1. Top donors of WASH aid

Multilateral Donors			Bilateral Donors		
Donor name	Commitments (millions US$)	Percent of total	Donor name	Commitments (millions US$)	Percent of total
World Bank Group	47,298	23.95%	Japan	34,355	17.40%
European Communities	14,762	7.48%	Germany	13,762	6.97%
Inter-American Development Bank	9,601	4.86%	United States	9,780	4.95%
Asian Development Bank	7,463	3.78%	France	7,649	3.87%
Arab Fund for Economic and Social Development	4,313	2.18%	Netherlands	4,593	2.33%
European Bank for Reconstruction and Development	2,822	1.43%	Spain	2,828	1.43%
Andean Development Corporation	2,732	1.38%	United Kingdom	2,394	1.21%
Asian Development Fund	2,360	1.20%	Denmark	2,347	1.19%
African Development Bank	1,895	0.96%	Kuwait	1,838	0.93%
North American Development Bank	1,572	0.80%	Sweden	1,728	0.88%

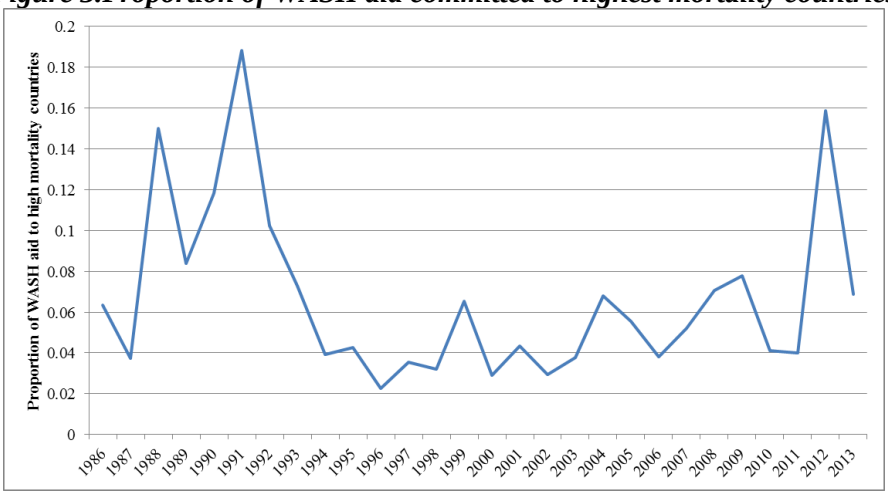
On the recipient side, 205 countries and territories received WASH aid over the period, among whom China and India were the largest in absolute terms, accounting for nearly 19 percent of total WASH aid commitments. Table 2 below shows the top ten recipients of WASH aid, in terms of both total dollars received and per capita.

Table 2. Top recipients of WASH aid

Top overall recipients			Top per capital recipients		
Country	Total WASH aid received (millions US$)	Percent of total	Country	Per capita WASH aid received (US$)	Total WASH aid received (millions US$)
China	$17,541	8.88%	Palestine Territories	744	$2,379
India	$15,867	8.04%	Dominica	707	$50
Morocco	$8,248	4.18%	Jordan	635	$3,404
Vietnam	$7,890	4.00%	Lebanon	524	$1,872
Brazil	$6,543	3.31%	Bahrain	432	$2,65
Mexico	$5,536	2.80%	Albania	397	$1185
Argentina	$5,466	2.77%	Djibouti	354	$285
Iraq	$4,882	2.47%	Lesotho	346	$670
Indonesia	$4,720	2.39%	Mauritania	339	$1,076
Egypt	$3,881	1.97%	Montenegro	334	$207

In an ideal world, donor would allocate WASH aid funding on the basis of the level of need in recipient countries. In fact, however, the responsiveness of WASH aid to recipient country need, measured in terms of the under-five mortality rate, has declined in recent years. Figure 4 shows the total amount of WASH aid and the proportion of WASH aid committed to the highest mortality countries, those in the ninetieth percentile for under-five mortality rate, in each year since 1985.

Figure 3.Proportion of WASH aid committed to highest mortality countries



(c) Constraints on WASH aid effectiveness

The vast aid effectiveness literature has identified numerous potential causes of aid ineffectiveness in the WASH sector and across all sectors of foreign aid. Burnside and Dollar (1997) contend that the economic policies of recipient countries, including especially their openness to foreign trade and investment, are important prerequisites for effective aid. In the WASH sector, Anand (2013) finds that the level of perceived corruption significantly reduces the impact of WASH aid on increasing access to improved sources of drinking water and sanitation, concluding that "much of the secret of success in delivering water and sanitation systems may lie outside the sector in terms of improving institutional environment and reducing corruption" (19). Gopalan & Rajan (2016) suggest that government stability, regulatory quality, and institutional effectiveness may affect WASH aid effectiveness, but find no empirical evidence, through their use of interaction terms in panel data models, of a joint effect.

In addition to those institutional, political, and economic constraints on aid effectiveness, the WASH sector in particular is also potentially subject to technical constraints related to geographical and demographic conditions of a recipient country. Among these are the size of the rural population; it is more difficult technically and more expensive to extend water delivery and sewer pipes to remote areas. Environmental scarcity of water in arid countries may also affect WASH aid effectiveness because less freshwater is available.

(d) Hypotheses

Based on the above review of the existing quantitative literature on aid effectiveness in general and in the WASH sector in particular, two specific hypotheses will be tested in the analysis described below:

Hypothesis 1: The amount of per capita WASH aid received by a country has a positive impact on the proportion of the population with access to improved sources of drinking water and sanitation and a negative impact on the child mortality rate in that country.

Hypothesis 2: The amount of per capita WASH aid received by a country will not have a beneficial impact on health outcomes only in countries in which institutional, economic, and technical constraints are present.

3. Data

(a) Independent variable

In the models described below, the WASH aid variable is constructed as the total dollar value of aid from all donors for WASH projects, in constant (2009) dollars, committed to a given country in a given year, divided by the total population of the country in that year, and summed over five years. The use of a moving sum is appropriate in this instance because data from AidData is in the form of commitments; depending on the nature of each aid project, it may take several years for funds to be disbursed and projects implemented.

This study utilities a panel dataset covering the years 1994 through 2013. In selecting countries to include in the sample, three income classes were defined based on the World Bank definitions of low-

income, middle-income, and high-income countries, whereby low-income countries are those with a GNI per capita of less than $1,045 or less in 2013; middle-income economies are those with a GNI per capita of more than $1,045 but less than $12,746; high-income economies are those with a GNI per capita of $12,746. Because the study is primarily interested in the effectiveness of WASH aid in developing countries, only those countries meeting the definition of low-income or middle-income were included in the sample for the main models, and then only for the years in which they met the definition.

(b) Dependent variables

Three national indicators were selected as the primary dependent variables against which to measure the impact of WASH aid. These are the proportion of the population that reported using an improved source of drinking water, as defined by the JMP; the proportion of the population that reported using an improved sanitation facility; and the under-five mortality rate, per 1000 births. All of the dependent variables were drawn from the World Bank's World Development Indicators (WDI), and are based on estimated developed by various divisions United Nations and national census agencies (World Bank, 2014). Due to the dispersion of the child mortality variable, it is expressed in natural logarithmic form in the statistical models described below.

(c) Control variables

Although the regression models are parsimonious, several control variables are included in each of the models. It is well established that economic development is strongly correlated with better health; wealthier countries tend to have better health care systems, more doctors, and more effective water and sanitation infrastructure; a healthier population, in turn, is generally more economically productive. As a measure of overall economic productivity, therefore, annual GDP per capita, measured in constant (2009) U.S. dollars, is included in each of the models discussed below. Total Official Development Assistance (ODA), measured in per capita, constant (2009) dollar terms, is also included in order to control for any aid-related effects unconnected to the WASH sector. It is possible, for instance, that ODA flows of all kinds might improve health through a general wealth effect, or through the impact of other specific sectors. In the models predicting the under-five mortality rate, the total aid committed to the health

sector, broadly defined, is included in order to control for effects from non-WASH aid. Finally, I include the Polity2 score from the Polity IV dataset, which measures the degree of democracy and authoritarianism in each country (Marshall & Jaggers, 2002). For the purposes of this study, I include the Polity2 score only as a general measure of regime structure, under the hypothesis that more democratic governments are more responsive to the health needs of their citizens.

4. Methods

(a) Panel data models

To test WASH aid's impact, I rely primarily three panel data models used previously in the aid effectiveness literature. The first is the Dynamic Panel Model (DPM), an extension of the fixed effects panel regression that accounts for the jointly increasing trends of the variables over time by including both a time variable and the lagged value of the dependent variable, according to the structural equation:

$$(1) \qquad y_{i,t} = \beta_0 + \beta_1 x_{i,t} + \beta_2 y_{i,t-5} + \beta_3 t + \alpha_i + + \mu_{i,t}$$

Where Y is the dependent variable, X is the vector of explanatory variables, α is the unobserved county-specific effect, t is a time variable, and $Y_{i,t-10}$ is the dependent variable lagged over ten years. By including time as an explanatory variable, this construction accounts for any global 'background' changes in health in over time, such as the development and diffusion of new medical technologies, and adjusts for any joint trends among the other variables (see Wilson, 2011; Judson & Owen, 1999).

As an alternative specification, I also employ the so-called Latent Growth Model (LGM), a variant of the multi-level mixed effects regression in which an independent time variable is estimated for each panel group, in this case individual countries. The model takes the generalized form:

$$(2) \qquad y_{i,t} = (\beta_0 + \gamma_{0,i}) + \beta_1 x_{i,t} + (\beta_2 + \gamma_{t,i})(t) + \mu_{i,t}$$

Where the term $(\beta_0 + \gamma_{0,i})$ is the country-specific intercept and $(\beta_1 + \gamma_{t,i})(T)$ represents the estimated rate of change over time. This flexible construction allows both random coefficients and random slopes, which is appropriate insomuch as health in recipient countries may begin at different initial states, and change at different rates. No lagged dependent variable is included in the LGM method (Beck & Katz, 2007; Wilson, 2011).

Endogeneity is a potential problem in all studies of aid effectiveness. There are two potential implications of donor allocation behavior. To the extent that donors explicitly target the neediest countries—i.e. those with the lowest levels of access to improved sources of drinking water and sanitation and with the highest child mortality rates—the impact of WASH aid may be understated in the models. On the other hand, to the extent that donors are concerned with showing results and tend to target countries that have had demonstrated success at expanding services and improving health, then the regression results may mistakenly attribute to WASH aid those successes.

The presumption of endogeneity requires rewriting (1) as:

$$(3) \qquad y_{i,t} = \beta_0 + \beta_1 x_{i,t} + \beta_2 y_{i,t-5} + \beta_3 t + \beta_4 z_{i,t} + \alpha_i + v_{i,t} + \mu_{i,t}$$

Where z represents the WASH aid variable, which, if it is assumed to be endogenous with respect to *y*, is correlated with the error term *v*. The equation is estimated using a two-stage least squares procedure, whereby the endogenous variable *z* is instrumented by an exogenous variable that is correlated with *z* but not with *y*. Following Michaeolowa & Weber (2007), aid funds committed to sectors other than the WASH sector were considered as potential instrumental variables, including the aid for transportation, mining, and energy projects, among others. Among the various sectors, aid for the transportation sector offers the best instrument, being highly correlated with WASH aid (r=0.97).

(b) Subgroup Analysis

Studies of conditional aid effectiveness have traditionally relied on the interpretation of interaction terms between, for instance, indices measuring policy conditions as in Burnside & Dollar (1997, 2000) and the amount of aid received. This approach has important insight into the conditions under which aid can be effected, but is limited by the availability of data pertaining to the factors that may affect aid effectiveness, such as perceptions of government and institutional quality.

This study relies instead on a series of regression estimated within subgroups of recipient countries from the full sample, defined based on the presence or absence of potential constraints in those countries during the time period examined. A total of eight potential constraints are identified were identified and tested. These are government ineffectiveness, poor rule of law, poor regulatory quality,

low democracy, high autocracy, barriers to international trade, high corruption, lack of voice and accountability, high rural population, and low freshwater availability. For each constraint, the model was estimated separately for a test group of recipient countries in which the constraint was present and for a control group of countries in which it was not. If the estimated impact of WASH aid is statistically significant and large among countries in the control group, but insignificant and small in the test group, then this would constitute evidence that the constraint is an important determinant of WASH aid impact.

The presence or absence of the constraint was inferred from the average value of variables from the World Governance Indicators (WGIs), Polity IV project, and WDIs across the time period examined. For example, countries with an average WGI rule of law score from 1994 to 2013 of less than -0.6 (the median value for low and middle income countries during that time period) were assigned to the test group for that constraint. Similarly, countries with average regulatory quality, government effectiveness, corruption control, or voice and accountability scores of less than the respective median values were assigned to the test group for the applicable constraint. Adopting the definitions of Marshall et al. (2002), countries with an average Polity2 score of less than 5 were considered to be non-democratic and those with an average Polity2 score of less than -4 were considered to be autocratic. Following Shamsadini et al. (2010), the test group for barriers to trade includes countries in which foreign trade accounted for less than 50 percent of GDP, on average. Using the definition of water scarcity cited in Hauge and Ellingsen (1998), the test group for the low water availability constraint includes countries with less than 1000 cubic meters of available freshwater per person per year, on average. The test group for the high rural population constraint includes countries in which, on average, more than 50 percent of the total population resided in rural areas.

5. Results

(a) Is WASH Aid Effective?

Table 1 shows the results of the statistical models relating per capita WASH aid and the three dependent variables of interest for the full sample of lower and middle income countries from 1994 through 2013. With respect to the effectiveness of WASH aid, the evidence is mixed. The WASH aid

variable is significant and negative in the LGM specification, suggesting that WASH aid per capita reduced mortality among the under-five population; however, it is insignificant in both the DPM and IV specifications. The opposite pattern is evident with regard the role of WASH aid in increasing the use of improved sources of drinking water and sanitation; the WASH aid variable is significant (and positive) when the DPM and IVM are used, but not using the LGM.

Among the covariates, GDP per capita is consistently statistically significant and negative, consistent with the hypothesis that wealthier countries are more likely to use improved WASH facilities and to experience lower child mortality rate. The amount of total aid received is generally significant and has a positive effect on health outcomes (i.e. the coefficient is positive in the models predicting the use of improved sources of drinking water and sanitation and negative in the models predicting child mortality. Consistent with Wilson's (2012) results, however, there does not appear to be any evidence for an impact of aid in the health sector on the child mortality rate in the full sample.

Table 3. Effectiveness of WASH aid in middle and low income countries

	Child Mortality			Improved Water Source			Improved Sanitation		
Model	DPM	LGM	IV	DPM	LGM	IV	DPM	LGM	IV
WASH aid	-0.003*	-0.006***	-0.006	0.137***	-0.012	0.332***	0.072***	-0.019	0.121***
	(0.002)	(0.002)	(0.009)	(0.022)	(0.010)	(0.043)	(0.022)	(0.012)	(0.0422)
Health aid	-0.003	0.002	-0.004						
	(0.002)	(0.002)	(0.007)						
Total aid	-0.021***	0.002	-0.020***	0.261***	0.208***	0.235***	0.303***	0.211***	0.297***
	(0.005)	(0.003)	(0.005)	(0.056)	(0.020)	(0.057)	(0.056)	(0.023)	(0.056)
GDP per capita	-0.100***	-0.095***	-0.097***	0.621***	-0.489***	0.365***	0.733***	0.056	0.668***
	(0.001)	(0.013)	(0.014)	(0.123)	(0.084)	(0.134)	(0.122)	(0.097)	(0.132)
Polity2	-0.010*	-0.006	-0.010*	0.034	-0.010	0.051	0.045	0.002	0.049
	(0.006)	(0.004)	(0.006)	(0.065)	(0.023)	(0.066)	(0.064)	(0.027)	(0.064)
Year	-0.016***	-0.038***	-0.016***	-0.012	0.591***	-0.014	-0.003	0.502***	-0.004
	(0.001)	(0.002)	(0.002)	(0.014)	(0.055)	(0.015)	(0.0142)	(0.048)	(0.014)
DV lag	0.604***		0.604***	1.009***		1.012***	0.990***		0.992***
	(0.015)		(0.015)	(0.005)		(0.006)	(0.006)		(0.006)
Constant	2.540***	4.847***	2.521***	-5.603***	73.427***	-4.162***	-5.9678**	51.649***	-5.649***
	(0.126)	(0.125)	(0.133)	(1.113)	(2.018)	(1.164)	(1.079)		(1.106)
Observations	2428	2428	2428	2428	2428	2428	2428	2428	2428
R squared	0.957		0.957	0.977		0.9774	0.992		0.9921
Log likelihood		2880.562			-1880.116			-2225.773	

*Notes: * p<0.10 ** p<0.05 *** p<0.01*

Standard errors in parentheses

(b) Where is WASH Aid Effective?

The non-finding regarding the effectiveness of aid in the WASH sector is consistent with the hypothesis that aid's impact is heterogeneous across different categories of recipient countries. The results of a subgroup analysis based on the income level of recipient countries reported in Table 2 support this idea. Recipient countries were divided into three subgroups, based loosely on the World Bank's definitions of low income, middle income, and high income countries. In the table, low income countries refer to those with a per capita GDP of less than $1000 in 2000 dollars; middle income countries are those with a per capita GDP between $1000 and $10,000; and high-income countries are those in which GDP is greater than $10,000 per capita. The WASH aid variable is a negative and highly statistically significant predictor of child mortality—meaning that the amount of WASH aid received tended to reduce child mortality--in all three of the model specifications when the sample includes only middle income countries; among low income and high income countries, however, the WASH aid variable is not significant. The pattern holds true with regard to the use of improved sources of drinking water and improved sources of sanitation; across all of the models, WASH aid appear to be effective only among middle income countries. This is illustrated graphically in Figure 4, which shows the estimated coefficient of the WASH aid variable when the regression model within six subgroups of recipient countries based on the per capita income.

Figure 4. Effectiveness of WASH aid by recipient country income level

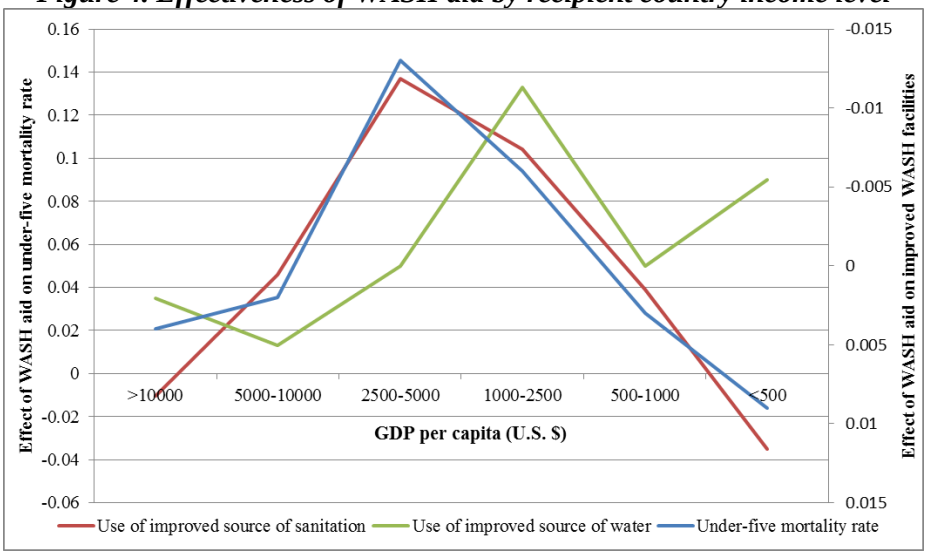


Table 4. WASH aid effect on under-five mortality rate by recipient country income level

	Low Income Countries			Middle Income Countries			High Income Countries		
	DPM	LGM	IV	DPM	LGM	IV	DPM	LGM	IV
WASH aid	0.008*	0.005	0.027	-0.007***	-0.012***	-0.022**	-0.004	0.010**	0.245*
	(0.004)	(0.006)	(0.022)	(0.003)	(0.003)	(0.010)	(0.003)	(0.004)	(0.146)
Health aid	-0.003	-0.001	-0.039***	-0.001	-0.001	0.009	0.005	0.012**	-0.208
	(0.003)	(0.005)	(0.015)	(0.002)	(0.003)	(0.008)	(0.004)	(0.005)	(0.139)
Total aid	-0.033***	0.010	-0.026***	-0.007	0.007	-0.004	0.005*	0.002	0.004
	(0.008)	(0.011)	(0.010)	(0.007)	(0.009)	(0.007)	(0.002)	(0.003)	(0.008)
GDP per capita	-0.010***	-0.255***	-0.132***	-0.128***	-0.245***	-0.111***	-0.017	-0.052**	-0.008
	(0.019)	(0.025)	(0.024)	(0.018)	(0.022)	(0.021)	(0.015)	(0.020)	(0.049)
Polity2	-0.018**	-0.0128	-0.010	0.001	0.0003	0.0002	0.015*	0.006	-0.015
	(0.009)	(0.0121)	(0.010)	(0.009)	(0.010)	(0.008)	(0.008)	(0.011)	(0.031)
Year	-0.040***	-0.034***	-0.012***	-0.017**	-0.033***	-0.018***	-0.011***	-0.034**	-0.007
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.006)
DV lag	0.720***		0.729***	0.538***		0.531***	0.657***		0.423***
	(0.023)		(0.026)	(0.019)		(0.019)	(0.024)		(0.153)
Constant	30.187***	73.767***	26.773***	36.55***	71.784***	38.525***	21.747***	71.782***	15.665***
	(4.002)	(5.246)	(4.747)	(3.726)	(4.461)	(4.015)	(3.901)	(4.753)	(13.225)
Observations	1025	1025	1025	1403	1403	1403	974	974	974
R squared	0.914		0.905	0.9099		0.910	0.9765		0.575
Log likelihood		613.261			879.108			489.080	

*Notes: * p<0.10 ** p<0.05 *** p<0.01*
Standard errors in parentheses

(c) Constraints on WASH Aid Effectiveness

There are several potential reasons why WASH aid is most effective in middle income countries. It may be the case that middle income countries are more likely than the poorest countries to have in place effective institutions that allow for the more efficient absorption of aid funds. These countries may be more economically open and thus better poised to take full advantage of international partnerships for development. Or, they may tend to be more democratic, and thus more responsive to the development needs of their populations. Alternatively, the poorest and neediest countries may tend to face technical and environmental constraints not present in wealthier nations that affect both their relative need and the potential impact of aid.

In order to test the role of each of potential economic, political, institutional, and technical constraints on WASH aid effectiveness, the statistical models were estimated within a series of subgroups based on the presence or absence of potential constraints. For each of the 10 potential constraints, a test group of recipient countries was defined comprising those countries in which the constraint was present and a corresponding control group was selected of countries in which the potential constraint was absent. The presence or absence of the potential constraints was inferred from the mean value in each country of indicator variables measuring, among other example, perceived corruption, government effectiveness, and freshwater available, across the time period examined.

For each set of test and control groups, nine regressions models were estimated, corresponding to the three alternative specifications and the three dependent variables. The results were similar with respect to the significance of the WASH aid variable across the three model specifications. To facilitate comparison between the groups, Table 4 below reports only the coefficient of the WASH aid variable from the IV regression models. Among the potential constraints, government ineffectiveness, poor regulatory quality, and high rural population have the strongest evidence suggesting that they limit the effectiveness of WASH aid. For these three constraints, the WASH aid variable is consistently insignificant in the sample of countries in which the constraint was present and is consistently significant in the sample of countries in which it was absent.

Table 5. Coefficient of WASH aid variable in countries with and without constraints

Model: Panel Instrumental Variable		Countries with constraint			Countries without constraint		
Constraint	Definition	Under-five mortality rate	Improved water source	Improved sanitation	Under-five mortality rate	Improved water source	Improved sanitation
Low democracy	Polity2 score less than 5	0.006 (0.010)	0.254*** (0.066)	0.194*** (0.076)	-0.009 (0.008)	0.360*** (0.070)	0.040 (0.041)
High autocracy	Polity2 score less than -4	0.023* (0.014)	0.359*** (0.125)	0.417** (0.185)	-0.003 (0.011)	0.255*** (0.051)	0.057 (0.036)
Closed to international trade	Foreign trade less than 50% of GDP	0.016 (0.018)	0.067 (0.106)	-0.225 (0.169)	-0.006 (0.011)	0.279*** (0.053)	0.154*** (0.051)
Poor rule of law	Rule of law score less than -0.6	-0.013 (0.011)	0.192** (0.090)	0.042 (0.034)	-0.067*** (0.024)	0.105*** (0.032)	0.128** (0.050)
Ineffective governance	Government effectiveness score less than -0.5	0.003 (0.011)	0.082 (0.092)	0.0419 (0.043)	-0.072*** (0.017)	0.146*** (0.042)	0.043*** (0.0159)
High corruption	Corruption control score less than -0.5	0.001 (0.012)	0.133*** (0.030)	0.024 (0.0297)	-0.084** (0.035)	0.084*** (0.021)	0.112*** (0.025)
Poor regulatory quality	Regulatory quality less than -0.4	0.003 (0.006)	0.083 (0.085)	0.090 (0.071)	-0.016** (0.008)	0.165*** (0.043)	0.121*** (0.048)
Poor voice and accountability	Voice and accountability less than -0.5	0.015 (0.011)	0.135 (0.096)	0.158*** (0.070)	-0.009 (0.017)	0.408*** (0.063)	0.012 (0.053)
Low water availability	Less than 5000m^3 freshwater per capita	0.005 (0.010)	0.339*** (0.073)	0.194*** (0.070)	-0.050*** (0.011)	0.299*** (0.063)	0.026 (0.055)
Dispersed population	Rural population greater than50%	0.003 (0.014)	0.429 (0.790)	0.094 (0.086)	-0.072*** (0.019)	0.158*** (0.054)	0.162*** (0.048)

*Notes: * p<0.10 ** p<0.05 *** p<0.01*
Standard errors in parentheses

(d) Sensitivity analysis

Because panel data regressions can be highly sensitive to inputs and model specifications, an extensive sensitivity analysis was conducted. First, additional control variables were identified and included in the regression models, including, among others, the proportion of the population living in rural areas, freshwater availability per capita, among openness to international trade. The inclusion of these variables did not affect the main results with respect to the significance of the WASH aid variables.

A second assumption made in the models above involves the use of five year sums of committed WASH aid as the independent variable of interest, which that the effectiveness of WASH aid should be measurable five years or fewer after disbursement. Five year sums are the most commonly used measure of aid volumes in the literature. It may be reasonable to question whether a longer time period might not be appropriate. This is especially true in the case of the WASH sector because the infrastructure projects required to supply fresh drinking water and adequate sanitation may take several years to become fully operational. For the purposes of sensitivity analysis, therefore, all of the models were repeated using ten year sums of WASH aid. Results were broadly similar, with WASH aid showing a negative and statistically significant effect on child mortality, particularly among middle income countries; indeed, the elasticity of WASH aid when expressed as a ten year sum was substantially larger than the five year sum and had a smaller confidence interval.

Third, all of the models were repeated using listwise deletion to remove observations with missing data. This approach substantially reduced sample size, but did not affect the main results. Fourth, the models were estimated using only untransformed variables, as opposed to natural logs. Fifth, the subgroup analysis of potential constraints on WASH aid effectiveness was repeated using binary interaction terms that equal 1 if a potential constraint is present in a given country and equal to zero otherwise. These changes did not significantly affect the main results.

It may be the case that different components of WASH aid are more likely than others to result in measurable changes in the use of improved WASH facilities and human health in recipient countries. Eight subsectors of WASH aid were defined based on the Aid Data activity codes discussed above. The

per capital commitments for each of the eight activities were included as independent variables in a series of regressions. Table 5 shows reports the coefficients from the DPM regressions corresponding to each activity. As the table shows, the effectiveness of WASH aid varies not only among categories of recipient countries, but also according to the component of WASH being tested and the dependent variable with which it is compared.

Among the eight activities that are included in the WASH aid sector, several were found to consistently improved health outcomes. Aid for large water delivery and sewer systems, the largest activity in terms of commitments, consistently has a significant and positive effect on rate of use of improved WASH facilities and a negative effect on child mortality, but only in middle income countries. Water policy aid and aid for basic water and sanitation also only

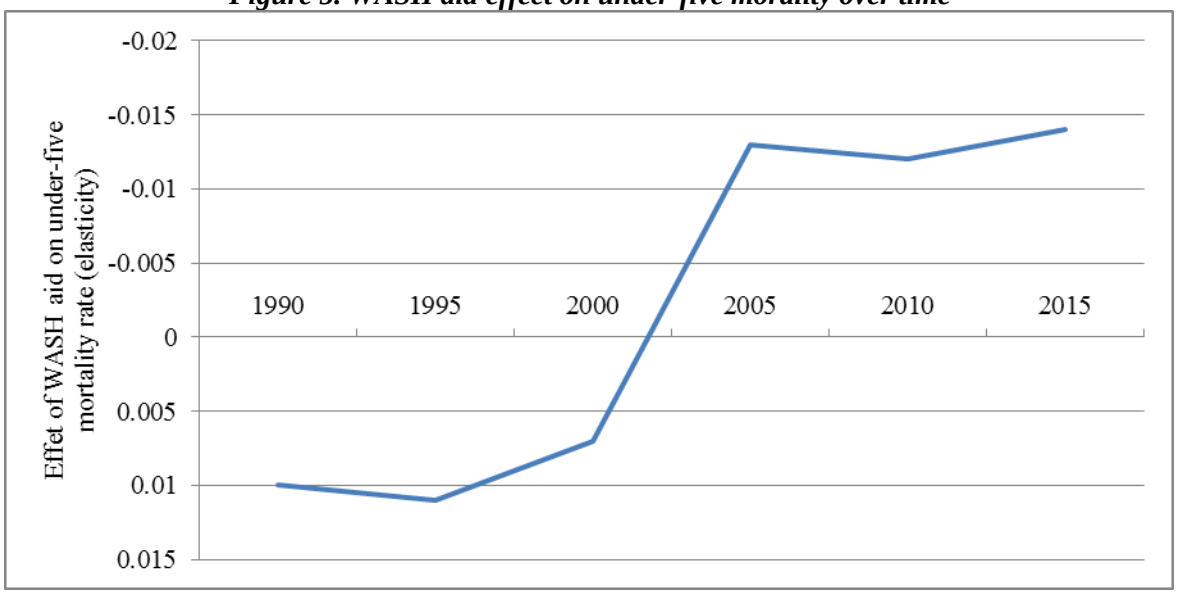
Table 4. Effectiveness of WASH aid by project activity category

Model: DPM	Under-five mortality rate		Use of improved water source		Use of improved sanitation	
Sample	Low Income	Middle Income	Low Income	Middle Income	Low Income	Middle Income
Basic Water Supply	-0.009* (0.005)	0.005 (0.004)	-0.062 (0.061)	-0.055 (0.065)	-0.034 (0.010)	0.075*** (0.023)
Water Training	-0.044* (0.025)	0.006 (0.032)	-0.045 (0.294)	-1.252 (1.161)	0.774** (0.333)	-0.160 (0.193)
Water Policy	0.011 (0.009)	0.004 (0.003)	-0.031 (0.057)	-0.026 (0.019)	-0.232 (0.212)	0.063*** (0.019)
Large Systems	-0.003 (0.006)	-0.001*** (0.000)	-0.015 (0.081)	0.045** (0.018)	0.044 (0.048)	0.053*** (0.015)
Waste Management	-0.021** (0.010)	-0.010*** (0.004)	-0.315 (0.260)	-0.102 (0.248)	0.166 (0.135)	0.057*** (0.021)
Water Research	-0.438* (0.224)	0.031 (0.132)	4.502* (2.322)	-0.161 (0.979)	-1.330 (2.982)	-1.132 (0.816)
River Development	0.012* (0.006)	-0.001 (0.004)	0.198*** (0.069)	-0.033 (0.029)	0.090 (0.077)	-0.007 (0.023)
Resources Protection	0.009 (0.007)	0.011* (0.006)	-0.015 (0.081)	-0.148 (0.157)	0.093 (0.078)	-0.017 (0.024)

*Notes: * p<0.10 ** p<0.05 *** p<0.01*
Standard errors in parentheses

Finally, the changing effectiveness of WASH aid over time was examined. Figure 5 below shows the results of a series of cross-sectional regression estimated for individual panels at five year intervals. Although not all of the coefficients are statistically significant, the Figure does show clear pattern of increasing effectiveness over time.

Figure 5. WASH aid effect on under-five morality over time



5. Conclusions

This paper contribute to an emerging literature investigating the conditions under which specific categories of foreign aid can be effective in producing positive development outcomes in recipient countries. The findings presented in this paper support a number of recent studies that have found evidence that some sectors of foreign aid can be shown to contribute to sector-specific development goals. This emerging literature stands in contrast to decades of research testing the aggregate effect of foreign aid on economic growth, which has been generally inconclusive—though largely negative—regarding the utility of aid as a tool for promoting development. Specifically, I find evidence that aid in the WASH sector has contributed to expanding access to clean drinking water and adequate sanitation in some, but not all, recipient countries. Specific types of institutional weakness and governmental policies are identified that tend to reduce aid's impact, including especially bureaucratic effectiveness and regulatory quality. The proportion of the population of recipient countries that resides in rural areas also appears to

affect the effectiveness of WASH aid; among countries with a majority rural population, there is only limited evidence for a statistically significant relationship between WASH aid and increased use of improved WASH facilities or reduced disease burden.

The major contribution of this study is the identification and testing of specific factors that affect the relationship between WASH aid funds and sector-specific outcomes. The results support the conclusions of Gopalan & Rajan (2016) and others that the effectiveness of aid differs among recipients as a function of institutional, economic, and demographic characteristics. The most important characteristics of recipient countries affecting the relationship between WASH aid and the outcome health indicators appear to be government effectiveness, regulatory quality, and rural population.

The WGI dataset measures government effectiveness in terms of perceptions of the quality of public services, the quality of the civil service, the degree of independence of the civil service from political pressure, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Specific attitudes that are included in the government effectiveness measure are satisfaction with public schools, public transportation, and basic health services, as well as bureaucratic quality and political instability. Regulatory quality measures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Taken together, therefore, the results suggest that WASH aid is less likely to contribute to positive outcomes in recipient countries in which an ineffective and unresponsive bureaucracy implements unfair competitive practices, price controls, excessive protections, and burdensome regulations.

Contrary to the findings of Gopalan & Rajan (2016), the proportion of the population of recipient countries that resides in rural areas also appears to affect the effectiveness of WASH aid; among countries with a majority rural population, there is only limited evidence for a statistically significant relationship between WASH aid and increased use of improved WASH facilities or reduced disease burden. This finding is consist, however, with many qualitative assessments of aid effectiveness in the WASH sector,

including recent UN GLAAS reports, which note repeatedly that rural areas are under-funded with respect to WASH investment.

Poverty itself appears to be a major—perhaps even the most important—constraint on WASH aid effectiveness. Low income and stagnant growth can lead to poor coverage for water and sanitation provision where cost recovery is an objective by constraining the ability of households to pay for service, which can detrimentally affect the sustainability of an infrastructure project. In countries where electrical service is poor due to entrenched poverty, the use of electric water pumps is constrained, limiting the impact that each dollar of WASH aid can have. Poverty may also affect the behavioral components of WASH aid. Financial constraints are also a widely cited reason for the lack of effective monitoring and evaluation of water projects, with potentially damaging consequences (Ndikumana & Pickbourn 2015).

Although studies such as this one are useful for identifying the characteristics of developing countries that may make them 'good' or 'bad' recipients of WASH aid, there is a pressing need for future research to investigate the extent to which aid can be used, in countries that possess the major constraints on aid effectiveness, to remove these constraints by building recipient country capacity. Given the proliferation of disaggregated data from AidData and other sources, it is now possible, as the preceding section shows, to test for impacts on development outcome of specific sub-sector activities, such as WASH policy development. A future research initiative is recommended to examine the effectiveness of foreign aid to contribute to capacity building in recipient countries, whether in the WASH sector or more generally, and to identify the specific activities that aid donors and their recipient partners can engage in to remove or ameliorate the constraints on aid effectiveness.

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