From Public Service Access to Service Quality: The Distributive Politics of Piped Water in Bangalore

Tanu Kumar
Postdoctoral Researcher
William & Mary
tkumar@wm.edu

Alison E. Post
Associate Professor
Political Science
U.C. Berkeley
aepost@berkeley.edu

Isha Ray
Associate Professor
Energy and Resources Group
U.C Berkeley
isharay@berkeley.edu

Megan Otsuka
Castlight Health
meganotsuka@berkeley.edu

Francesc Pardo-Bosch
Postdoctoral Scholar
Escola Superior d'Administració i Direcció d'Empreses (ESADE)
francesc.pardo@esade.edu

Abstract

The local public goods and distributive politics literatures focus overwhelmingly on government spending and service access. Yet service quality can vary dramatically and be targeted strategically. We provide one of the first analyses of a key dimension of service quality: intermittency, which affects vital services like water and electricity for hundreds of millions of people. We illustrate how to study it by highlighting both the specific facets of intermittency that are salient to citizens and that may be manipulated separately, and how infrastructure network structure shapes allocation. The existing literature shows that access to water connections (like access to many other local public goods) is typically associated with higher socio-economic status and residence in strategically important electoral districts. In contrast, we find that water flows through pipes more frequently and predictably in low-income areas—thereby underscoring the importance of studying intermittency, and service quality more generally, as distinct phenomena.

INTRODUCTION

The distribution of vital public services such as education, health, and electricity in low- and middle-income countries (LMICs) is a central theme in political economy. Much of this research examines how politicians disproportionately channel service access to members of the same ethnic or religious group, whether politicians are more likely to target swing or core voters, and other socio-political factors influencing allocation (e.g., Blaydes 2011; Cammett and Issar 2010; Kramon and Posner 2013; Golden and Min 2013). Identifying patterns of service access is essential to our understanding of whose needs are met or remain unmet under status quo arrangements. Service access, however, is not a guarantee of good quality service; given access, service quality can vary dramatically (e.g., Auerbach 2016; Bohlken Forthcoming; Callen, Gulzar, and Rezaee 2020).

In this paper we argue that intermittency is a crucial, yet understudied, form of service quality in the developing world that is just beginning to attract attention within political economy. Intermittent services are those that would ideally be delivered continuously, but are in fact discontinuous, often with unpredictable start and end times. For example, hundreds of millions of people with piped water access receive services intermittently—perhaps just one or two days a week, for a few hours at a time (van den Berg and Danilenko 2011). Many electricity systems deliver services discontinuously, with power interruptions occurring daily; urban customers in the least developed economies experience up to 100 times the service interruptions as those in the OECD countries do.[1] Mass transit services may also be intermittent, with departure times diverging from official

[1] Ratio calculated from values reported in Gertler et al. (2017, 25). On the prevalence of electricity blackouts in LMICs, see also Min (2015, 43–44).

schedules, and health clinics may operate at unpredictable times. Intermittency, these examples show, is commonplace in low- and middle-income countries, and distinct from other dimensions of service quality, such as safety (e.g. the quality of water delivered through piped networks), or adequacy (e.g. electricity at consistent voltage such that lights do not flicker).[2]

Relative to our rich understanding of how service access is politically allocated, little is known about how intermittency is allocated. Service continuity is rarely thought of as a public good in its own right, yet different areas of LMIC cities experience more or less intermittent services. There are reasons to expect that patterns may differ between access and intermittency. In the water sector, legally-independent utilities—that could be organs of state rather than municipal governments, or even private concessionaires—manage water allocations *within* piped water networks. In contrast, additional political actors influence the expansion of service network boundaries, and thus affect who can *access* the network; elected city-level officials or neighborhood associations, for example, often help finance service expansions to new areas. Thus, the actors that control water flows often have different mandates and are exposed to different political pressures than those controlling access. In addition, the unit at which targeting is feasible also differs for access and intermittency. A piped water connection can be granted at the household level provided there are supply lines in the vicinity, whereas once households possess network connections, water is distributed to entire network segments.

[2] While worker absenteeism can detract greatly from service quality (e.g. if a doctor is absent and one must see a community health worker without the same expertise), it is distinct from intermittency. The term "intermittency" refers to the complete, and typically unpredictable, disruption of services.

This paper makes three contributions to the Political Economy literatures on distributive politics and local public goods provision. First, we highlight the importance of service quality, and specifically service intermittency, as an understudied arena of distributive politics. Second, we make the case that the distributive politics of intermittency within infrastructure networks is significantly shaped by engineering requirements. Therefore, it is essential to understand the physical layout of the infrastructure, because services can only be politically manipulated by isolatable geographic segments within the overall network. Third, we define a rigorous approach to analyzing intermittency. This approach identifies and measures specific dimensions of service quality that are salient for citizens and that may be manipulated separately, such as predictability of service start and end times, service frequency, service duration, and throughput (i.e. pressure for water). We find that inadequacies along all dimensions may not co-occur. Whereas Kramon and Posner (2013) have shown that allocation patterns vary across different services, we show how different dimensions of quality can be differentially distributed within a single service.

We illustrate our approach by studying the allocation of intermittently-provided piped water services in Bangalore, India, a city of ~8.5 million.[3] We analyze a unique dataset containing geo-coded household-level survey information about intermittency, rather than relying on citywide averages.[4] We leverage fine-grained maps that depict each hydraulically-distinct network segment of the water network, or "valve area" (VA), in our study area in Eastern Bangalore. We find that VA-level characteristics predict variation in

[3] Population figure from the Indian census, 2011.
[4] E.g., IBNET reports average hours of service per day for water utilities across the globe.

service frequency and predictability. Existing scholarship on infrastructural inequalities in India and elsewhere has consistently found that social and economic exclusion is associated with poor access to piped water networks. However, we find that VAs in which large fractions of the population are low-income[5] or from Scheduled Castes or Scheduled Tribes (SC/ST) receive more predictable and frequent service.

The last section of our paper considers potential explanations of these pro-poor service allocations within Bangalore's piped system. We consider the hypothesis that there are political incentives to allocate more predictable water services to low-income and SC/ST voters because they comprise an important voting bloc with limited access to substitutes. A second hypothesis concerns the relative political insulation of Bangalore's state- (as opposed to city-) controlled water utility from local officials, and the resulting "professional" nature of the water utility. These hypotheses can serve as starting points for future research on how service quality, conditioned upon access, could cement or alleviate existing social inequalities in LMIC cities.

THE DISTRIBUTIVE POLITICS OF INFRASTRUCTURE SERVICES

Intermittency is understudied relative to service access

Our exhaustive search of published studies of local public goods provision in LMICs shows that the vast majority examines differing levels of expenditure on, and access to, services and distribution networks (e.g. Alesina, Baqir and Easterly (1999), Baldwin and Huber (2010) and Banerjee and Somanathan (2007); see Table SI.19). This

[5] "Low-income" is a relative term. Our main proxy for low-income household status is lack of possession of a motorized vehicle, such as a scooter.

literature considers how social and political factors affect variation in access and expenditures. A large body of work in distributive politics analyzes how the allocation of local public services disproportionately benefits particular ethnic, racial, or caste groups (see Golden and Min 2013). In the Indian case, Besley, Pande, Rahman and Rao (2004) find that this unequal allocation of services happens because local government heads steer public goods to members of the same caste; Chandra (2004) argues that politicians in patronage democracies like India favor voters of the same ethnicity;[6] and Bertorelli et al. (2017) find that lower caste and income groups receive worse public services in Bangalore. Min (2015), however, observes that the rural poor in Uttar Pradesh enjoy improved access to electricity during election years, due in part to the rise of a party championing scheduled-caste interests.

Urban political ecology research on the water sector in India and beyond also suggests that characteristics such as income, caste, religion affect household access to the water network. Because connections with politicians help to secure either formal or informal access to the water network, slum residents, and particularly poor households in outlying slums, possess lower rates of network connectivity. In Mumbai, for example, the poor (Gandy 2008; Graham, Desai, and McFarlane 2013) and Muslims (Contractor 2012; Graham, Desai, and McFarlane 2013) have lower rates of network access.

A second body of scholarship on distributive politics and local public goods provision emphasizes institutional and political variables over socio-demographic

[6] Recent scholarship suggests that caste favoritism, and even identification, may be decreasing in urban India (e.g., Banerjee and Somanathan 2007; Dunning and Nilekani 2013; Thachil 2017).

characteristics.[7] Studies examine whether democracies are more redistributive than autocracies in service-provision, especially to the rural poor (e.g., Min 2015; Trotter 2016). Scholars also debate the extent to which political actors steer access toward "core" supporters, as opposed to "swing" voters or districts, with active debates on whether or not higher levels of political competitiveness encourage more government spending on local infrastructures (e.g., Meseguer and Aparicio 2012). In India, some scholarship finds that elected officials strongly favor core supporters (e.g., Breeding 2011; Min 2015; Chandra 2004), or areas with dense networks of local party operatives (Auerbach 2016). Others find that elected officials target electorally vulnerable districts, or swing voters within such districts (Golden and Min 2013; on electricity, Baskaran, Min, and Uppal 2015; on roads, Bohlken Forthcoming). In general, heads of governments appear to allocate funds preferentially to districts controlled by members of their own party (i.e., aligned districts), whether they are swing or core. The presence of local leaders and intermediaries—who are often party operatives—also helps communities and households to secure benefits (Auerbach 2016; Jha, Rao, and Woolcock 2007).

Measuring intermittency

While there has been extensive scholarship on access and expenditures, the local public goods provision and distributive politics literatures have devoted far less attention to which groups secure *better* services within intermittent systems.[8] Other dimensions of

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[7] For a review, see Golden & Min (2013).
[8] See Table SI.19. Exceptions include Murillo (2009) and Min (2015), who discuss the repercussions of intermittent electricity service but do not examine its distributional incidence. (Min (2015) examines year-by-year aggregate variation in electricity delivery, rather than everyday fluctuations.) On the other hand, Miguel (2004) examines variation

service quality are addressed in fewer than one-fifth of these studies. Sector-specific work in other fields, however, recognizes intermittency in its own right. Studies on electricity have documented the prevalence of, and consumer dissatisfaction with, service disruptions and rolling blackouts (e.g., Aklin et al. 2016; Crane and Roy 1992). Engineering research suggests that intermittent water supply can reduce household consumption levels to below internationally recommended levels (Kumpel et al. 2017), and increases the likelihood that water becomes contaminated before reaching households (e.g., Kumpel and Nelson 2013). Intermittent service may also be *unpredictable* as official supply schedules are often inaccurate because of aging infrastructure systems, power outages, and administrative inefficiencies.

Intermittency tends to affect the poor disproportionately because they have worse access to substitutes for state services. Low-income households receiving intermittent and unpredictable water services, for example, must wait to collect and store water; higher income households have pumps that automatically fill storage tanks when water services commence, and the load-bearing roofs that such tanks require. Alternative providers such as private water vendors emerge to supplement state provision (Kjellén and McGranahan 2006; Solo 1999), but water from these sources is costly (see Post, Bronsoler, and Salman 2017).

Like all aspects of service quality, intermittency is multi-faceted. Studying the distribution of intermittency rigorously and systematically, therefore, should focus on multiple outcome variables. For example, several hours of water at low pressure and

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in the flow rate of well water, a measure of intermittency, in rural East Africa. Min (2019) examines the targeting of power outages in Ghana.

certain timing is not at all the same service as a short duration of flow with good pressure, arriving unpredictably. Household circumstances will determine which leads to higher coping costs. We identify four relevant dimensions: (a) the **frequency** of service; (b) the **predictability** of arrival times; (c) **throughput** (e.g. water pressure); and (d) the **duration** of supply intervals.[9] These dimensions of intermittency impact households differently, tend to be affected by different infrastructural constraints, and afford bureaucrats and elected officials different opportunities to influence allocations. Table 1 illustrates these dimensions for a range of local public services.

Table 1. Key Dimensions of Intermittent Services

	Water	**Electricity**	**Mass Transit**	**Primary Health Care**
Predictability	Whether or not piped water arrives at a specific time	Whether or not electricity blackouts or brownouts occur at specific times	Whether or not trains or buses arrive on schedule	Whether or not clinics are open consistently during working hours
Frequency	Number of times a week water is supplied	Number of times a week / month electricity blackouts or brownouts occur	Frequency of buses or trains, esp. relative to need	Frequency with which key services are available (vaccinations, exams, etc.)
Duration	Length of water supply sessions	Length of electricity supply session (or conversely of blackouts)	Length of service window during day (e.g. night services available?)	Hours per day when services are available

[9] We focus here only on intermittency. Price and safety are other dimensions of service quality.

Throughput	Water pressure during supply session	Voltage (higher or lower than necessary for electrical appliances and lights)	Capacity of vehicles, relative to demand	Number of patients that can be seen at a time or in a day per facility

Targeting intermittency

Recent work on the political ecology of the Indian water sector suggests that factors similar to those access to a piped water connection may explain the allocation of intermittently-provided water within the network. In ethnographic studies of water allocations in neighborhoods in Mumbai, Anand (2012) and Björkman (2015, 161) argue that city councilors pressure utility employees to reallocate water from one neighborhood to another, to allocate less water less reliably to informal settlements, and to discriminate against predominantly Muslim slums (Anand 2011b, 430). Rusca et al. (2017, 142) find similar conditions in Lilongwe, Malawi, where poor neighborhoods receive poor quality water and with lower frequency.

Nevertheless, distributional patterns may look different elsewhere. After all, the political actors who extend water networks may not be the same as those who manage water flows within them; their political mandates could differ. Moreover, the technical constraints on manipulating services vary significantly between water connections and water flows.

The specific physical characteristics of infrastructure networks such as those for electricity, water or rail services, and the material characteristics of the resources they carry, shape the targeting of services. That physical infrastructure constrains political allocations is rarely acknowledged in political economy scholarship. In electricity networks, power is allocated by substation-level distribution feeders within the transmission system. Urban water networks are constrained by the carrying capacities of water mains and distribution pipes to different sections of the city.[10] Elevation gradients within the system also affect flows.[11] Finally, when utilities do not possess sufficient water to fully pressurize the network at once, they pressurize small segments of the water network— "valve areas" servicing roughly 50 – 200 households—in rotation, distributing water to hydraulically isolatable neighborhoods at different points in time (Hyun, Post, and Ray 2018; Andey and Kelkar 2007; Ilaya-Ayza et al. 2017).

This means that utilities typically cannot target individual households, but must grant or withhold services from particular network segments at any one time. If a city cannot cut off power to a hospital, for example, the homes on the same distribution feeder will not experience blackouts, whatever be their income, caste or political affiliation. In other words, networked services are a form of club goods.

Scholarship on distributive politics typically analyzes the allocation of club goods by placing projects within political units, because this facilitates analyses of how services or infrastructure are targeted to elected officials and their constituencies. For example, Min and Golden aggregate data from electricity service divisions into political units (2014). Where detailed network map data exists, however, it is possible to examine allocations by network segments—these segments are often smaller than traditional

[10] See Tiwale *et al.* (2018) on the Lilongwe, Malawi case.

[11] Engineering research on water intermittency shows how network structure and elevation can contribute to inequitable allocations (e.g., De Marchis et al. 2011; Manohar and Mohan Kumar 2014).

political units, which allows for more fine-grained examination of patterns of service targeting *within* political jurisdictions. We take this more granular approach in our study.

OUR CASE: PIPED WATER SERVICES IN BANGALORE

We illustrate our approach to the distributive politics of intermittency by examining water flows within a section of Eastern Bangalore serviced by the utility's piped network. While patterns of *access* to the piped water network have been investigated in Bangalore (see below), there were no data sources on household-level experiences with intermittent water delivery when our study began. We undertook a large-scale survey of recipients of piped water to create a unique dataset capturing experiences with intermittency; this allowed us to assess the extent to which the main predictors of service access emphasized in the literature can also explain water intermittency.

Piped water and sewerage services in the metropolitan area are provided by the Bangalore Water Supply and Sewage Board (BWSSB). BWSSB is an organ of the state Government of Karnataka. The Karnataka government appoints BWSSB's governing board members, who must possess technical qualifications, and who cannot be elected officials. BWSSB's chairman is always a senior member of the prestigious and non-partisan Indian Administrative Service.

BWSSB is charged with serving one of India's largest cities: the 2011 Census put Bangalore's population at 8.5 million, but current (unconfirmed) estimates are closer to 11 million. It has been argued that BWSSB is a relatively well-functioning utility (e.g., Connors 2005; McKenzie and Ray 2009); comparisons with Delhi and Chennai from

2009, for example, show that Bangalore has good pipeline coverage, on average significantly more hours of water service per day (four times higher than Delhi), and a high revenue collection ratio (i.e. water paid for as a proportion of water sold).[12] Nevertheless, as late as 2000, roughly one-third of the population had partial or no access to the piped water network, with a lack of access concentrated among the poor (Benjamin 2000, 39).[13] In 2014, Krishna et al. found that households in newly settled slums with predominantly scheduled caste populations had no access to the city's water network (Krishna, Sriram, and Prakash 2014, 8).

In our study, we collected original data to capture variation in household-level experiences with intermittency.[14] In consultation with BWSSB and a local social enterprise called NextDrop, we located our study in Subdivision E3 (see Figure 1), one of the utility's 32 subdivisions.[15] This outlying area of ~200,000 inhabitants in Eastern Bangalore was connected to the utility's main network six years before our study, and thus possessed water supply infrastructure of reasonably consistent age and quality throughout.[16] The entire study area is served by a single reservoir, and is divided into 124 valve areas (VAs) that are pressurized in rotation (Figure 2). Situating our study fully

[12] These data are from the urban water benchmarking group IB-NET; website http://database.ib-net.org/quick?goto=one_click accessed August 2017. Bangalore and Delhi data were only available for 2009.
[13] In some areas, populations received no services despite being on the network and paying for services (see Connors 2005; Ranganathan 2014).
[14] Data for this study is already published through Dataverse; a link will be provided upon publication.
[15] This study was conducted jointly with an impact evaluation of household water notification services provided by NextDrop. See below for more detail.
[16] A small set of areas still received service from legacy piped "borewell" systems that included household connections. These were built by village and town governments before BBMP annexed this area.

within E3 also allowed us to control for a number of technical and administrative variables that could potentially affect allocations.[17] According to our survey data, 74% of households relied exclusively on the piped water supply, while the remaining 26% supplemented water received from BWSSB with that from other sources.[18] This area included a range of income, caste, and religious groups, as well as what BWSSB engineers estimated to be representative variation in service quality. Our focus on one subdivision made it feasible to develop a street-level sampling protocol, which is important given the inaccuracy of customer lists and other potential sampling frames. The limitation of this approach is that we cannot describe the allocation of intermittency citywide, nor can we assess the influence of infrastructural, social or political factors that do not vary within our study area.

Our 2015 survey in E3 confirmed that the subdivision contained variable service quality, despite the uniform age and condition of the water network. Over 85% of households received water services only once or twice a week, while some received services every day. About 70% of households reported that their water did not come at a predictable time. In other words, there was clearly variation in service quality to explain.

The demographics of our site were similar to those of Bangalore more broadly. E3 contained a range of settlement types, from areas dominated by middle-to-high income apartment blocks, to areas of lower middle-class housing, to precarious settlements.

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[17] The network is divided into six zones, each of which draws on different supply reservoirs that can provide differing levels of water service to utility customers. The Eastern zone, for example, receives comparatively low levels of water per capita: 83 liters per day compared with 149 liters in the South (Manohar and Mohan Kumar 2014, 614).

[18] All respondents indicated that they received piped supply. Our 2015 survey is described in greater detail below.

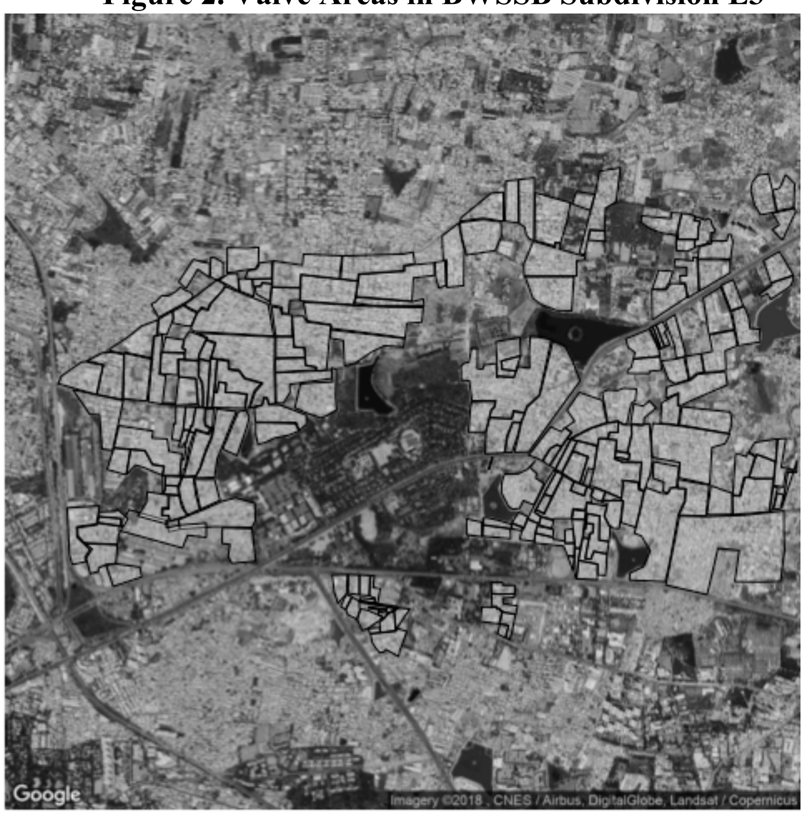
Consistent with the overall pattern in Bangalore,[19] these low-income clusters were very small, and sometimes contained religiously and ethnically mixed populations. The E3 income distribution was similar to the overall Bangalore population in broad terms, with roughly 33% falling within the bottom third of the city income distribution.[20] Furthermore, 12.5% of the households in the sample were Muslim families, compared with 13.9% of families in Bangalore overall according to the 2011 census. The subdivision had lower rates of extreme poverty than Bangalore as a whole, however: only 2% of the households in our sample possessed "kuchta" roofs (made from grass, thatch, mud, wood, or corrugated metal), whereas 2011-2012 IHDS data suggests that 15% of Bangalore households do. This is to be expected given that the poorest households live outside the reaches of the piped water network.

[19] In 2011, Bangalore's officially recognized slums contained an average of only 1209 residents. Newer, unrecognized slums are typically smaller in size.

[20] The 2011-2012 India Human Development Survey (IHDS) reports that 63% of the Bangalore population possessed a scooter or other type of motorized vehicle; in our study area, approximately 70% did. This is a similar ratio to urban India overall (75% for metropolitan areas, 73% for other urban locations) according to the IHDS. See: https://ihds.umd.edu/.

Figure 1. BWSSB Subdivision E3

Figure 2. Valve Areas in BWSSB Subdivision E3



Source: Valve Area maps courtesy of NextDrop, superimposed over Google satellite imagery.

Expectations for targeting in Bangalore's E3 subdivision

Given these background conditions, which groups might receive better quality piped water supply, in terms of predictability, frequency, duration, and throughput? The distributive politics literature would suggest that socio-economically disadvantaged groups receive access crucial services at lower rates, with the possible exception of those groups of households that serve as "vote banks" for particular political parties. As noted above, the political ecology literature finds these factors to be associated with water flows as well. Given the social and economic diversity of our study site, we are able to examine whether valve areas inhabited by members of particular social, ethnic, or income groups receive better quality water services than valve areas dominated by other groups. In particular, we can examine whether households living in valve areas with large numbers of SC/ST households, migrant households, Muslim households, low-income households, or those with a certain partisan affiliation received more intermittent services. Given that we administered our survey in 2015, a year in which city council elections were held, we are able to examine if strategic targeting occurred.[21]

Targeting by social characteristics should be possible where social groups cluster together, and these clusters are large enough to comprise large fractions of valve areas. Low-income neighborhoods, for instance —though smaller in Bangalore than in many cities—are typically larger than most VAs in our study area. Similarly, some VAs had large concentrations of Muslim households or of Congress party (INC) supporters,

[21] The municipal election was held in August 22, 2015.

suggesting that targeting by religion or party could also be possible (Figure SI.1).[22] Any correlations between household characteristics (such as income, religious affiliation) and service quality should be observable at the VA level.

While our main focus is the targeting of specific social and economic groups at the VA level, we also control for features of municipal wards, the smallest political units within which valve areas are located. Following the distributive politics literature, we focus on political alignment and district competitiveness. Our alignment variable reflects whether or not the ward councilor comes from the same party as that governing at the state level. Given that BWSSB is legally independent of the municipal authorities and is governed by state appointees, we would expect the party in control of the state, rather than of the municipal government, to have more influence over BWSSB's activities. A party governing at the state level interested in consolidating power at the city level could pressure the utility to provide better services in more competitive local districts, for example. Given the size of our study area, these dynamics would be observable primarily in terms of variation across city wards rather than state-level legislative constituencies. [23]

As noted earlier, our approach emphasizes how households experience the various dimensions of intermittency, as the incidence of these dimensions may not be correlated. We extend standard intuitions from the literature on water access to the four dimensions we identified (Table 2), noting that some dimensions of intermittency are easier to manipulate than others within piped networks. Given that the valves that allow water to

[22] Maps showing the VA-level concentration of other household characteristics available upon request.
[23] There are 198 wards, and only 28 state legislative (MLA) constituencies, in Bangalore. These wards each encompass roughly 15 valve areas.

flow in and out are operated manually, water service frequency and predictability could be allocated more generously to some VAs over others. Service frequency, however, is harder to manipulate in the short run than predictability because of interdependencies within the citywide water network.[24] Water pressure is also hard to allocate strategically because small hills and individually-owned "booster" pumps create elevation gradients within individual VAs. Households may also care about some dimensions more than others; storage-constrained households would be concerned with frequency of deliveries because long intervals between deliveries increase the risk of running out of water, whereas households whose members work away from home may need predictable services more than those with an adult member at home in the day. Manipulating the duration of supply sessions could be a strategic move in some contexts, and is possible once the VA is being serviced, but the majority of households in our study area possessed household (rather than shared) taps and did not need to queue for water. A supply session of 2-3 hours would typically be enough time to fill a household's storage containers.

Table 2. Dependent Variables: Dimensions of Water Intermittency

Dimension	**Expectations for Study Area**	**Operationalization**
Predictability	Targeting attractive & possible (within constraints) at VA level	• Does water come at a specific time of day or specific day of the week? • Are scheduled supplies ever cancelled?
Frequency	Targeting attractive & possible (within constraints) at VA level	• How many times a week does water arrive?

[24] Even given the nature of water supply infrastructure in places like Bangalore—which include informal connections, booster pumps, and the constant threat of new pipe bursts—utilities still rotate water pressure throughout their grids on rough schedules and can deviate from these when necessary; services outages may occur upon occasion, of course, because of the fragility of the system.

Duration	Targeting less attractive but possible at VA level	• How long does water stay on when it comes?
Throughput	Targeting attractive but very difficult	• How strong is water pressure during supply sessions?

THE DISTRIBUTION OF INTERMITTENCY IN EASTERN BANGALORE

Data and Sampling

To examine the allocation of intermittently-supplied water within E3, we created a geo-coded dataset of households that we placed in VAs, the smallest units of water allocation in Bangalore. This is the first time, to our knowledge, that such fine-grained data on the technical features of infrastructure have been incorporated into analyses of the distributive politics of water, or of infrastructure-based services beyond water.

We collected data in subdivision E3 through a two-wave in-person survey administered to the same set of households in April-May and October-November of 2015. The survey was designed and administered as part of a larger project, which included an impact evaluation of a text-messaged based system of notifications about water arrival times. We focus our analysis here on wave 1 data, which could not have been affected by the intervention. Within E3, we defined 10 low-income and 20 mixed income blocks to ensure that our study area was representative of the subdivision, and that it covered most of the residential area with piped water. We systematically sampled households within these blocks.[25] Enumerators asked to speak with the person responsible for managing the household's water supply, so 80% of our respondents were women. Given our sampling strategy and size of our sample (n = 2948), we do not

[25] SI Section II describes the data collection in greater detail.

expect that our study sample deviated significantly from the underlying population in the area, other than with respect to gender.[26]

Since we contend that services delivered through infrastructure networks must be targeted at the level of physical units, we measured valve-area as well as household level variables. We relied on maps that NextDrop had created so that they could place households within the correct VAs (see Figure 2). The utility itself did not possess maps of this infrastructure. VAs are invisible from the street level and have been modified extensively over time. Therefore the "water valvemen" charged with opening and closing valves were the ones with the best knowledge of VA boundaries. NextDrop personnel created the maps by walking the edges of the VAs with the valvemen and taking GPS coordinates. The maps thus represent a unique data source.

We placed our sample households in their specific VAs using household GPS readings we collected during our surveys.[27] Geographic coverage within these valve areas approximated the "every third household" sampling strategy we followed in our survey.[28] We sampled 23 households on average in each valve area. This allowed us to characterize each VA based on averaged survey responses from households residing in each area (see Table 3).

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[26] Some households did not respond to all of the survey questions, so the N for each of the regression tables varies.
[27] Three GPS readings with at least five-meter precision were taken for each household, and then averaged. We used QGIS to place households in VAs based on these coordinates. See SI. Section II for greater detail.
[28] Though our sampling protocol involved surveying every third household, households uniformly covered territory within VAs to different degrees due to variation in residential density. We therefore rated the "coverage" of each VA so as to conduct robustness checks with our analysis, ensuring results were robust to including only VAs with large numbers of household observations and good geographic distributions.

Table 3. Descriptive Statistics for Independent Variables

Variable	Mean	St. Dev.	Min	Max
HH level variables				
Elevation (technical control)	905.789	62.116	211.533	1,389.800
Cauvery Supply (technical control)	0.857	0.350	0	1
Muslim	0.125	0.331	0	1
Low income	0.300	0.458	0	1
Urban migrant	0.338	0.473	0	1
SC/ST	0.182	0.386	0	1
Congress supporter	0.196	0.397	0	1
VA level variables				
Muslim	0.139	0.241	0.000	1.000
Urban Migrant	0.347	0.229	0.000	1.000
Low income	0.307	0.231	0.000	1.000
Local Leader	0.447	0.499	0	1
SC/ST	0.231	0.263	0	1
Congress supporter	0.237	0.209	0	1
Ward level control variables				
Margin of victory	0.098	0.091	0.0005	0.237
INC Corporator	0.286	0.488	0	1

Dependent variables

Our survey questions captured all four dimensions of water allocation in intermittent systems (Table 2, above): (i) predictability of water arrival times; (ii) service frequency; (iii) duration, or the average length of a delivery session; and (iv) water pressure (i.e., throughput), which can greatly affect the availability of water for different household uses. Table 2 (above) shows these dimensions, and the survey questions that operationalized them as dependent variables. For all dependent variables, a higher category indicates better service.

We used our household survey responses to measure the specific dimensions of intermittency (Table 4), as BWSSB and similar utilities in low and middle-income countries do not possess this information at such a granular level. To avoid concerns about the potential subjectivity of survey responses, we piloted our questions extensively, and found that respondents tended to describe supply schedules and conditions in similar terms.[29] Correlations between the responses of households living in particular VAs suggest that respondents perceived similar supply conditions with respect to particular dimensions of intermittency, especially frequency and predictability.[30] Figure 3 illustrates variation across VAs in the number of days between water supply sessions; notably, household-reported variation is far greater than that of the water utility's official supply schedule. However, the correlation between different dimensions of intermittency at the household level was low, underscoring our intuition that the logic of allocation for each likely varies (Table 5).

[29] For example, respondents who received regular service would generally be able to name specific supply windows, such as "Tuesday mornings."

[30] The intra-cluster correlation (where a valve is considered a cluster) for the number of days between water supply sessions is 0.54, and for whether or not water arrives at a specific time is 0.29.

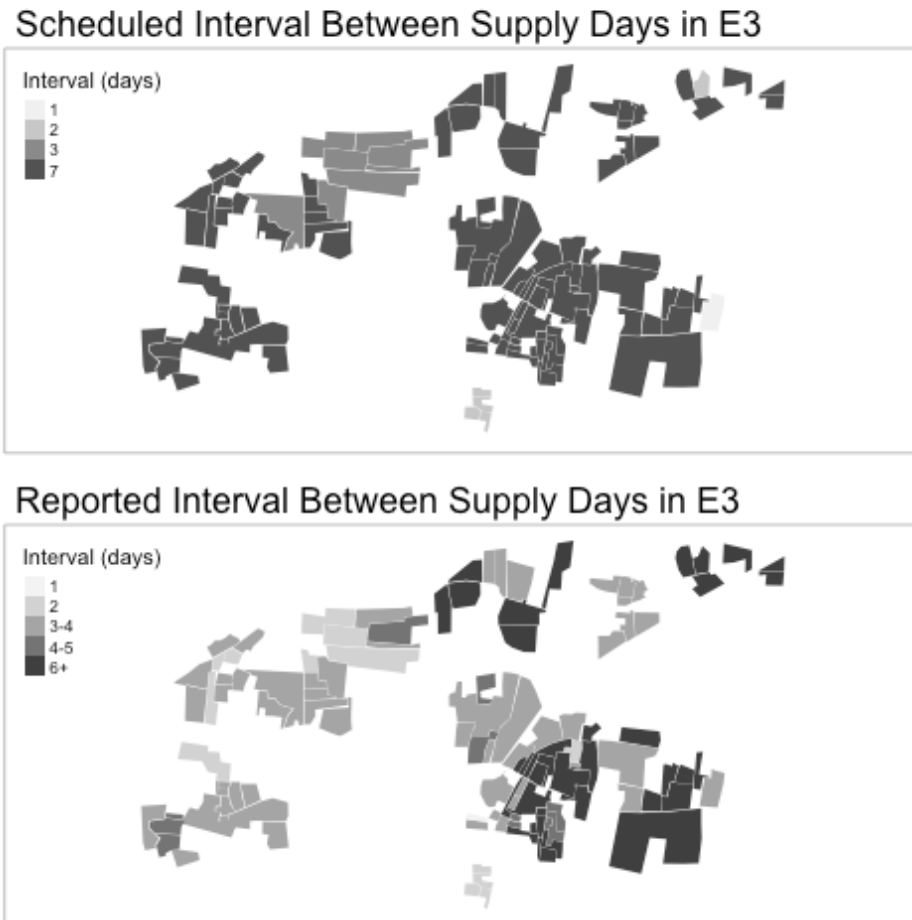
Table 4. Tabulated Responses for Dependent Variables

Variable Response option	N individuals choosing response
Whether water comes at a specific time	
Yes	805
No	2045
Interval between supply days	
Everyday	69
Every 2 days	409
Every 3-4 days	1434
Every 4-5 days	286
Every 6+ days	705
Duration of water when it comes on	
Less than 2 hours	548
2-3 hours	956
3-4 hours	771
4+ hours	584
Whether or not service is cancelled on supply days	
No	1030
Rarely	750
Yes	712
Water pressure level	
Weak	240
Moderate	1748
Strong	444

Table 5. Spearman rank correlation matrix for service quality measures at household level

	Predictability	Service Frequency	Duration	Cancellations	Pressure
Predictability	1.00	-0.02	0.06	-0.18	0.07
Service Frequency	-0.02	1.00	0.08	-0.07	0.05
Duration	0.06	0.08	1.00	0.02	0.12
Cancellations	-0.18	-0.07	0.02	1.00	0.00
Pressure	0.07	0.05	0.12	0.00	1.00

Figure 3. Day Intervals Between Water Supply in BWSSB Subdivision E3



Note: Scheduled supply day intervals from BWSSB. Reported interval map displays modal responses from household surveys geo-located in each VA.

Main independent variables

We also collected data on household characteristics that the literature reports to be associated with more or less privileged access to services (Table 3). These include household income, religious affiliation, SC/ST status, migrant status, and partisan affiliation. We assessed household socio-economic status through multiple measures, including household assets (such as possession of a motorized vehicle), and self-placement in income brackets. We measure these variables at both the household and

VA-level to reflect the fact that targeting might happen at either level. Figure SI.1 portrays VA variation in the percentage of low-income and Muslim households.

Technological controls

We also asked respondents whether or not they received water through the Cauvery system (i.e. through relatively new pipelines carrying river water) in addition to or instead of the legacy borewell systems, an older and inferior form of household piped supply. Given its recent installation, Cauvery service would likely be associated with better service on all intermittency dimensions. We also recorded the elevation of each household, as higher elevations are typically harder to service. We measure these variables at the household level, as these features can vary at the household level within VAs.[31]

Political controls

We also placed the VAs within wards, the main unit of political representation in Bangalore, to account for the possibility that governing parties may target "swing" or "core" districts. Eight of Bangalore's 198 wards fall into E3. We placed VAs in the wards based on where the majority of the populated territory fell.[32] For each ward, we collected data on the partisan affiliation of the ward representative (corporator), which told us whether s/he came from the same party as the party in control of the state in

[31] In a number of cases (14.2%), households retained access to the legacy borewell (CMC) system while also receiving new Cauvery services, and a small number of households (4.8%) received piped water from the CMC system only.

[32] We used Google Earth satellite imagery to place VAs in wards. One VA was split evenly between two wards, so we dropped it from the analysis.

Spring 2015, the Congress (INC) party. This allowed us to control for the possibility that the governing Congress party targeted "core" constituencies by including a variable for Congress control at the ward level. To control for the possibility that Congress targeted "swing" wards, we calculated a margin of victory measure for the 2015 elections following Golden and Min (2013). We interacted this with Congress control, because these are the competitive districts in which Congress could claim credit for influencing water services. Given the small number of wards in our dataset, we treat these primarily as control variables in the empirical analysis. We also included a VA-level variable reflecting the presence of a local leader to whom residents could take their concerns, which was measured as the percentage of survey respondents reporting the existence of a local leader in their area.

Modeling Strategy and Results

As our dependent variables are dichotomous or ordinal in nature, we estimate logistic and ordinal logistic models to assess the relationship between household, VA, and ward characteristics, and five dependent variables capturing the four different dimensions of water intermittency: predictability (of arrival time plus frequency of supply cancellations), frequency, supply duration, and pressure.[33]

[33] There are several flavors of ordinal logistic regression. Ours uses the following parameterization:

$$\log\left(\frac{P(Y>j)}{1-P(Y>j)}\right) = S_j = \alpha_j + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p, \quad j = 2,\ldots, J-1, J$$

where J represents the number of levels in the dependent variable, and p represents the number of independent variables. This cumulative logit parameterization specifies that the outcome of interest is observing a particular value of the dependent variable or greater (Parry 2016).

These models include not only household-level characteristics such as religion, but also VA attributes such as the percentage of Muslim households.[34] Model 1 contains all of our household and valve-area predictors, and clusters standard errors by VA. Clustering standard errors by valve areas helps account for any unmeasured heterogeneity between valve areas in terms of their underlying infrastructure. Model 2 substitutes ward fixed effects for clustered standard errors at the VA level to see if patterns are driven by unobserved ward-level heterogeneity. In Model 3, we add a variable reflecting whether or not the ward's corporator is aligned—i.e., from the same party as that which controls the state government (the INC for this period)—and again cluster standard errors by VA. In Model 4, we control for political background conditions by interacting alignment with the margin of victory in a given ward during the 2015 election cycle.[35] All standard errors are computed using a bootstrapping technique.

Our modeling strategy also acknowledges the strong correlations among several of our measures of valve area characteristics (Table SI.1). The low-income valve area variable is strongly correlated with the SC/ST valve area measure (0.59). Similarly, our percentage Muslim variable is strongly correlated with the percentage supporting the Congress party (0.46). We include each of the highly correlated variables on its own in

[34] We also estimate "naïve" models that examine the relationship between intermittency and household characteristics cited in the literature--such as religion and income--but ignore the location of households in VAs. The results of these analyses are presented in Tables SI.17 and SI.18. They suggest that unless one accounts for VA-level variables, it appears that household characteristics are associated with differing service quality.

[35] We cannot include ward fixed effects in Models 3 and 4 because our data is cross-sectional and we include ward-level variables. We do not have sufficient variation in the data to fit a model containing clustered standard errors in Model 4.

the models, as well as place both in the model, to assess the strength of the relationship of each characteristic with the dependent variables.

Our models of supply predictability and frequency provide strong evidence that targeting of specific groups occurs at the VA level. Predictability and frequency are arguably the two most important dimensions in reducing the time needed to wait for, collect and store water. Low-income and SC/ST VAs receive more rather than less predictable water supply, and more frequent services. VA characteristics appear less important for other indicators of service quality (Tables SI.2-SI.4).

Table 6 reports results for whether or not water comes at a specific time. Here, the main variable consistently associated with more predictable water arrival times, across specifications, is the percentage of households in the VA that are low-income. For Model 1, a one standard deviation increase in the low-income VA variable (a 19% increase in the proportion of low-income households in each VA), the odds of water arriving at a specific time are 59% greater (see Figure 4).[36] This finding runs counter to the sizeable consensus in the literature that economically marginal populations receive worse water services, if they receive it at all. Other VA characteristics we might expect to be important based on the literature are not consistently associated with predictability: the presence of local leaders is not significant across specifications, suggesting that local leaders may not always be channels to better services; and variables reflecting a large Muslim or migrant population experience less predictability, but results are not significant across specifications. (Note that the number of VAs containing majority

[36] To calculate the odds ratio, we used the formula OR = $e^{\beta * a}$, where β is the log-odds regression coefficient and a is the change in X for which we are calculating a change in the odds ratio.

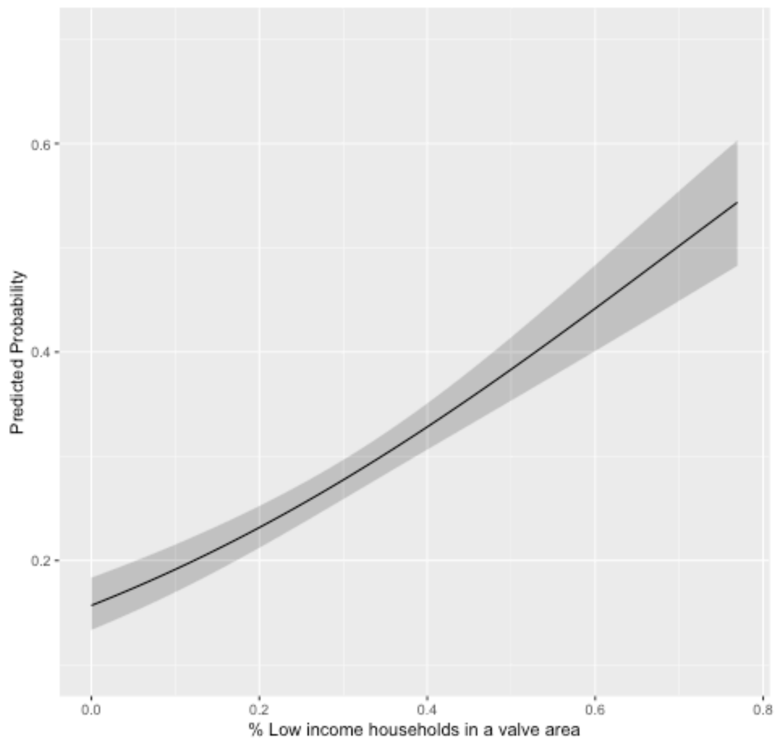
Muslim households is much smaller than the number of VAs with majority low-income households (Figure SI.1)). When Congress support is substituted for our household and valve area level Muslim variables, it is also not consistently significant across specifications (Table SI.5). The association between the low-income VA variable and predictable services remains statistically significant even when we control for the margin of victory in the latest elections and the corporator's alignment with the party governing at the state level. When the percentage SC/ST is substituted for the low-income valve area variable, we observe a similarly strong relationship with more predictable services (Table A.1). When both of these highly-correlated variables are included in the model, the SC/ST relationship is more robust (Table SI.7).

Table 6. Predictability of Water Supply in Eastern Bangalore, April-May 2015

	Whether water arrives at a specific time			
	(1)	(2)	(3)	(4)
Household-level characteristics				
Elevation	-0.001	-0.002*	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Cauvery Supply	0.252	0.201	0.273	0.221
	(0.357)	(0.131)	(0.361)	(0.125)
Urban Migrant	-0.083	-0.088	-0.082	-0.081
	(0.088)	(0.103)	(0.086)	(0.101)
Muslim	0.166	0.195	0.165	0.175
	(0.156)	(0.168)	(0.163)	(0.162)
Low income	0.084	0.090	0.084	0.087
	(0.099)	(0.102)	(0.098)	(0.101)
VA-level characteristics				
Urban Migrant	-0.526	-1.267***	-0.971	-1.577***
	(0.804)	(0.366)	(0.976)	(0.331)
Muslim	-0.288	-0.900**	-0.377	-0.951***
	(0.583)	(0.310)	(0.564)	(0.285)
Low Income	2.413**	2.184***	2.542**	1.756***
	(0.777)	(0.307)	(0.773)	(0.270)
Local leader	-0.172	-0.239*	-0.198	-0.174
	(0.248)	(0.101)	(0.247)	(0.096)
Ward-level characteristics				
Margin of victory				-5.750***
				(0.683)
INC Corporator			0.459	-0.026
			(0.323)	(0.135)
Margin X INC Corp.				-106.179***
				(5.404)
Constant	-0.680	0.763	-0.832	0.847
	(0.836)	(0.743)	(0.820)	(0.746)
Ward dummies	No	Yes	No	No
SEs clustered at VA	Yes	No	Yes	No
N	2,850	2,850	2,850	2,850
R^2	0.069	0.142	0.077	0.124
chi^2	140.992***(df = 9)	297.556***(df = 15)	156.118***(df = 10)	257.184***(df = 12)

*p < .05; **p < .01; ***p < .001. Logistic regressions were used to estimate models. The higher category indicates that water arrives at a specific time. A positive log odds coefficient indicates that as the value of the independent variable increases, the likelihood of having predictable water increases.

Figure 4. Predicted probability for whether water comes at a specific time (Model 1)



Our results from models of weekly service frequency (Table 7) also show similar patterns. Valve areas comprised more heavily of low-income households receive more frequent supply in most, but not all, of our specifications.[37] A one standard deviation increase in the percentage low-income VA variable is associated with a 45% higher odds of more frequent service (Figure 5). When we substitute our percentage SC/ST valve area variable for the percentage low-income variable, we consistently observe a significant positive relationship; valve areas with larger SC/ST populations receive water supply

[37] When INC support at the household and valve area level is substituted for our Muslim variables, the VA area level variable is inconsistently associated with less frequent service.

more frequently (Table A.2).[38] Valve areas with larger fractions of Muslims or urban migrants receive less frequent services in the specifications including ward fixed effect or ward-level political variables, but not in models including standard errors clustered by valve area, leaving us less able to reach firm conclusions regarding these patterns. The presence of local leadership in the VA is not consistently correlated with service frequency across specifications. These patterns remain unchanged even when we include control variables for the margin of victory, alignment, and the interaction between the two.

Results for our other dependent variables display no striking patterns of allocation (see Tables SI.2-SI.4). In these cases, no household-level predictors other than Cauvery supply exert a consistent effect; as we would expect, supply duration and water pressure are better for the relatively new Cauvery connections, and supply cancellations are less frequent. Valve area characteristics appear less important here, as well; however, valve areas with larger fractions of urban migrants do report receiving supply cancellations less often, which may indicate that migrants are settling in areas with more dependable services.

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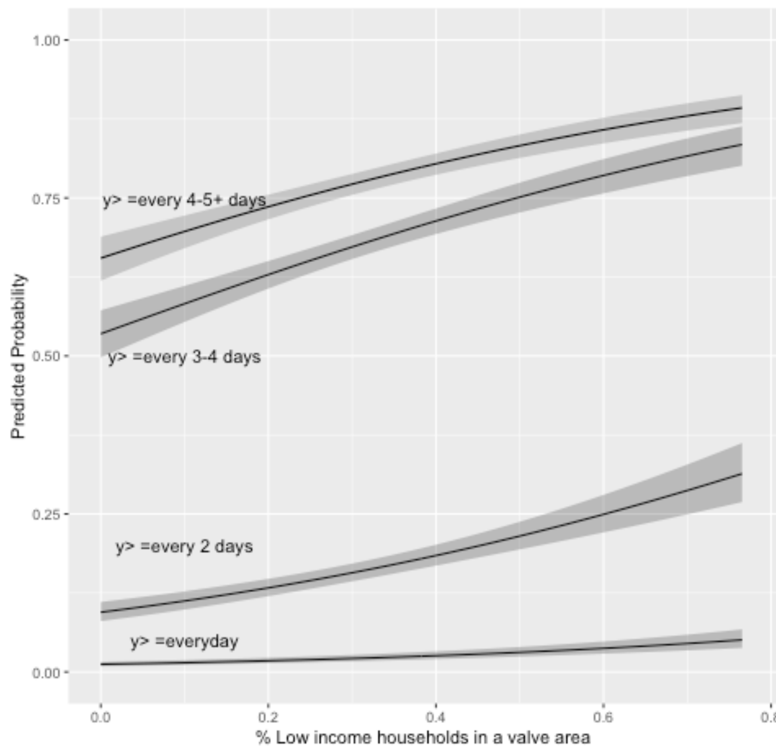
[38] When we include both variables in the model, both variables lose significance, reflecting their strong correlation (Tables SI.7 and SI.8).

Table 7. Water Supply Frequency, Eastern Bangalore, April-May 2015

	Water Supply Frequency			
	(1)	(2)	(3)	(4)
y> =every 4-5 days	-0.042	-1.492	0.586	1.144
	(0.936)	(0.792)	(0.952)	(0.781)
y> =every 3-4 days	-0.541	-2.137**	-0.048	0.503
	(0.913)	(0.793)	(0.912)	(0.782)
y> =every 2 days	-2.942**	-4.849***	-2.696**	-2.150**
	(0.937)	(0.802)	(0.906)	(0.785)
y> =everyday	-5.089***	-7.054***	-4.864***	-4.313***
	(1.098)	(0.819)	(1.065)	(0.805)
Household-level characteristics				
Elevation	0.002*	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Cauvery Supply	-0.250	-0.348*	-0.397	-0.416**
	(0.341)	(0.135)	(0.390)	(0.139)
Urban Migrant	-0.078	-0.108	-0.109	-0.110
	(0.064)	(0.084)	(0.074)	(0.084)
Muslim	-0.042	-0.040	-0.053	-0.050
	(0.105)	(0.118)	(0.110)	(0.112)
Low income	0.013	0.003	0.001	0.001
	(0.074)	(0.086)	(0.082)	(0.087)
VA-level characteristics				
Urban Migrant	-1.488	0.710*	0.559	0.436
	(0.935)	(0.282)	(0.864)	(0.255)
Muslim	-1.367	-1.032***	-1.092	-1.319***
	(0.824)	(0.281)	(0.802)	(0.249)
Low Income	1.930*	1.074***	1.517	1.217***
	(0.933)	(0.252)	(0.907)	(0.248)
Local leader	-0.006	0.368***	0.133	0.143
	(0.324)	(0.090)	(0.322)	(0.077)
Ward-level characteristics				
Margin of victory				-1.884***
				(0.490)
INC Corporator			-2.476***	-2.634***
			(0.389)	(0.129)
Margin X INC Corp.				-31.260
				(77.041)
Ward dummies?	No	Yes	No	No
SEs clustered at VA	Yes	No	Yes	No
N	2,903	2,903	2,903	2,903
R^2	0.072	0.282	0.256	0.264
chi^2	200.138***(df = 9)	877.614***(df = 15)	782.919***(df = 10)	811.251***(df = 12)

*p < .05; **p < .01; ***p < .001. Ordinal logistic regressions were used to estimate models. A higher category indicates more frequent service. The reference category is "y=every 6+ days." A positive log odds coefficient indicates that as the value of the independent variable increases, the likelihood of getting more frequent service increases.

Figure 5. Predicted probability for water supply frequency (Model 1)



The strong association between lower VA socioeconomic status and more predictable and frequent service remains highly significant under a variety of additional robustness checks. To address possible measurement bias for our independent variables, we dropped from our analysis any VAs for which we had low levels of coverage by surveyed households.[39] Similarly, since many VA characteristics were calculated based on household responses, we dropped VAs with two or fewer household responses to

[39] To code the survey coverage of each VA, we first calculated the total acreage comprised by each VA using QGIS and categorized VAs as small (under 10 acres), medium (10-20 acres), or large (greater than 20 acres). Coverage categories of poor, fair, good, or very good were then assigned to each VA. Poor coverage VAs were those with surveyed households only on the edges for small VAs or in one corner for medium or large VAs. Only areas occupied by households were included in this process; areas occupied by vacant land or a lake were ignored. Results for predictability and frequency are in Tables SI.11 and SI.12.

questions regarding religion, household assets, migrant status, etc. (11 of the 123 VAs). Low-income (or SC/ST) populations remained strongly associated with more predictable service, and to lesser extent with service frequency.

It could be argued that respondents from households with automatically filling water tanks might be less informed about the frequency and predictability of water supply, and that this might have affected our results. We repeated our analysis on the subset of our sample without such tanks, and obtained similar results.[40] To address the concern that the new Cauvery pipelines in E3 might have been systematically extended to particular groups—and that our Cauvery variable might therefore introduce post-treatment bias—we estimated our models with the only subset of households receiving some Cauvery supply, dropping the households that received only CMC supply.[41] Another robustness check employed an alternative method for classifying households as low-income, namely an indicator for whether or not they reported a household monthly income of less than Rs. 10,000 per month.[42] Results in all these cases were similar to those of our main models.

Finally, it is possible that rather than revealing real patterns of service delivery, our results are simply driven by a bias in measurement. It could be argued that respondents from low-income households would be less likely to report dissatisfaction with their water service than higher-income respondents, because their expectations of

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[40]See Tables SI.13-SI.14.
[41] As an example: if lower income areas were less likely to receive Cauvery service, then a regression estimating the association between low-income VA status that controls for Cauvery service might underestimate the impact of low-income VA status on service quality (See Tables SI.9-SI.10).
[42] See Tables SI.15-SI.16.

government bureaucracies are low in general.[43] Our household surveys did, in fact, report high levels of satisfaction with BWSSB as a utility across class and caste. Nevertheless, this measurement problem is likely to apply to Muslim respondents as well, as this marginalized group is also likely to have low expectations of government bureaucracy. We do not, however, see similar patterns of allocation for Muslim households and valve areas, suggesting our results are not driven by measurement bias.

DISCUSSION

The strong and significant association between economically and socially marginal populations and more frequent and predictable services is in contrast to almost all the literature on income groups and infrastructure access.[44] While we observe these associations within just one part of the city, they are nonetheless striking, especially given the social and economic diversity of the district. While we are not in a position to offer a definitive account of these results, we can offer some hypothetical explanations that build on previous work and suggest fruitful avenues for future research.

One possible explanation is that politicians distribute benefits and services in these communities to create "vote banks" for elections (e.g., Breeding 2011). State-level elected officials may know that low-income households struggle most with water intermittency and may therefore direct the utility to deliver more frequent and reliable services to

[43] Franceys and Jalakam (2010) found that low-income populations in Hubli, India, adjusted their expectations after becoming accustomed to poor service quality.
[44] While Min (2015) finds that the rural poor were more likely to access electricity during election years than at other times in the Indian state of Uttar Pradesh, this increased access did not come at the expense of higher income users; rather, excess power was purchased from the central grid and distributed to poor villages during election years.

predominantly low-income VAs. Moderate- to high-income households with automatic tanks, in contrast, are less exposed to the costs of intermittency. They would be less likely to shift their political support in response to modest improvements (or deteriorations) in supply. A predominance of SC/ST households in a particular VA may serve as a proxy for socio-economic status for utility employees who are interested in targeting low-income households—a reasonable assumption given that many SC/ST households are low-income. Additionally, elected officials may wish to specifically target SC/ST voters; this is plausible given reports of increasing partisan competition over the SC/ST vote in Karnataka.[45] Though the political variables included in Tables 6 and 7 serve as controls, our results provide some indication that particularly competitive wards received more predictable and frequent water services during an election year, especially when an "aligned" city councilor from the Congress party held office.

The patterns we observe may instead (or also) suggest that the BWSSB management exercises a substantial degree of autonomy from local officials and has decided to deliver more frequent services to populations it knows to be in need. Several factors could explain BWSSB's independence. First, BWSSB—unlike the politicized Mumbai water utility (see Anand (2011a); Björkman (2015))—is an organ of the state, rather than the city, government. Yet the elected representatives most active at the neighborhood level are corporators—city ward representatives. Their links with BWSSB officials are generally informal and indirect.[46] In addition, BWSSB is a legally

[45] For example, see: https://timesofindia.indiatimes.com/india/the-caste-factor-in-karnataka-why-rahul-gandhi-and-amit-shah-are-mutt-hopping/articleshow/63725848.cms.
[46] Our conversations with BWSSB engineers corroborated this point.

independent, professionalized enterprise rather than a state government ministry, which means that even state-level elected officials may have limited influence on its operations. Benjamin (2000) critiques this institutional format for water service in Bangalore precisely because elected officials are bypassed. BWSSB has shown itself willing to improve services for slum residents in the past through network extension projects into poor districts (see Connors 2005), which lends some credence to this perspective.

A third possibility is that economically and socially marginal VAs may enjoy better service because the valvemen responsible for opening and closing water valves exercise some discretion as they move water around. Our ethnographic research in another district in Bangalore, however, found that though many valvemen felt strong connections with low-income communities (see also Björkman (2015) on Mumbai), and did have some control with respect to duration of flow, they did not generally have control over service frequency or predictability. We therefore find the first two structural explanations to be more compelling than one centered on valveman discretion.

CONCLUSION

In this paper, we highlighted the importance of service intermittency, and the delivery of service quality more broadly, as a mode of distributive politics in the developing world. We also showed that intermittency has multiple dimensions, such as frequency, predictability and duration of supply, not all of which may be allocated according to the same criteria.

Analyzing four different dimensions of intermittency reveals that all forms of service quality may not be correlated – households may receive services that are good on one dimension and poor on others. Our model results highlight the extent to which the benefits and burdens associated with these delivery dimensions can be distributed differently. While low-income and SC/ST VAs in our study experienced more predictable and frequent services, they did not receive noticeably different water pressure levels or fewer supply cancellations. Research on the distributive politics in other infrastructure-based sectors, such as electricity and public transit, or on other services more broadly, would profit from examining how dimensions of intermittency in these services work to cement or alleviate urban inequalities.

Electoral incentives, BWSSB management's relative insulation from local politics, or some combination of these, could explain why the patterns of allocation we observe *within* the water network in Eastern Bangalore do not reflect patterns of *access to* the water network observed by other scholars in the Bangalore metropolitan area, as well as elsewhere. *Within-network* allocations may, under conditions such as those in our study area, be more pro-poor. However, we acknowledge that the poorest of the poor typically reside outside water networks, and would be included in studies assessing access patterns. They are excluded from our data set because they could not benefit from redistributive practices within the water network.

Our findings should serve as a prompt for further research on infrastructure and inequality. Scholarship should assess whether similar patterns are observed elsewhere in Bangalore, in more residentially segregated cities,[47] and in cities with different institutional arrangements for water management, as well as during non-election years. In addition, understanding how elected official interface with legally-independent utilities, the

[47] See Gayer and Jaffrelot (2012) on variation in segregation across Indian cities.

organizational structure and financing of service provision, and the behaviors of street-level bureaucrats in local public goods provision would provide a better understanding of the *implementation* of distributive politics (see Williams 2017).

These potential explanations aside, our results demonstrate that, when studying the allocation of service quality within a network, knowledge about physical networks can shed light on political patterns shaping service delivery. Within the piped water network, the unit of distribution – and therefore of discrimination – is a hydraulically isolatable area and not a household or political district.

We also note that the distributional patterns we observed here reveal the variation in service quality experienced across neighborhoods from different socio-economic strata in Bangalore. Much compelling political economy scholarship on local public goods provision and distributive politics focuses on explaining variation within and across slums (e.g., Auerbach 2016; Krishna, Sriram, and Prakash 2014; Jha, Rao, and Woolcock 2007). While such analyses uncover important variation in what particular low-income groups receive, they do not address broader patterns of allocation that operate at the city scale.

Overall, our study of intermittency demonstrates that crucial dimensions of service quality can vary greatly even among those who have access to a service. To understand the causes and predictors of this variation, it is essential to disaggregate service quality into different dimensions that may be perceived and targeted differently. Analyses of the distribution of infrastructure services like water and electricity must also consider how infrastructure networks channel allocations, as well as how infrastructural units relate to underlying settlement patterns. Such analyses are necessarily granular in scale and require significant investment in collecting data on everyday service quality, which is rarely done in our field.

WORKS CITED

Aklin, Michael, Chao-yo Cheng, Johannes Urpelainen, Karthik Ganesan, and Abhishek Jain. 2016. "Factors Affecting Household Satisfaction with Electricity Supply in Rural India." *Nature Energy* 1 (November): 1–6.

Alesina, Alberto, Reza Baqir, and William Easterly. 1999. "Public Goods and Ethnic Divisions." *Quarterly Journal of Economics* 114 (4): 1243–84.

Anand, Nikhil. 2011a. "PRESSURE: The PoliTechnics of Water Supply in Mumbai." *Cultural Anthropology* 26 (4): 542–64. https://doi.org/10.1111/j.1548-1360.2011.01111.x.

———. 2011b. "Toward an Anthropology of Water in Mumbai's Settlements." In *A Companion to the Anthropology of India*, edited by Isabelle Clark-Deces. Blackwell Companions to Anthropology. Wiley-Blackwell.

———. 2012. "Municipal Disconnect: On Abject Water and Its Urban Infrastructures." *Ethnography* 13 (4): 487–509. https://doi.org/10.1177/1466138111435743.

Andey, Subhash P., and Prakash S. Kelkar. 2007. "Performance of Water Distribution Systems during Intermittent versus Continuous Water Supply." *Journal AWWA* 99 (8): 99–106. https://doi.org/10.1002/j.1551-8833.2007.tb08011.x.

Auerbach, Adam Michael. 2016. "Clients and Communities." *World Politics* 68 (01): 111–48.

Baldwin, Kate, and John D. Huber. 2010. "Economic versus Cultural Differences: Forms of Ethnic Diversity and Public Goods Provision." *American Political Science Review* 104 (04): 644–62.

Banerjee, Abhijit, and Rohini Somanathan. 2007. "The Political Economy of Public Goods: Some Evidence from India." *Journal of Development Economics* 82 (2): 287–314.

Baskaran, Thushyanthan, Brian Min, and Yogesh Uppal. 2015. "Election Cycles and Electricity Provision: Evidence from a Quasi-Experiment with Indian Special Elections." *Journal of Public Economics* 126 (June): 64–73. https://doi.org/10.1016/j.jpubeco.2015.03.011.

Benjamin, Solomon. 2000. "Governance, Economic Settings and Poverty in Bangalore." *Environment and Urbanization* 12 (1): 35–56. https://doi.org/10.1177/095624780001200104.

Berg, Caroline van den, and Alexander Danilenko. 2011. *The IBNET Water Supply and Sanitation Performance Blue Book: The International Benchmarking Network for Water and Sanitation Utilities Databook*. The World Bank. http://elibrary.worldbank.org/doi/book/10.1596/978-0-8213-8582-1.

Bertorelli, Ebony, Patrick Heller, Siddharth Swaminathan, and Ashutosh Varshney. 2017. "Does Citizenship Abate Class? Evidence and Reflections from Bangalore." *Economic & Political Weekly* 52 (32): 47–57.

Besley, Timothy, Rohini Pande, Lupin Rahman, and Vijayendra Rao. 2004. "The Politics of Public Good Provision: Evidence from Indian Local Governments." *Journal of the European Economic Association* 2 (2–3): 416–26. https://doi.org/10.1162/154247604323068104.

Björkman, Lisa. 2015. *Pipe Politics, Contested Waters: Embedded Infrastructures of Millennial Mumbai*. Durham, NC: Duke University Press.

Blaydes, Lisa. 2011. *Elections and Distributive Politics in Mubarak's Egypt*. New York, NY: Cambridge University Press.
Bohlken, Anjali Thomas. Forthcoming. "Development or Rent-Seeking?: How Political Influence Shapes the Provision of Infrastructure." *British Journal of Political Science*.
Breeding, Mary E. 2011. "The Micro-Politics of Vote Banks in Karnataka." *Economic and Political Weekly* 46 (14): 71–77. https://doi.org/10.2307/41152055.
Callen, Michael, Saad Gulzar, and Arman Rezaee. 2020. "Can Political Alignment Be Costly?" *Journal of Politics* 82 (2): 612–26.
Cammett, Melani, and Sukriti Issar. 2010. "Bricks and Mortar Clientelism: Sectarianism and the Logics of Welfare Allocation in Lebanon." *World Politics* 62 (3): 381–421.
Chandra, Kanchan. 2004. *Why Ethnic Parties Succeed: Patronage and Ethnic Head Counts in India*. Cambridge University Press.
Connors, Genevieve. 2005. "When Utilities Muddle through: Pro-Poor Governance in Bangalore's Public Water Sector." *Environment and Urbanization* 17 (1): 201–218.
Contractor, Qudsiya. 2012. "Quest for Water: Muslims at Mumbai's Periphery." *Economic & Political Weekly* 47 (29): 61–67.
Crane, Alan T., and Robin Roy. 1992. "Competition, Trading, and the Reliability of Electric Power Service." *Annual Review of Energy and the Environment* 17 (1): 161–86.
De Marchis, M., C.M. Fontanazza, G. Freni, G. La Loggia, E. Napoli, and V. Notaro. 2011. "Analysis of the Impact of Intermittent Distribution by Modelling the Network-Filling Process." *Journal of Hydroinformatics* 13 (3): 358–73.
Dunning, Thad, and Janhavi Nilekani. 2013. "Ethnic Quotas and Political Mobilization: Caste, Parties, and Distribution in Indian Village Councils." *American Political Science Review* 107 (1): 35–56. https://doi.org/10.1017/S0003055412000573.
Franceys, Richard, and Anand Jalakam. 2010. "The Karnataka Urban Water Sector Improvement Project: 24x7 Water Supply Is Achievable." Field Note. Washington D.C.: World Bank.
Gandy, Matthew. 2008. "Landscapes of Disaster: Water, Modernity, and Urban Fragmentation in Mumbai." *Environment and Planning A* 40 (1): 108–30. https://doi.org/10.1068/a3994.
Gayer, Laurent, and Christophe Jaffrelot, eds. 2012. *Muslims in Indian Cities: Trajectories of Marginalisation*. Noida, India: Harper Collins Publishers India.
Gertler, Paul J., Kenneth Lee, and A. Mushfiq Mobarak. 2017. "Electicity Reliability and Economic Development in Cities: A Microeconomic Perspective." 3.2. EEG State-of-Knowledge Paper Series. Oxford Policy Management.
Golden, Miriam, and Brian Min. 2013. "Distributive Politics Around the World." *Annual Review of Political Science* 16: 73–99. https://doi.org/10.1146/annurev-polisci-052209-121553.
Graham, Stephen, Renu Desai, and Colin McFarlane. 2013. "Water Wars in Mumbai." *Public Culture* 25 (1 69): 115–41. https://doi.org/10.1215/08992363-1890486.

Hyun, Christopher, Alison E. Post, and Isha Ray. 2018. "Frontline Worker Compliance with Transparency Reforms: Barriers Posed by Family and Financial Responsibilities." *Governance* 31: 65–83.

Ilaya-Ayza, A.E., C. Martins, E. Campbell, and J. Izquierdo. 2017. "Implementation of DMAs in Intermittent Water Supply Networks Based on Equity Criteria." *Water* 9 (11): 851.

Jha, Saumitra, Vijayendra Rao, and Michael Woolcock. 2007. "Governance in the Gullies: Democratic Responsiveness Adn Leadership in Delhi's Slums." *World Development* 35 (2): 230–46.

Kjellén, Marianne, and Gordon McGranahan. 2006. "Informal Water Vendors and the Urban Poor." Human Settlements Discussion Paper Series. London: International Institute for Environment and Development London. http://www.mumbaidp24seven.in/reference/informal_water_vendors.pdf.

Kramon, Eric, and Daniel N. Posner. 2013. "Who Benefits from Distributive Politics? How the Outcome One Studies Affects the Answer One Gets." *Perspectives on Politics* 11 (02): 461–74. https://doi.org/10.1017/S1537592713001035.

Krishna, Anirudh, M S Sriram, and Purnima Prakash. 2014. "Slum Types and Adaptation Strategies: Identifying Policy-Relevant Differences in Bangalore." *Environment & Urbanization* 26 (2): 568–84.

Kumpel, Emily, and Kara L. Nelson. 2013. "Comparing Microbial Water Quality in an Intermittent and Continuous Piped Water Supply." *Water Research* 47 (14): 5176–88.

Kumpel, Emily, Cleo Woelfle-Erskine, Isha Ray, and Kara L. Nelson. 2017. "Measuring Household Consumption and Waste in Unmetered, Intermittent Piped Water Systems." *Water Resources Research* 53 (1): 302–15. https://doi.org/10.1002/2016WR019702.

Lipton, Michael. 1977. *Why Poor People Stay Poor: Urban Bias in World Development*. Cambridge MA: Harvard University Press.

Manohar, Usha, and M. S. Mohan Kumar. 2014. "Modeling Equitable Distribution of Water: Dynamic Inversion-Based Controller Approach." *Journal of Water Resources Planning and Management* 140 (5): 607–19. https://doi.org/10.1061/(ASCE)WR.1943-5452.0000368.

McKenzie, David, and Isha Ray. 2009. "Urban Water Supply in India: Status, Reform Options and Possible Lessons." *Water Policy* 11 (4): 442–460.

Meseguer, Covadonga, and Francisco Javier Aparicio. 2012. "Migration and Distributive Politics: The Political Economy of Mexico's 3x1 Program." *Latin American Politics and Society* 54 (4): 147–78.

Miguel, Edward. 2004. "Tribe or Nation? Nation Building and Public Goods in Kenya versus Tanzania." *World Politics* 56 (3): 327–62. https://doi.org/10.1017/S0043887100004330.

Min, Brian. 2015. *Power and the Vote: Elections and Electricity in the Developing World*. New York, NY: Cambridge University Press.

———. 2019. "Political Favoritism and the Targeting of Power Outages." Working Paper E-89442-GHA-1. London: International Growth Centre.

Min, Brian, and Miriam Golden. 2014. “Electoral Cycles in Electricity Losses in India.” *Energy Policy* 65 (February): 619–25. https://doi.org/10.1016/j.enpol.2013.09.060.

Murillo, Maria Victoria. 2009. *Political Competition, Partisanship, and Policy Making in Latin American Public Utilities*. New York, NY: Cambridge University Press.

Parry, Stephen. 2016. “StatNews #91 Ordinal Logistic Regression Models and Statistical Software: What You Need to Know.” Cornell University Statistical Consulting Unit. June 2016. https://www.cscu.cornell.edu/news/statnews/stnews91.pdf.

Post, Alison E., Vivian Bronsoler, and Lana Salman. 2017. “Hybrid Regimes for Local Public Goods Provision: A Framework for Analysis.” *Perspectives on Politics* 15 (4): 952–66.

Ranganathan, Malini. 2014. “Paying for Pipes, Claiming Citizenship: Political Agency and Water Reforms at the Urban Periphery: Political Agency and Water Reforms in Bangalore.” *International Journal of Urban and Regional Research* 38 (2): 590–608. https://doi.org/10.1111/1468-2427.12028.

Rusca, Maria, Akosua Sarpong Boakye-Ansah, Alex Loftus, Giuliana Ferrero, and Pieter van der Zaag. 2017. “An Interdisciplinary Political Ecology of Drinking Water Quality. Exploring Socio-Ecological Inequalities in Lilongwe’s Water Supply Network.” *Geoforum* 84 (August): 138–46. https://doi.org/10.1016/j.geoforum.2017.06.013.

Solo, Tova Maria. 1999. “Small-Scale Entrepreneurs in the Urban Water and Sanitation Market.” *Environment and Urbanization* 11 (1): 117–132.

Thachil, Tariq. 2017. “Do Rural Migrants Divide Ethnically in the City? Ethnographic and Experimental Evidence from India.” *American Journal of Political Science* 61 (4): 908–26.

Tiwale, Sachin, Maria Rusca, and Margreet Zwarteveen. 2018. “The Power of Pipes: Mapping Urban Water Inequities through the Material Properties of Networked Water Infrastructures - The Case of Lilongwe, Malawi.” *Water Alternatives* 11 (2): 314–35.

Trotter, Philipp A. 2016. “Rural Electrification, Electrification Inequality and Democratic Institutions in Sub-Saharan Africa.” *Energy for Sustainable Development* 34: 111–29.

Wallace, Jeremy. 2014. *Cities and Stability: Urbanization, Redistribution, and Regime Survival in China*. New York, NY: Oxford University Press.

Williams, Martin J. 2017. “The Political Economy of Unfinished Development Projects: Corruption, Clientelism, or Collective Choice?” *American Political Science Review* 111 (4): 705–23.

Table A.1. Predictability of Water Supply in Eastern Bangalore, April-May 2015 (low income status replaced with SC/ST status)

	Whether water comes at a specific time			
	(1)	(2)	(3)	(4)
Household-level characteristics				
Elevation	-0.002*	-0.002*	-0.001*	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
Cauvery Supply	0.431	0.317*	0.485	0.360**
	(0.374)	(0.137)	(0.401)	(0.133)
Urban Migrant	-0.087	-0.086	-0.086	-0.084
	(0.092)	(0.100)	(0.090)	(0.102)
Muslim	0.149	0.164	0.151	0.156
	(0.161)	(0.168)	(0.161)	(0.167)
SC/ST	-0.067	-0.064	-0.057	-0.065
	(0.140)	(0.128)	(0.139)	(0.125)
VA-level characteristics				
Urban Migrant	-0.131	-1.294***	-0.650	-1.310***
	(0.896)	(0.380)	(1.043)	(0.358)
Muslim	0.688	-0.186	0.657	-0.178
	(0.613)	(0.323)	(0.581)	(0.291)
SC/ST	2.050***	1.447***	2.233***	1.563***
	(0.592)	(0.238)	(0.569)	(0.223)
Local leader	-0.093	-0.149	-0.131	-0.124
	(0.241)	(0.097)	(0.242)	(0.091)
Ward-level characteristics				
Margin of victory				-5.401***
				(0.669)
INC Corporator			0.569	0.073
			(0.353)	(0.136)
Margin X INC Corp.				-105.476***
				(5.233)
Constant	-0.357	1.135	-0.558	0.979
	(0.768)	(0.741)	(0.790)	(0.728)
Ward dummies?	No	Yes	No	No
SEs clustered at VA	Yes	No	Yes	No
N	2,850	2,850	2,850	2,850
R^2	0.072	0.128	0.083	0.124
chi^2	147.364**df = 9)	266.573***(df = 15)	169.879***(df = 10)	257.015***(df = 12)

*p < .05; **p < .01; ***p < .001. Logistic regressions were used to estimate models. The higher category indicates receiving predictable service. A positive log odds coefficient indicates that as the value of the independent variable increases, the likelihood of having predictable water increases.

Table A.2. Water Supply Frequency, Eastern Bangalore, April-May 2015, April-May 2015 (low income status replaced with SC/ST status)

	Water Service Frequency			
	(1)	(2)	(3)	(4)
y> =every 4-5 days	0.108	-1.558*	0.711	1.164
	(0.850)	(0.765)	(0.931)	(0.780)
y> =every 3-4 days	-0.411	-2.207**	0.066	0.514
	(0.832)	(0.766)	(0.889)	(0.782)
y> =every 2 days	-2.860***	-4.926***	-2.582**	-2.138**
	(0.862)	(0.774)	(0.874)	(0.786)
y>=everyday	-4.996***	-7.133***	-4.731***	-4.284***
	(1.014)	(0.787)	(1.017)	(0.801)
Household-level characteristics				
Elevation	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Cauvery Supply	-0.076	-0.251	-0.271	-0.304*
	(0.352)	(0.133)	(0.369)	(0.138)
Urban Migrant	-0.081	-0.111	-0.114	-0.114
	(0.065)	(0.083)	(0.073)	(0.085)
Muslim	-0.048	-0.048	-0.067	-0.064
	(0.108)	(0.124)	(0.117)	(0.117)
SC/ST	-0.003	-0.022	-0.036	-0.038
	(0.097)	(0.104)	(0.104)	(0.104)
VA-level characteristics				
Urban Migrant	-1.163	0.881**	0.767	0.646*
	(0.911)	(0.291)	(0.966)	(0.276)
Muslim	-0.553	-0.566	-0.493	-0.771**
	(0.671)	(0.304)	(0.726)	(0.259)
SC/ST	2.055***	1.230***	1.381*	1.158***
	(0.603)	(0.192)	(0.563)	(0.182)
Local leader	-0.027	0.363***	0.142	0.147
	(0.338)	(0.092)	(0.331)	(0.080)
Ward-level characteristics				
Margin of victory				-1.520**
				(0.489)
INC Corporator			-2.389***	-2.524***
			(0.412)	(0.141)
Margin X INC Corp.				-31.012
				(77.002)
Ward dummies?	No	Yes	No	No
SEs clustered at VA	Yes	No	Yes	No
N	2,903	2,903	2,903	2,903
R^2	0.099	0.287	0.261	0.267
chi^2	277.812***(df = 9)	895.441***(df = 15)	799.367***(df = 10)	821.490***(df = 12)

*p < .05; **p < .01; ***p < .001. Ordinal logistic regressions were used to estimate models. A higher category indicates more frequent service. A positive log odds coefficient indicates that as the value of the independent variable increases, the likelihood of getting more frequent service increases.