

The Burden of Water Shortages on Informal Firms

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Abstract

The informal sector in developing economies is a significant source of livelihood for a sizable portion of the population. This study uncovers the effect of poor water infrastructure on the productivity of informal firms. This is achieved using firm-level data for 12 developing economies between 2009

and 2014. The findings indicate that an increase of one standard deviation of the total duration of water shortages in a month can lead to annual average losses of about 14.5 percent of the monthly sales per worker for the average informal firm in the sample that uses water for business activities.

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The Burden of Water Shortages on Informal Firms

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1. Introduction

Water scarcity, induced by climate change, may result in declines in economic growth of about 6 percent in some regions. More importantly the impacts of water mismanagement are likely to fall disproportionately on the poor (World Bank, 2016). Thus, the informal sector – also known as the sector of the poor – is likely to suffer productivity losses due to water scarcity. Water scarcity or poor water infrastructure may manifest itself in terms of water shortages experienced by informal firms. While a range of policies, from accelerating formalization to better education, have been considered to improve the productivity of informal firms (Aftab and Rahim, 1988; Amin and Islam, 2015; Djankov et al. 2002), very little attention has been afforded to the effect that poor infrastructure quality, specifically water infrastructure, may have on informal firms.

Informality is normal in developing economies. Estimates of the size of the informal sector have varied widely from 20% of net domestic product in India (Chaudhuri, Schneider, and Chattopadhyay, 2006) to 30–33% in Tanzania (Bagachwa and Naho, 1995) and 40–60% in Brazil (Henley, et al., 2009). Estimates from Schneider et al. (2010) indicate that the average size of the shadow economy as a percentage of official GDP is 25.1 percent in South Asia, 34.7 percent in Latin America and the Caribbean, and 38.4 percent in Sub-Saharan Africa. This is in contrast to the OECD, where the figure is 13.5%. In terms of informal employment, Golub and Hayat (2014) estimate that in low-income Sub-Saharan African economies, the informal sector accounts for between 80% and 97% of employment. In Bangladesh, 75% of firms are unregistered (Giorgi et

al., 2017). Furthermore, there are a number of reasons the informal sector will remain large. Informal firms rarely become formal (La Porta and Shleifer 2014). Premature deindustrialization – where countries are running out of industrial opportunities – has resulted in a shift of labor towards the informal sector (Rodrik, 2016). Additionally, the formal sector may be unable to absorb rising labor force populations, leading to labor being absorbed into the informal sector. More importantly, the well-being of the poor is largely dependent on the informal sector.

The role of the informal sector has been widely contested. One side considers informal firms to be entrepreneurs being held back by undue government intervention (De Soto 1989, 2000). Another side sees informal firms as parasites competing unfairly with formal firms following rules and regulations (Farrell 2004). A third angle is to view informality through a dual economy perspective where formal and informal firms are seen to be fundamentally different – they serve different markets and hardly compete with each other (La Porta and Shleifer 2014). There is a general consensus that the informal sector is less productive and more stagnant than the formal sector (La Porta and Shleifer 2014).

The role of water infrastructure has been explored in the literature through a number of dimensions – at the household level, the water utility level, and the formal firm level. Studies have explored the effect of water access and reliability on time allocation and health outcomes in households (Thomas 1992; Ilahi and Grimard, 2000; Koolwal and Van de Walle, 2013; Smiley, 2016; Ashraf et al., 2017) as well as the performance of urban water utilities (Jiang and Zheng, 2014; Coulibaly and Rodriguez, 2004). For the formal business sector, studies have estimated the role of water as an input in manufacturing for developed economies where data are available (Reynaud, 2003;

Dupont and Renzetti, 2001). More in line with this study, a number of papers have explored the effect of poor water infrastructure quality on formal firms, with mixed findings (Iimi, 2011; Moyo, 2011; Escribano et al., 2010; Bogetic and Olusi, 2013; Davis et.al, 2001). The literature on the effect of water infrastructure on firm performance is far limited relative to other business environment factors such as power infrastructure, access to finance and labor regulations (see for example Stel et al., 2007; Safavian and Sharma, 2009; Kaplan 2009, Alterido et al., 2011; Fisher-Vanden et al. 2015; Allcott et al., 2016). To our knowledge, there are no studies on water infrastructure in the informal firm sector.

Given the size of the informal sector, the link between water infrastructure quality and informal firm performance warrants empirical verification. This study adds to the literature on water infrastructure quality by exploring the effect of poor water infrastructure on the productivity of informal firms for 12 developing economies across Sub-Saharan Africa, East Asia, and Latin America² (Table A1 in the appendix). There are a number of possible links between water infrastructure and informal firm performance. On the one hand poor water infrastructure quality may be far more detrimental for informal than formal firms if the former have fewer resources to compensate for infrastructure and public good deficits such as water shortages. On the other hand, informal firms may develop alternative supply options that do not rely on water networks, and thus may be relatively less affected by water infrastructure unreliability.

Water infrastructure in cities deals with a set of attributes that determine the quality of water service delivery. Water initially starts as a public good at the source. As it reaches the pipe, it turns

² The 12 economies are Angola, Argentina, Burkina Faso, Cameroon, Cabo Verde, Democratic Republic of Congo, Ghana, Guatemala, Kenya, Myanmar, Peru, and Rwanda.

into both a private and a merit good as it is a necessity for life. In cities, these challenges are compounded by the fact that the cost of building multiple water systems is excessive and thus unlikely. Water must be supplied through a single network, that therefore has a single owner—a monopolist (World Bank, 2017). A natural monopolist accrues unavoidable advantages, regardless of being public or private in its engagement with regulators and customers. Furthermore, investments in infrastructure are lumpy – considerable costs are incurred to make improvements. However, infrastructure investments are not enough. Institutions that generate the right incentives will allow infrastructure to be effective (Ashraf et al., 2016; Allcott et al., 2016). How well economies address these challenges will go a long way in determining the service delivery quality. In the sample for this study, a substantial proportion of the urban population has access to improved water sources, 8 of 12 economies had 90 percent or more urban population access to improved water in 2015.³ Three of the four remaining economies have at least 80 percent or more urban population access to improved water. Only Angola is the standout with 74 percent access.

The source of the data for the study is surveys of informal firms collected by the World Bank’s Enterprise Analysis unit. Informal firms are defined as firms that are not registered with the relevant authorities. While there are other measures of informality such as size of activity, lack of financial statements, mobility, and access to bank credit (Benjamin and Mbaye, 2012), the broader literature tends to use registration as the criterion for informal firms and this is a convenient definition for data collection (Loayza and Rigolini, 2011; Rand and Torm, 2012). The study finds that the total duration of water shortages has a statistically significant negative effect on the labor productivity of informal firms. A one standard deviation increase in a days’ worth duration of

³ Improved water sources include piped water on premises, public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection.

water shortages in a month experienced by a firm can lead to annual average losses of about 14.5 percent of the monthly sales per worker of the average informal firm in the sample that uses water for business activities.

To summarize, the study contributes to the literature in the following ways: (a) it is the first study to establish and quantify the effect of poor water infrastructure quality on the productivity of informal firms, and (b) the study uses a rich data set that covers over 2,400 informal firms, of which 710 use water for business activities, and the data are comparable across 12 economies. Section 2 introduces the data, section 3 provides the empirical specification, section 4 presents the results and section 5 concludes.

2. Data

The main data source of the analysis is the surveys of informal firms, defined as unregistered firms, conducted by the World Bank Enterprise surveys unit (henceforth called Informal Enterprise Surveys). The data encompass about 2,400 informal firms over a cross-section of 12 economies across Africa, East Asia, and Latin America between 2009 and 2014. About 710 firms use water for business activities and water shortage data are only available for these firms. The sample of analysis is these 710 firms unless otherwise indicated. Table A1 (in the appendix) presents the list of countries with the total duration of water shortages in days over a month. The highest figure is from Ghana with an average of 6.75 days of water shortages over a month. The lowest is Burkina Faso with 0.01 days. For the full sample, on a typical month the average sales per worker for a firm is about US\$1,173 without about 2 to 3 employees. About 55 percent of the firms in the sample manufacture their own product. Unfortunately a larger number of the surveys do not have detailed information on the activity of the informal firms. For 8 countries in the sample, such

detailed information is available and provided in table A2 in the appendix.⁴ Firms are distributed into 19 types of activities. Selling food or groceries (street-food sellers, restaurants) is the largest activity for these 8 economies with 22% of the informal firms involved in this activity. Second largest is manufacturing of clothes or shoes undertaken by about 13% of informal firms in the 8 countries. Of course, the distribution of activities may differ for the full sample used for this analysis. Majority of the firms live in fixed premises – about 76 percent as shown in the summary statistics in table 1. A nationally representative sample of informal firms would require a complete list of unregistered firms in an economy. By definition such a list is difficult to attain given they are not documented. To our knowledge, such a list does not exist for any country at the national or even city level. Thus, although the data are not nationally representative, some steps are taken in the data collection process to limit selection bias.

Data collection for the informal surveys is carried out as follows. For the Informal Enterprise Surveys, an urban center is typically divided into zones to yield a predetermined number of interviews. For instance, in the Kenya Informal Enterprise survey, five urban centers were broken down into 122 zones. A number of zones are then randomly selected to be interviewed. Typically more than one enumerator is allocated to each zone. Each enumerator is presented with maps identifying a predefined starting point that tends to be at opposite ends of the zone to ensure interviews are dispersed within a zone. The enumerators are instructed to follow the direction of the street and obtain a predetermined number of interviews. This process limits selection bias given the zones are randomized across the city, but the process cannot ensure a representative sample of informal firms. The enumerators identify informal firms and confirm their status using a short screener questionnaire. Once the informal status is confirmed, the interview begins with the main questionnaire. Most studies tend to follow a similar approach by relying on a random sample of informal firms taken from one or two main urban centers of the economy that are not nationally representative (Grimm et al., 2012; Harris, 2014; Middleton, 2007; Rand and Torm, 2012). A considerable advantage of

⁴ The 8 economies are Angola, Argentina, Democratic Republic of Congo, Guatemala, Kenya, Myanmar, Peru, and Rwanda.

the informal enterprise surveys is that they employ the same methodology and the same survey instruments across countries. The resulting data set where informal firms across 12 economies over 3 continents can be compared due to similar methodology is a rarity and ideal for this study.

3. Empirical Specification

Informal firms may lack resources to offset inadequate infrastructure, and thus we expect water shortages to affect their output. Informal firms also tend to be labor intensive and thus water shortages may have a direct effect on labor productivity. It should be noted that informal firms operate in a very different environment than formal firms. Informal firms typically do not maintain any records and may even operate on a day-to-day or seasonal basis. Therefore, most survey questions pertain to the last month of activities. Furthermore, the lack of records implies that several covariates that typically enter a productivity analysis estimation are impossible to be directly measured, but can be approximated using information about firm characteristics. We follow the literature and estimate the following equation using OLS (Amin and Islam, 2015).

$$\lnprod_{irj} = \gamma_1 Water_{irj} + \gamma_2 Size_{irj} + \gamma_3 h_{irj} + \gamma_4 k_{irj} + \gamma_5 X_{irj} + region_r + \epsilon_{irj} \quad (1)$$

Where \lnprod is the log of sales per worker of firm i in region (within-country) r , and country j over a typical month. Firm size is captured as the log of total number of employees ($Size$) over a typical month. The details of how sales and employment data for a typical month are calculated are as follows. The survey questionnaire asks firms to report their sales and employment figures for the last month. If these figures for the last month were abnormal then the firms report the sales and employment figures for a typical month as well. Thus, to account for factors such as the seasonality of the business, for the variables \lnprod and $Size$ we use the values for the last month only for firms that indicate last month was a normal month. For firms that indicate that the last month was not normal we use the estimates for a regular month

over the last calendar year. Thus, the resulting labor productivity variable is for a typical month. The main variable of interest (described in detail in the next subsection) is the indicator of water infrastructure (*Water*). We use a number of variables to proxy for human capital (*h*) and physical capital (*k*).

The estimation of the effect of water on productivity in equation (1) is susceptible to endogeneity concerns. On one hand it could be argued that water shortages are exogenous given that the duration of shortages may be difficult to predict. However, if water shortages are endogenous or predictable, firms may have adapted to such realities by using alternative sources of water or increasing storage (Bais et al., 2010).⁵ Firms may also locate in areas where there are alternate sources of water, thereby being buffered from water shortages. In these cases, we would not uncover any effect of water shortages on firm productivity –we would obtain conservative estimates of the impact of water on firm productivity as they would be biased downwards. Another concern is that it is likely that more productive firms choose to locate in areas with better water infrastructure. It is difficult to do away completely with this issue, but we limit it as best as we can within the confines of the data by controlling for other firm-level factors (*X*) to account for the sorting of firms across locations based on their observable characteristics (details in the next section). We also account for location-specific time invariant factors by using region fixed effects (*region*). Finally, we conduct a battery of checks to confirm the robustness of our findings.

Main Explanatory Variable

The main explanatory variable is the total duration of water shortages in the last month experienced by an informal firm, expressed in days (*Water*). The mean value for the total duration of water shortages over the last month for an informal firm is 1.33 days. This variable is calculated by combining two pieces of information obtained from the surveys. The first is the number of incidents of water shortages per day over

⁵ In the electricity sector, adaptation in terms of self-generation has not always been the case. Fisher-Vanden et al. (2015) find that self-generation did not increase due to power outages in China, but there were changes in the input mix.

the last month. Firms are asked in the last month, how many incidents of insufficient water supply did this establishment experience? The second measure is the average duration of water shortages for each incident. Thus, the total duration of water shortages is calculated by multiplying the number of water shortage incidents over the last month by the average duration of each incident. As part of the robustness check, the effect of each of the components of the total duration of water shortages variable on labor productivity is explored. Summary statistics are presented in table 1.

To explore what types of firms experience poor water service delivery, the total duration of water shortages is regressed on a number of variables. The results are presented in table A4 in the appendix. There are two variables that are significantly correlated with the total duration of water shortages. The first is that firms located in fixed premises or households face fewer water shortages than mobile firms. The coefficient is statistically significant at the 5% level. The other variable is whether an informal firm manufactures its own product. The coefficient is positive, indicating that manufacturing firms face more water shortages, however, the finding is barely statistically significant at the 10% level. Other factors such as firm size, use of electricity, and access to finance that could be correlated with a firm's vulnerability or ability to buffer water shortages are found to have statistically insignificant coefficients.

Other Explanatory Variables

We capture the main determinants of productivity consistent with the literature— human capital (h) and physical capital (k) (Kneller and Misch, 2014). Additionally, we proxy for firm size using the log of total number of employees ($Size$) over the last month. Firm size has been found in the literature to be an important determinant of labor productivity for informal firms (Benjamin and Mbaye, 2012; Amin and Islam, 2015). Finally firms may sort into locations based on observable characteristics. We account for these firm-level factors (X) that broadly fall into two categories – access to finance, and the business environment in terms of government interactions and security from crime. We also include a dummy

variable indicating whether or not a firm is a manufacturing firm. We account for location-specific time invariant omitted variables with location fixed effects.

Human capital is captured through several owner and manager characteristics, where manager is defined as the main decision maker. These characteristics include whether the largest owner has secondary education or higher, manager years of experience, whether the largest owner has a formal job or looked for one in the last two years, and whether the largest owner started another business in the last 3 years. In about 59 percent of informal firms in the sample the largest owner has a secondary education or higher. On average, managers of informal firms have 9.5 years of experience. About 14 percent of the informal firms in our sample have a largest owner who had a job in the formal sector over the last two years, with 61 percent indicating they started another business in the last 3 years.

We account for physical capital using dummy variables to capture a firm's use of various assets. We control for whether or not a firm uses machinery in its current operations, and similarly whether or not a firm uses vehicles for its current operations. About 43 percent of the firms use machinery for current operations, with only 19 percent using vehicles for current operations. The use of physical capital is likely to be correlated with the use of electricity for business activities. Thus, we control for whether or not a firm uses electricity for business activities, which is the case for 71 percent of informal firms in the sample.

We control for the ability of firms to access finance by using binary variables to capture whether the firm has a bank account or a loan. About a quarter of the informal firms in the sample have a bank account. Only 13 percent of the firms have a loan. It is important to note that these measures may be correlated with the use of physical capital. Use of a bank account for business activities may imply the firm has access to finance that could be used to obtain physical capital. The existence of an outstanding loan may imply that the firm has some physical capital to use as collateral in obtaining a loan. In order to capture the financial stability of the firm, despite being unregistered, we include a variable that indicates whether or not the firm

produces or sells under contract from another business or person. This is only the case for 21 percent of the firms.

Finally, we also include a number of covariates to account for the business environment the firm operates in. These include whether or not firms experienced crime in the last month as well as whether they pay for security. About 8 percent of the firms experienced crime over the last month, although 24 percent of the firms pay for security. Furthermore, we also capture whether the firm makes payments to remain unregistered. This is the case for 9 percent of the firms. Summary statistics are provided in table 1.

4. Results

The main results for water infrastructure and labor productivity are presented in table 2. In all estimations Hubert-White robust standard errors are used, clustered by region (within country) and sector. In the first column we present a parsimonious regression with just the total duration of water shortages and location fixed effects. The coefficient for the total duration of water shortages is negative, statistically significant at the 5% level. Thus, an increase in the total duration of water shortages leads to lower labor productivity of informal firms. In column 2 of table 1, we include firm size, a manufacturing sector dummy variable, and our measures of human and physical capital. The negative coefficient for the total duration of water shortages is retained, while the statistical significance rises to the 1% level. Measures of human capital such as manager experience and whether the largest owner has a secondary education have the expected positive coefficients, statistically significant at the 5% and 1% level, respectively. Of the measures of physical capital, all coefficients are positive as expected however only the coefficient of the use of vehicles for operations is statistically significant (at the 1% level). Firm size has a negative relationship with labor productivity which is consistent with the literature (Amin and Islam, 2015). Manufacturing informal firms appear to be more productive than informal firms in other sectors.

In column 3 of table 2, we now add the control variables capturing a firm's ability to access finance. The coefficient for the total duration of water shortages remains negative, statistically significant at the 1% level. There is hardly any change in the magnitude of the effect of water shortages on firm productivity. Of all the access to finance variables added, only the variable capturing whether a firm produces or sells under contract from another business or person is statistically significant (1% level). This variable may also be capturing informal network effects, which can be important for the survival of informal firms.

Finally in column 4 of table 2, we add the final set of variables capturing the business environment. Column 4 follows the main specification indicated in equation (1) and is henceforth our base specification. The total duration of water shortage in a month has a negative effect on the labor productivity of informal firms. The coefficient, as in column 3, is statistically significant at the 1% level with hardly a change in the magnitude from the previous specifications. The coefficients of the variables for firm size, human capital and physical capital that were statistically significant in columns 1 through 3 of table 2 retain their significance in column 4. None of the business environment variables added is statistically significant.

In terms of the magnitude of the effects, using the base specification presented in column 4 of table 2, an increase of a day's worth of water shortages (24 hours) in a month leads to 3.7 percent loss in monthly sales per worker. Thus, if an informal firm faced a week of continuous water shortages, it would incur losses in the order of 26% of their sales per worker that month. A one standard deviation increase in the total duration of water shortages in days leads to losses to the order of 14.5 percent of monthly sales per worker.

4.1 The Components of the Total Duration of Water Shortages

The total duration of water shortages in days is calculated by combining the number of incidents of water shortages in a month, with the average duration for each shortage. In table 3, we take the same specification in column 4 of table 2 but substitute the total duration of water shortages in days with each of its components. In column 1 of table 3 we only include the average duration of a water shortage in hours. In

column 2 we only include the number of incidents of water shortages. Finally in column 3 we include both. The results indicate that the number of incidents of water shortages does not matter for firm productivity. Instead the duration of the shortages is what is detrimental for the productivity of informal firms. The coefficient of the average duration of an incident of water shortage is negative and significant at the 5% level. The coefficient for the number of incidents of water shortages over a month is statistically insignificant. This finding is intuitive as short incidents of water shortages can be easily overcome while water shortages of longer duration may be harder to adapt to.

4.2 Robustness Check – Power Outages and Sector of Activity

The estimates of the effects of poor water infrastructure on the productivity of informal firms could be capturing the degree of power infrastructure in the economy in general. In the main specification we control for whether or not a firm uses electricity. We do have information on power outages, but we do not include it in the main specification, as questions pertaining to power outages were asked only of informal firms that used electricity for business activities. Thus, any specification including power outages would reduce the sample to only informal firms that use both water and electricity for business activities. However, as a robustness check we include indicators of power outages in our base specification and present the results in table 4.

In column 1 of table 4, we include both the incidents and the average duration of power outages. In column 2 of table 4 we include the total duration of power outages in days, which is constructed the same way as our total duration of water shortages indicator. In both columns we also include whether or not the informal firm makes use of a generator. The sample size drops to 476 informal firms. In both cases, the coefficient of the total duration of water shortages in days over the last month has a negative effect on firm productivity, statistically significant at the 5% level. The coefficients of the power outages variables are statistically insignificant in both columns 1 and 2 of table 4. Thus, we can at least state that our findings are robust to the effect of poor power infrastructure. A stronger interpretation may be that informal firms are more likely

to have adapted to power outages than water shortages, and thus the latter has a negative impact on their productivity while the former does not.

The findings may differ by the sector of activity of the firm. As indicated in table A2 (in the appendix), manufacturing activities primarily include small-scale manufacturing of clothes, shoes, baked foods, and furniture. Service sector activities mainly include retailing groceries, hair dresser and barber shops, and selling business/ computer /phone services. In columns 3 and 4 of table 4, we split the sample by manufacturing and service firms respectively, and estimate the base specification presented in column 4 of table 2. The coefficient of the total duration of water shortages is negative and statistically significant for manufacturing informal firms, but statistically insignificant for services firms. Thus, the results may be driven by the effect of water shortages on informal firms that use water for processing.

4.3 Robustness Check - Heckman Selection Model

The Informal Enterprise Surveys only ask water infrastructure questions to firms that use water for business activities. Only about 710 firms fall into this category in the sample. Thus, we also attempt to model the selection of firms that use water for business activities using a Heckman selection model. The identifying variable for the selection equation is whether or not a firm is located in a household or a fixed premise with a permanent structure. The argument is that stationary informal firms within a permanent structure are more likely to be connected to the water system. The data confirm this with about 27 percent of firms located in fixed premises using water for business activities, and only 19% of firms not located in fixed premises use water for business activities. Thus, firms located in fixed premises are more likely to use water for business activities and thus face issues related to water shortages. Mobile informal firms cannot be connected to a piped water supply and so are unlikely to use water for business activities. When they do use water, they may need to obtain it from alternative sources such as water vendors. Thus, their business activities are unlikely to be immediately affected by piped water shortages. Therefore in combination with equation (1), we estimate equation (2) below:

$$Prob(wtr)_{irj} = \alpha_1 Water_{irj} + \alpha_2 Size_{irj} + \alpha_3 h_{irj} + \alpha_4 k_{irj} + \alpha_5 X_{irj} + region_r + \mu_{irj} \quad (2)$$

Where $Prob(wtr)_{irj}$ is the probability that the firm uses water for business activities, and $PermFix$ is a dummy variable that takes the value 1 if a firm is located in a household or in a fixed premise with a permanent structure. However, there is a possibility that the exclusion restriction may be violated if informal firms that are within fixed premises are more productive than informal firms in temporary or mobile structures. A priori it is not possible to tell whether this is the case. However, there is no statistically significant difference between labor productivity for informal firms in the sample that are located within fixed premises and those in mobile premises. Furthermore a regression of labor productivity on fixed premises with all the covariates in equation (1) shows that the coefficient for fixed premises is statistically insignificant. This is true for both the whole sample and the sample with water variables.⁶ While not definitive this provides some indication that the exclusion restriction may not be violated.

In table 5 we present the findings of the Heckman selection model. The main specification in column 1 of table 5 mimics column 4 of table 2. As shown in column 2 of table 5, the location of firms in a household or a fixed premise with a permanent structure is positively and statistically significantly related to the likelihood that a firm uses water for business activities. The findings indicate that the total duration of water shortages have a negative effect on firm productivity, statistically significant at the 1 percent level. The magnitude is slightly higher for the Heckman selection model than the base specifications in column 4 of table 2. The Wald test rejects the null that the two equations are independent, thus justifying the use of the Heckman selection model. It is worth noting that the marginal effect of water shortages for firms that do not use water as an input may not be useful for policy makers concerned with water infrastructure. Thus, for all robustness checks we use the base specification in column 4, table 2.

⁶ Regression results not presented but available from the author.

4.4 Robustness Check – Extreme Observations and Country Dominance

One possible concern is that the findings are being driven by extreme observations. Another is that the results are dominated by a particular country, and exclusion of that country results in insignificant coefficients for the total duration of water shortages. We run robustness checks on both these possibilities. In table A3 in the appendix we report the coefficient of total duration of water shortages for our main specification (table 2 column 4) when we exclude the extreme observations for labor productivity and total duration of water shortages. We exclude the top 1%, bottom 1% and both top and bottom 1% observations of both variables. As shown in table A3 in the appendix, the sign and significance of the coefficient of total duration of water shortages are unaffected, indicating the findings are robust to extreme values of both the dependent variable and the main variable of interest.

In figure 1 in the appendix we graph the coefficient and the 95% confidence interval of the total duration of water shortages as we drop one country at a go from the sample. Figure 1 (in the appendix) shows that the results are not dominated by any particular country in the sample as we retain the sign and significance at 5% of the coefficient of total duration of water shortages.

4.5 Robustness Check – Location and Size Averages

To limit concerns of endogeneity, we follow the literature by transforming our water shortage variable into averages of location, size, and sector minus the firm's own response to alleviate simultaneity bias between business environment and productivity (Reyes et al., 2011; Commander and Svejnar, 2011). The drawback to this method is that it reduces heterogeneity in the business environment variable, and sufficient observations are needed to obtain meaningful averages. We transform the water shortage variables as follows. We create a size variable that has six size categories: 1, 2, 3, 4, 5, and 6 and above employees. This ensures that each category has at least 5% of the sample, given that the average number of employees per firm is 2.7. We then create total water shortage duration cell averages using this size variable in addition to location (urban center), and whether the firm is within a fixed premise. The average excludes the response

of the individual firm. This is presented in column 1 in table 6. In column 2 we also include detailed business activity as part of the cell average. The coefficients for the cell average of water shortage duration are negative and statistically significant at the 10% level. The low statistical significance is likely due to the low number of observations in the informal first data set. Regardless, this adds an additional layer of robustness to the findings.

4.6 Robustness Check: Non-linear Effects and Water Shortage Firm Sample

The relationship between water shortages and labor productivity may be non-linear. To explore further the non-linear effects, we divide the total duration of water shortages into bins. The results are presented in columns 1 and 2 of table 7. In column 1 we have 3 bins – (i) no water shortages, (ii) between 1 and 4 days of water shortages, and (iii) 5 or more days of water shortages. This ensures that there are at least 67 observations for each bin. In column 2 we have 4 bins: (i) no water shortages, (ii) between 1 and 4 days of water shortages, (iii) between 5 and 10 days of water shortages, iv) 11 or more days of water shortages. In this specification, we ensure each bin has at least 30 observations. The results in both columns 1 and 2 are relative to the bin with no water shortages. As shown in table 7, the effects of water shortages are driven mostly by the bin with the highest days of water shortages. In column 1, the coefficient of the bin of 5 or more days of water shortages is negative and statistically significant at the 5% level. The other bin (between 1 and 4) has a negative coefficient but is statistically insignificant. In column 2, the coefficient bin with 11 or more days of water shortages is negative and statistically significant at the 1% level. The other bins have negative coefficients that are statistically insignificant.

Our main findings may include two distinct types of firms - those that have experienced a water shortage and those that have not. This assumes a degree of linearity in the results. To explore this further, we trim down the sample to only firms that experienced water shortages. As shown in column 3 of table 7, the main findings are unchanged – the coefficient of the total duration of water shortages in days over the last month

have a negative effect on labor productivity, statistically significant at the 1% level. However, the magnitude is much larger when compared to our base results in column 4 of table 2 (-0.051 vs. -0.037).

4.7 Additional Results: Enumerator Bias, Household Accounts, and Family Labor

Several additional checks were performed. To account for enumerator bias, for the 9 of the 12 economies that have information on enumerators, enumerator and survey fixed effects are added to the main specification. Monthly fixed effects are also used to account for seasonality (table A6). The main results are unaffected with the inclusion of these variables. The results also stand when sales for the last month are used to measure labor productivity, regardless of whether they are abnormal, instead of sales in a usual month (table A7). Controlling for interview length has no effect on the main results. On average, almost 30 percent of informal firms are family labor. Controlling for family labor has no effect on the main results (table A8). Whether an owner maintains separate accounts between the household and the firm does not affect the findings, although the negative effect of water durations on labor productivity is much greater for firms that keep the accounts separate (table A9). Finally, we find limited evidence that the total duration of water shortages is correlated with input choice (table A5).

5. Conclusions

Infrastructure challenges are considered to be a main concern for the formal sector, but little attention is afforded to what role they may play in the informal sector. This study established a hitherto unexplored relationship – the effect of water shortages in terms of the total duration of water insufficiency incidents on firm productivity. The study finds a negative and significant effect of the total duration of water shortages on labor productivity. A one standard deviation increase in the total duration of water shortages in days leads to losses to the order of 14.5 percent of monthly sales per worker. The results survive a battery of robustness checks including poor power infrastructure, selection bias, and both extreme observations and country dominance.

The conclusion that poor water infrastructure quality hurts the more vulnerable elements in society is not surprising but has yet to be established in the literature. With looming water challenges, one can expect that issues of water infrastructure quality may worsen. This study serves to draw attention to the risks water challenges pose to the informal sector. The informal sector is large, and any losses suffered in the sector may have important implications for the well-being of a large section of the poor, which could turn back the clock on several advancements achieved by the development community, particularly in the areas of poverty and health. We hope this study encourages more research efforts in this area.

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Table 1: Summary Statistics*

Variables	Mean	Std. Dev.	Min	Max
Labor Productivity (log of sales per worker)	5.17	1.40	-3.42	12.00
Total duration of water shortages last month (in days)	1.33	3.95	0	25
Average length of water shortage in hours (0 if no shortage experienced)	5.03	19.27	0	336
Total number of water shortage incidents over the last month (0 if no shortage)	1.70	4.35	0	30
Log of total number of employees in regular month	0.68	0.71	0	3.22
Largest owner has secondary education or higher: Y/N	0.59	0.49	0	1
Manager experience (years)	9.53	8.73	1	50
Largest owner has a job in formal sector or looked for one over last 2 years Y/N	0.14	0.35	0	1
Largest owner started another business in the last three years Y/N	0.61	0.49	0	1
Firm uses electricity for activity Y/N	0.71	0.45	0	1
Firm uses machinery in its current operations Y/N	0.43	0.50	0	1
Firm uses vehicles in its current operations Y/N	0.19	0.39	0	1
Manufacturing firm Y/N	0.55	0.50	0	1
Produces or sells under contract from another business or person Y/N	0.21	0.41	0	1
Firm uses bank account to run business Y/N	0.25	0.44	0	1
Firm has a loan at this time Y/N	0.13	0.34	0	1
Firm pays informal payment to remain unregistered Y/N	0.09	0.29	0	1
Firm experienced crime last month Y/N	0.08	0.27	0	1
Firm pays for security Y/N	0.24	0.43	0	1
Firm located within household or fixed premises & permanent structure Y/N	0.76	0.43	0	1

*Summary statistics only for firms in the sample of the main specification in table 2.

Table 2: Water shortages and labor productivity

	Labor Productivity (logs)			
	coef/se	coef/se	coef/se	coef/se
	(1)	(2)	(3)	(4)
Total duration of water shortages last month (in days)	-0.033**	-0.037***	-0.036***	-0.037***
	(0.015)	(0.012)	(0.011)	(0.011)
Log of total number of employees in regular month		-0.506***	-0.560***	-0.560***
		(0.114)	(0.110)	(0.111)
Largest owner has secondary education or higher: Y/N		0.296***	0.278**	0.286**
		(0.114)	(0.124)	(0.135)
Manager experience (years)		0.017**	0.016**	0.016**
		(0.007)	(0.007)	(0.007)
Largest owner has a job in formal sector or looked for one over last 2 years Y/N		0.033	0.033	0.021
		(0.144)	(0.137)	(0.136)
Largest owner started another business in the last three years Y/N		-0.129	-0.136*	-0.128
		(0.080)	(0.079)	(0.079)
Firm uses electricity for activity Y/N		0.099	0.069	0.078
		(0.096)	(0.087)	(0.080)
Firm uses machinery in its current operations Y/N		0.041	0.022	0.037
		(0.089)	(0.092)	(0.090)
Firm uses vehicles in its current operations Y/N		0.467***	0.455***	0.464***
		(0.079)	(0.089)	(0.095)
Manufacturing firm Y/N		0.180**	0.150*	0.144*
		(0.071)	(0.080)	(0.084)
Produces or sells under contract from another business or person Y/N			0.361***	0.379***
			(0.122)	(0.136)
Firm uses bank account to run business Y/N			0.179	0.188
			(0.131)	(0.121)
Firm has a loan at this time Y/N			-0.017	0.000
			(0.071)	(0.073)
Firm pays informal payment to remain unregistered Y/N				-0.251
				(0.168)
Firm experienced crime last month Y/N				0.062
				(0.231)
Firm pays for security Y/N				-0.079
				(0.181)
Constant	5.205***	5.812***	6.045***	6.146***
	(0.012)	(0.196)	(0.191)	(0.198)
Location (within country) Fixed Effects	YES	YES	YES	YES
Number of observations	710	710	710	710
Adjusted R2	0.274	0.332	0.341	0.341

note: *** p<0.01, ** p<0.05, * p<0.1, Hubert-White robust standard errors clustered at the region-sector level in brackets

Table 3: Water Shortage Incidents and Average Duration of Incidents

	Labor Productivity (logs)		
	coef/se	coef/se	coef/se
	(1)	(2)	(3)
Average length of water shortage, 0 if no shortage experienced	-0.007** (0.003)		-0.007** (0.003)
Total number of water shortage incidents over the last month, 0 if no shortage		0.001 (0.009)	0.002 (0.007)
Log of total number of employees in regular month	-0.561*** (0.111)	-0.552*** (0.110)	-0.561*** (0.111)
Largest owner has secondary education or higher: Y/N	0.263** (0.134)	0.280** (0.138)	0.262* (0.135)
Manager experience (years)	0.016** (0.007)	0.015** (0.007)	0.016** (0.007)
Largest owner has a job in formal sector or looked for one over last 2 years Y/N	0.032 (0.136)	0.017 (0.136)	0.033 (0.135)
Largest owner started another business in the last three years Y/N	-0.109 (0.078)	-0.120 (0.081)	-0.107 (0.079)
Firm uses electricity for activity Y/N	0.098 (0.081)	0.097 (0.080)	0.099 (0.081)
Firm uses machinery in its current operations Y/N	0.028 (0.090)	0.040 (0.091)	0.029 (0.090)
Firm uses vehicles in its current operations Y/N	0.450*** (0.093)	0.470*** (0.100)	0.450*** (0.093)
Manufacturing firm Y/N	0.149* (0.085)	0.133 (0.081)	0.148* (0.085)
Produces or sells under contract from another business or person Y/N	0.373*** (0.132)	0.382*** (0.134)	0.373*** (0.132)
Firm uses bank account to run business Y/N	0.192 (0.120)	0.186 (0.121)	0.193 (0.121)
Firm has a loan at this time Y/N	-0.000 (0.072)	-0.013 (0.075)	-0.001 (0.072)
Firm pays informal payment to remain unregistered Y/N	-0.232 (0.168)	-0.225 (0.175)	-0.231 (0.168)
Firm experienced crime last month Y/N	0.052 (0.236)	0.060 (0.247)	0.050 (0.237)
Firm pays for security Y/N	-0.074 (0.174)	-0.077 (0.175)	-0.073 (0.174)
Constant	6.136*** (0.197)	6.074*** (0.195)	6.129*** (0.203)
Location (within country) Fixed Effects	YES	YES	YES
Number of observations	710	710	710
Adjusted R2	0.342	0.334	0.341

note: *** p<0.01, ** p<0.05, * p<0.1, Hubert-White robust standard errors clustered at the region-sector level in brackets

Table 4: Robustness Check - Power Outages and Sector of Activity

Dependent Variable	Labor Productivity (logs)			
	Firms that use power for business activities		Manufacturing Firms (manufactures product by itself)	Retail and Other Service Firms
	coef/se	coef/se	coef/se	coef/se
Total duration of water shortages last month (in days)	-0.063** (0.025)	-0.063** (0.025)	-0.038** (0.018)	-0.059 (0.050)
Total number of power outage incidents per day over the last month	0.082 (0.133)			
Average length of power outage, 0 if no outage experienced	0.005 (0.004)			
Total duration of power outages last month (in days)		0.025 (0.018)		
Firm uses generator Y/N	-0.196 (0.136)	-0.201 (0.129)		
Firm uses electricity for activity Y/N			0.134 (0.141)	0.028 (0.179)
Log of total number of employees in regular month	-0.513*** (0.123)	-0.512*** (0.123)	-0.609*** (0.189)	-0.549*** (0.133)
Largest owner has secondary education or higher: Y/N	0.161 (0.219)	0.155 (0.219)	0.142 (0.174)	0.528** (0.218)
Manager experience (years)	0.008 (0.007)	0.008 (0.007)	0.020 (0.012)	0.009 (0.008)
Largest owner has a job in formal sector or looked for one over last 2 years Y/N	-0.164 (0.205)	-0.152 (0.196)	-0.052 (0.271)	0.143 (0.280)
Largest owner started another business in the last three years Y/N	-0.042 (0.089)	-0.033 (0.095)	-0.151 (0.125)	-0.074 (0.182)
Firm uses machinery in its current operations Y/N	0.064 (0.136)	0.068 (0.131)	0.095 (0.180)	-0.023 (0.179)
Firm uses vehicles in its current operations Y/N	0.366*** (0.099)	0.378*** (0.101)	0.370** (0.171)	0.498** (0.218)
Manufacturing firm Y/N	0.056 (0.106)	0.058 (0.108)		
Produces or sells under contract from another business or person Y/N	0.316* (0.167)	0.314* (0.168)	0.250* (0.128)	0.752*** (0.223)
Firm uses bank account to run business Y/N	0.257 (0.165)	0.263 (0.172)	0.326* (0.171)	0.047 (0.207)
Firm has a loan at this time Y/N	-0.073 (0.081)	-0.074 (0.079)	-0.100 (0.119)	-0.062 (0.194)
Firm pays informal payment to remain unregistered Y/N	-0.249** (0.126)	-0.251* (0.129)	0.064 (0.258)	-0.509 (0.418)
Firm experienced crime last month Y/N	0.199	0.201	-0.210	0.291

	(0.256)	(0.256)	(0.328)	(0.343)
Firm pays for security Y/N	0.013	0.014	0.248*	-0.414
	(0.139)	(0.138)	(0.142)	(0.336)
Constant	6.573***	6.573***	6.317***	5.433***
	(0.377)	(0.377)	(0.436)	(0.700)
Location (within country) Fixed Effects	YES	YES	YES	YES
Number of observations	476	476	387	323
Adjusted R2	0.367	0.368	0.434	0.287

note: *** p<0.01, ** p<0.05, * p<0.1, Hubert-White robust standard errors clustered at the region-sector level in brackets

Table 5: Water shortages – Heckman selection model

	Labor Productivity (logs)	Water Used for Business Activity
	coef/se	coef/se
	(1)	(2)
Total duration of water shortages last month (in days)	-0.041*** (0.012)	
Firm located within household or fixed premises & permanent structure Y/N		0.281*** (0.051)
Log of total number of employees in regular month	-0.235 (0.193)	0.316*** (0.070)
Largest owner has secondary education or higher: Y/N	0.038 (0.202)	-0.181** (0.081)
Manager experience (years)	0.003 (0.006)	-0.011** (0.004)
Largest owner has a job in formal sector or looked for one over last 2 years Y/N	0.129 (0.166)	0.093 (0.111)
Largest owner started another business in the last three years Y/N	-0.126 (0.082)	0.037 (0.049)
Firm uses electricity for activity Y/N	0.196* (0.103)	
Firm uses machinery in its current operations Y/N	-0.035 (0.156)	-0.097 (0.165)
Firm uses vehicles in its current operations Y/N	0.729*** (0.107)	0.173*** (0.063)
Manufacturing firm Y/N	0.369*** (0.119)	0.166** (0.079)
Produces or sells under contract from another business or person Y/N	0.305* (0.166)	-0.118 (0.074)
Firm uses bank account to run business Y/N	0.066 (0.143)	-0.053 (0.071)
Firm has a loan at this time Y/N	0.108 (0.109)	0.060 (0.079)
Firm pays informal payment to remain unregistered Y/N	-0.135 (0.130)	0.076 (0.100)
Firm experienced crime last month Y/N	0.140 (0.178)	-0.113 (0.094)
Firm pays for security Y/N	-0.230 (0.333)	-0.238** (0.113)
Constant	3.620*** (1.184)	-1.643*** (0.469)
/athrho	1.243*** (0.297)	

/Insigma	0.454***	
	(0.144)	
rho	0.846	
sigma	1.574	
lambda	1.332	
Wald test for indep. Eqns. (rho = 0) Prob > chi2	0.000	
Location (within country) Fixed Effects	YES	YES
Number of observations		2,488

note: *** p<0.01, ** p<0.05, * p<0.1, Hubert-White robust standard errors clustered at the region-sector level in brackets. Note that rho is the correlation coefficient of the error terms from the selection and the regression equation. Sigma is the estimator of the standard error of the residual in the regression equation. Lambda is Inverse mills ratio (rho x sigma). Significance of lambda depends on rho as indicated by the Wald test.

Table 6: Water shortages – Sector and location averages

	Labor Productivity (logs)	
	coef/se	coef/se
Total water duration cell average: size, region, and fixed premise location	-0.038*	
	(0.021)	
Total water duration: cell average of size, sector, region, and fixed premise location		-0.034*
		(0.018)
Log of total number of employees in regular month	-0.596***	-0.562***
	(0.129)	(0.140)
Largest owner has secondary education or higher: Y/N	0.263**	0.317**
	(0.127)	(0.142)
Manager experience (years)	0.014*	0.013
	(0.007)	(0.009)
Largest owner has a job in formal sector or looked for one over last 2 years Y/N	-0.099	-0.180
	(0.146)	(0.156)
Largest owner started another business in the last three years Y/N	-0.119	-0.078
	(0.087)	(0.115)
Firm uses electricity for activity Y/N	0.102	0.030
	(0.088)	(0.127)
Firm uses machinery in its current operations Y/N	0.085	0.103
	(0.089)	(0.099)
Firm uses vehicles in its current operations Y/N	0.455***	0.471***
	(0.111)	(0.173)
Manufacturing firm Y/N	0.110	0.126
	(0.082)	(0.106)
Produces or sells under contract from another business or person Y/N	0.357***	0.295***
	(0.115)	(0.092)
Firm uses bank account to run business Y/N	0.119	0.141
	(0.139)	(0.143)
Firm has a loan at this time Y/N	0.051	-0.034
	(0.093)	(0.124)
Firm pays informal payment to remain unregistered Y/N	-0.171	-0.171
	(0.268)	(0.364)
Firm experienced crime last month Y/N	-0.013	-0.011
	(0.263)	(0.239)
Firm pays for security Y/N	-0.057	-0.127
	(0.233)	(0.183)

Constant	6.262*** (0.260)	6.179*** (0.285)
Location (within country) Fixed Effects	YES	YES
Number of observations	638	482
Adjusted R2	0.347	0.312

note: *** p<0.01, ** p<0.05, * p<0.1, Hubert-White robust standard errors clustered at the region-sector level in brackets

Table 7: Non-linear effects and Water Shortage Firm Sample

Dependent Variable	Labor Productivity (logs)			
	Sample	Full Sample		Only Firms that Experienced a Water Shortage
	coef/se	coef/se	coef/se	
Total Duration of Water Shortages: Between 1 and 4 days	-0.049 (0.098)	-0.049 (0.097)		
Total Duration of Water Shortages: 5 or more days	-0.526** (0.213)			
Total Duration of Water Shortages: Between 5 and 10 days		-0.460 (0.489)		
Total Duration of Water Shortages: 11 or more days		-0.571*** (0.166)		
Total duration of water shortages last month (in days)			-0.051*** (0.012)	
Log of total number of employees in regular month	-0.561*** (0.112)	-0.562*** (0.113)	-0.976*** (0.152)	
Largest owner has secondary education or higher: Y/N	0.294** (0.140)	0.293** (0.143)	0.504*** (0.164)	
Manager experience (years)	0.016** (0.007)	0.016** (0.007)	0.029*** (0.011)	
Largest owner has a job in formal sector or looked for one over last 2 years Y/N	0.023 (0.135)	0.024 (0.135)	-0.688** (0.319)	
Largest owner started another business in the last three years Y/N	-0.136* (0.078)	-0.134* (0.077)	0.201 (0.165)	
Firm uses electricity for activity Y/N	0.096 (0.079)	0.092 (0.081)	-0.126 (0.244)	
Firm uses machinery in its current operations Y/N	0.033 (0.090)	0.034 (0.091)	0.083 (0.257)	
Firm uses vehicles in its current operations Y/N	0.459*** (0.093)	0.463*** (0.091)	0.032 (0.146)	
Manufacturing firm Y/N	0.140* (0.084)	0.140* (0.085)	0.505*** (0.185)	
Produces or sells under contract from another business or person Y/N	0.377*** (0.131)	0.377*** (0.129)	0.513** (0.242)	
Firm uses bank account to run business Y/N	0.179 (0.125)	0.180 (0.127)	-0.074 (0.296)	
Firm has a loan at this time Y/N	0.012 (0.070)	0.009 (0.073)	0.014 (0.159)	
Firm pays informal payment to remain unregistered Y/N	-0.261	-0.265	-0.263	

	(0.186)	(0.169)	(0.445)
Firm experienced crime last month Y/N	0.059	0.060	0.463
	(0.232)	(0.231)	(0.577)
Firm pays for security Y/N	-0.080	-0.080	-0.197
	(0.183)	(0.183)	(0.532)
Constant	6.134***	6.141***	5.525***
	(0.220)	(0.231)	(0.663)
Location (within country) Fixed Effects	YES	YES	YES
Number of observations	710	710	173
Adjusted R2	0.339	0.338	0.161

note: *** p<0.01, ** p<0.05, * p<0.1, Hubert-White robust standard errors clustered at the region-sector level in brackets

APPENDIX:**Table A1: Country Composition and Total Duration of Water Shortages**

Country	Year	Total duration of water shortages last month (in days)
Angola	2010	0.84
Argentina	2010	0.05
Burkina Faso	2009	0.01
Cameroon	2009	0.19
Cabo Verde	2009	0.45
Democratic Republic of Congo	2013	1.20
Ghana	2013	6.75
Guatemala	2010	0.29
Kenya	2013	0.65
Myanmar	2014	0.68
Peru	2010	0.09
Rwanda	2011	0.02

Table A2: Informal Firm Activity for 8 economies

Firm Activity	No. of Firms	Percentage of Sample
Manufacturing of clothes or shoes	68	12.69
Manufacturing of baked food (Baker)	63	11.75
Manufacturing of coffee, sugar, oil, dry fruits and other processed foods (exclude restaurants, street food-sellers)	19	3.54
Manufacturing of handcrafts	15	2.80
Manufacturing of furniture	31	5.78
Manufacturing of metal products	22	4.10
Manufacturing of household items	8	1.49
Other manufacturing (not included above)	53	9.89
Selling food or Groceries (street-food sellers, restaurants)	119	22.20
Selling of clothes or household items	2	0.37
Selling of other goods	7	1.31
Selling of business/computer/phone service	27	5.04
Transport Services	3	0.56
Cleaning and washing services	7	1.31
Hairdressers and barber shops	49	9.14
Professional Services (including internet services)	1	0.19
Repairing services	11	2.05
Construction	3	0.56
Other services (not included above)	28	5.22
Total	536	100.00

The 8 economies are: Angola, Argentina, Democratic Republic of Congo, Guatemala, Kenya, Myanmar, Peru, and Rwanda

Table A3: Extreme Observations Exclusion

Extreme Value Observation Exclusion: Total Water Shortage Duration			
	Bottom 1%	Top 1%	Top and Bottom 1 %
	coef/se	coef/se	coef/se
Total duration of water shortages last month (in days)	-0.036*** (0.010)	-0.035** (0.015)	-0.035*** (0.011)

Extreme Value Observation Exclusion: Labor Productivity			
	Bottom 1%	Top 1%	Top and Bottom 1 %
	coef/se	coef/se	coef/se
Total duration of water shortages last month (in days)	-0.027*** (0.010)	-0.032*** (0.010)	-0.022** (0.011)

Table A4: Water Shortage and Correlates

	Total duration of water shortages last month (in days)
	coef/se
Log of total number of employees in regular month	-0.217 (0.205)
Largest owner has secondary education or higher: Y/N	0.189 (0.188)
Manager experience (years)	0.011 (0.019)
Largest owner has a job in formal sector or looked for one over last 2 years Y/N	0.151 (0.148)
Largest owner started another business in the last three years Y/N	-0.172 (0.361)
Firm uses electricity for activity Y/N	-0.269 (0.309)
Firm uses machinery in its current operations Y/N	-0.090 (0.266)

Firm uses vehicles in its current operations Y/N	-0.240
	(0.555)
Manufacturing firm Y/N	0.273*
	(0.153)
Produces or sells under contract from another business or person Y/N	-0.025
	(0.184)
Firm uses bank account to run business Y/N	0.083
	(0.258)
Firm has a loan at this time Y/N	0.308
	(0.470)
Firm pays informal payment to remain unregistered Y/N	-0.590
	(0.441)
Firm experienced crime last month Y/N	-0.040
	(0.756)
Firm pays for security Y/N	-0.093
	(0.199)
Firm located within household or fixed premises & permanent structure Y/N	-0.883**
	(0.358)
Constant	2.411***
	(0.798)
<hr/>	
Location (within country) Fixed Effects	YES
<hr/>	
Number of observations	706
<hr/>	
Adjusted R2	0.405
<hr/>	

note: *** p<0.01, ** p<0.05, * p<0.1

Table A5: Water Shortages and Capital and Labor use

Model	Probit	Probit	OLS	OLS
Dependent Variable	Firm uses machinery in its current operations Y/N	Firm uses vehicles in its current operations Y/N	Log of total number of employees in regular month	Manager experience (years)
	coef/se	coef/se	coef/se	coef/se
Total duration of water shortages last month (in days)	-0.005 (0.019)	-0.010 (0.036)	-0.007 (0.006)	0.065 (0.129)
Log of total number of employees in regular month	0.201 (0.160)	0.532*** (0.107)		1.544*** (0.542)
Largest owner has secondary education or higher: Y/N	0.434*** (0.119)	0.013 (0.151)	0.006 (0.058)	-1.831** (0.862)
Manager experience (years)	0.018*** (0.006)	-0.000 (0.005)	0.007*** (0.002)	
Largest owner has a job in formal sector or looked for one over last 2 years Y/N	-0.238** (0.099)	-0.118 (0.149)	0.175*** (0.053)	-0.826 (0.513)
Largest owner started another business in the last three years Y/N	-0.148 (0.106)	0.051 (0.154)	0.027 (0.032)	-2.248*** (0.630)
Firm uses electricity for activity Y/N	0.819*** (0.157)	0.217 (0.207)	0.023 (0.059)	-0.374 (0.773)
Manufacturing firm Y/N	0.557*** (0.116)	0.111 (0.095)	0.060** (0.029)	0.657 (0.403)
Produces or sells under contract from another business or person Y/N	0.106 (0.119)	-0.145 (0.148)	0.197*** (0.062)	0.954 (1.019)
Firm uses bank account to run business Y/N	0.146 (0.192)	0.479*** (0.153)	0.194*** (0.068)	-0.055 (0.826)
Firm has a loan at this time Y/N	-0.040 (0.125)	0.159 (0.190)	0.151 (0.097)	1.408 (0.938)
Firm pays informal payment to remain unregistered Y/N	0.486*** (0.165)	0.314 (0.250)	-0.112 (0.079)	-0.253 (1.343)
Firm experienced crime last month Y/N	-0.554*** (0.121)	-0.055 (0.199)	0.103 (0.103)	1.004 (1.103)
Firm pays for security Y/N	-0.064 (0.073)	-0.097 (0.147)	0.229*** (0.075)	-0.701 (0.618)
Firm uses machinery in its current operations Y/N			0.077	2.122***

			(0.081)	(0.755)
Firm uses vehicles in its current operations Y/N			0.274***	-0.122
			(0.055)	(0.655)
Constant	-0.917***	-2.351***	2.190***	0.308
	(0.148)	(0.173)	(0.087)	(1.342)
Location (within country) Fixed Effects	YES	YES	YES	YES
Number of observations	691	677	710	710
Adjusted R2	0.204	0.203	0.400	0.072

note: *** p<0.01, ** p<0.05, * p<0.1

Table A6: Enumerator bias

Dependent Variable	Labor Productivity (logs)		
	Interviewer Fixed Effects	Interviewer and Supervisor Fixed Effects	Interviewer, Supervisor, and Survey Month Fixed Effects
	coef/se	coef/se	coef/se
Total duration of water shortages last month (in days)	-0.033*** (0.013)	-0.028*** (0.010)	-0.030*** (0.011)
Log of total number of employees in regular month	-0.685*** (0.174)	-0.687*** (0.185)	-0.655*** (0.172)
Largest owner has secondary education or higher: Y/N	0.179 (0.150)	0.152 (0.155)	0.155 (0.143)
Manager experience (years)	0.025** (0.013)	0.026** (0.013)	0.027** (0.013)
Largest owner has a job in formal sector or looked for one over last 2 years Y/N	0.277 (0.212)	0.215 (0.231)	0.215 (0.229)
Largest owner started another business in the last three years Y/N	-0.091 (0.135)	-0.099 (0.142)	-0.120 (0.169)
Firm uses electricity for activity Y/N	0.131 (0.157)	0.205 (0.158)	0.228 (0.166)
Firm uses machinery in its current operations Y/N	-0.208* (0.118)	-0.235* (0.130)	-0.269** (0.129)
Firm uses vehicles in its current operations Y/N	0.229 (0.204)	0.261 (0.187)	0.217 (0.213)
Manufacturing firm Y/N	0.316*** (0.077)	0.312*** (0.077)	0.327*** (0.084)
Produces or sells under contract from another business or person Y/N	0.557*** (0.189)	0.553*** (0.183)	0.544** (0.221)
Firm uses bank account to run business Y/N	0.431** (0.203)	0.548** (0.228)	0.517** (0.243)
Firm has a loan at this time Y/N	0.267 (0.212)	0.291 (0.216)	0.261 (0.240)
Firm pays informal payment to remain unregistered Y/N	-0.412** (0.182)	-0.383* (0.203)	-0.360* (0.205)
Firm experienced crime last month Y/N	0.088	0.147	0.115

	(0.372)	(0.357)	(0.389)
Firm pays for security Y/N	-0.089	-0.134	-0.168
	(0.125)	(0.112)	(0.111)
Constant	7.948***	7.838***	6.167***
	(0.879)	(0.859)	(0.690)
Interviewer Fixed Effects	YES	YES	YES
Supervisor Fixed Effects	YES	YES	YES
Survey Month Fixed Effects	YES	YES	YES
Location (within country) Fixed Effects	YES	YES	YES
Number of observations	479	479	479
Adjusted R2	0.485	0.497	0.510

note: *** p<0.01, ** p<0.05, * p<0.1

Table A7: Time reference of sales and Interview length

	Labor Productivity (logs) based on sales of the last month	Labor Productivity (logs) based on sales of the usual month
	coef/se	coef/se
Total duration of water shortages last month (in days)	-0.028*** (0.008)	-0.037*** (0.011)
Interview length (in minutes)		-0.0003 (0.001)
Log of total number of employees in regular month	-0.552*** (0.100)	-0.561*** (0.112)
Largest owner has secondary education or higher: Y/N	0.300*** (0.088)	0.286** (0.136)
Manager experience (years)	0.017** (0.007)	0.015** (0.007)
Largest owner has a job in formal sector or looked for one over last 2 years Y/N	0.045 (0.136)	-0.004 (0.134)
Largest owner started another business in the last three years Y/N	-0.092 (0.074)	-0.134* (0.078)
Firm uses electricity for activity Y/N	0.024 (0.068)	0.071 (0.083)
Firm uses machinery in its current operations Y/N	0.030 (0.078)	0.058 (0.089)
Firm uses vehicles in its current operations Y/N	0.399*** (0.082)	0.477*** (0.100)
Manufacturing firm Y/N	0.118 (0.074)	0.143* (0.086)
Produces or sells under contract from another business or person Y/N	0.242** (0.120)	0.391*** (0.147)
Firm uses bank account to run business Y/N	0.198* (0.104)	0.164 (0.133)
Firm has a loan at this time Y/N	-0.127 (0.130)	0.002 (0.074)
Firm pays informal payment to remain unregistered Y/N	-0.002 (0.123)	-0.219 (0.158)
Firm experienced crime last month Y/N	-0.062 (0.207)	0.067 (0.231)
Firm pays for security Y/N	0.098 (0.105)	-0.110 (0.198)
Constant	5.858*** (0.198)	6.155*** (0.209)

Location (within country) Fixed Effects	YES	YES
Number of observations	713	706
Adjusted R2	0.339	0.343

note: *** p<0.01, ** p<0.05, * p<0.1

Table A8: Family labor

	Labor Productivity (logs)		
	coef/se	coef/se	coef/se
Total duration of water shortages last month (in days)	-0.025** (0.010)	-0.024** (0.011)	-0.028*** (0.010)
Family labor Y/N	-0.134 (0.112)		
No. of family labor		0.004 (0.046)	
Share of family labor			-0.095 (0.143)
Log of total number of employees in regular month	-0.513*** (0.125)	-0.547*** (0.130)	-0.540*** (0.113)
Largest owner has secondary education or higher: Y/N	0.280** (0.131)	0.288** (0.132)	0.273** (0.137)
Manager experience (years)	0.015** (0.007)	0.015** (0.007)	0.015** (0.007)
Largest owner has a job in formal sector or looked for one over last 2 years Y/N	0.101 (0.150)	0.105 (0.154)	0.105 (0.152)
Largest owner started another business in the last three years Y/N	-0.167** (0.068)	-0.180** (0.072)	-0.167** (0.067)
Firm uses electricity for activity Y/N	0.090 (0.080)	0.085 (0.080)	0.092 (0.078)
Firm uses machinery in its current operations Y/N	0.036 (0.085)	0.041 (0.087)	0.043 (0.085)
Firm uses vehicles in its current operations Y/N	0.390*** (0.086)	0.385*** (0.086)	0.383*** (0.087)
Manufacturing firm Y/N	0.101 (0.088)	0.100 (0.089)	0.094 (0.089)
Produces or sells under contract from another business or person Y/N	0.341*** (0.104)	0.334*** (0.105)	0.337*** (0.107)
Firm uses bank account to run business Y/N	0.183 (0.120)	0.189 (0.123)	0.193 (0.122)
Firm has a loan at this time Y/N	0.005 (0.067)	-0.012 (0.068)	0.000 (0.072)
Firm pays informal payment to remain unregistered Y/N	-0.104	-0.091	-0.098

	(0.104)	(0.104)	(0.103)
Firm experienced crime last month Y/N	0.021	0.027	0.024
	(0.241)	(0.243)	(0.244)
Firm pays for security Y/N	-0.004	0.006	-0.001
	(0.138)	(0.133)	(0.135)
Constant	5.021***	4.986***	5.006***
	(0.265)	(0.250)	(0.266)
Location (within country) Fixed Effects	YES	YES	YES
Number of observations	704	704	702
Adjusted R2	0.369	0.367	0.369

note: *** p<0.01, ** p<0.05, * p<0.1

Table A9: Accounts together versus accounts separate

Dependent Variable	Labor Productivity (logs)	
	Business and Household Accounts Separate	Business and Household Accounts Together
Sample	coef/se	coef/se
Total duration of water shortages last month (in days)	-0.111*** (0.043)	-0.014* (0.008)
Log of total number of employees in regular month	-0.722*** (0.206)	-0.491*** (0.113)
Largest owner has secondary education or higher: Y/N	0.407* (0.233)	0.186 (0.144)
Manager experience (years)	-0.001 (0.005)	0.020** (0.010)
Largest owner has a job in formal sector or looked for one over last 2 years Y/N	-0.272 (0.200)	0.229 (0.155)
Largest owner started another business in the last three years Y/N	-0.143 (0.089)	-0.069 (0.108)
Firm uses electricity for activity Y/N	0.141 (0.136)	0.163 (0.111)
Firm uses machinery in its current operations Y/N	0.339** (0.150)	-0.092 (0.126)
Firm uses vehicles in its current operations Y/N	0.460*** (0.143)	0.397*** (0.135)
Manufacturing firm Y/N	0.277** (0.138)	-0.009 (0.064)
Produces or sells under contract from another business or person Y/N	0.554*** (0.135)	0.167 (0.137)
Firm uses bank account to run business Y/N	0.396** (0.176)	0.212** (0.088)
Firm has a loan at this time Y/N	0.258 (0.167)	-0.126 (0.145)
Firm pays informal payment to remain unregistered Y/N	-0.963** (0.392)	0.143 (0.201)
Firm experienced crime last month Y/N	0.185 (0.379)	-0.055 (0.202)
Firm pays for security Y/N	-0.218	-0.090

	(0.390)	(0.085)
Constant	5.103***	6.894***
	(0.730)	(0.276)
Location (within country) Fixed Effects	YES	YES
Number of observations	276	430
Adjusted R2	0.299	0.402

note: *** p<0.01, ** p<0.05, * p<0.1

Figure 1: Country Dominance

