Impacts of Piped Water Shortages on Labor Supply: Evidence from Mexico City

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Abstract

Urban water shortages are an increasingly urgent challenge in large cities, driven by population growth, climate change, and aging infrastructure. In Mexico City—where households lack alternative sources—disruptions to piped supply force residents to either wait at home for public deliveries or spend money on private water trucks and bottled water. These shocks can affect both time and income, creating theoretically ambiguous effects on labor supply. This paper provides the first causal evidence on the labor market consequences of piped water shortages. I combine high-frequency labor panel data with a novel proxy that interacts rainfall-driven variation in reservoir storage with each block's location within Mexico City's gravity-fed pipeline network. This variation predicts changes in residential water consumption. A drop in reservoir levels from the median to the fifth percentile reduces weekly hours worked by about one hour, on average. Effects are heterogeneous: female formal employees—with access to job protections—reduce hours worked, likely reallocating time toward caregiving and household duties, while female informal employees increase hours, potentially to offset the financial burden of shortages. These findings highlight how gender roles and job informality jointly mediate labor supply responses to water insecurity in urban settings.

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Keywords: water shortages, piped water, labor supply, informal employment, gender, urban infrastructure, developing countries

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1. Introduction

Water shortages in cities are a growing global issue driven by climate change-induced droughts and rapid urbanization—68% of the world's population is projected to live in urban areas by 2050 (UN, 2019). As of 2016, 36.7% of large cities worldwide faced water supply constraints (He et al., 2021); this share is expected to rise to 55.9% by 2050. Ensuring adequate water supply is especially challenging for municipal utilities in developing countries, where financial constraints and aging infrastructure are common (Ashraf et al., 2021). As climate risks intensify, understanding the social and economic impacts of infrastructure disruptions has become increasingly urgent.

This paper asks how piped water shortages affect urban labor supply—a critical but underexplored dimension of water insecurity. These shortages alter both the time and income constraints that households face. When piped water runs out, households may have to wait at home for public deliveries and devote more time to coping activities—potentially reducing hours worked. They may also incur higher expenses to secure supply, including paying for private water trucks and bottled water when service is not restored quickly, which could increase labor supply to offset these costs. These opposing time and income pressures make the net effect on labor supply theoretically ambiguous. Prior research has shown that gaining in-home piped access improves household welfare by reducing the time burden and stress of water collection (Devoto et al., 2012). This paper builds on that literature by examining what happens when already-connected households experience service interruptions—highlighting labor supply as a key margin of adjustment. To my knowledge, this is the first study to combine individual-level labor panel data with sub-city variation in piped water shortages—allowing plausibly causal estimates of labor market impacts in a megacity.

Estimating the effects of piped water shortages is empirically challenging. Most cities that experience them lack systematic data on when and where disruptions occur—especially at high frequency and sub-city spatial scales. In addition, shortages are often endogenous to local socioeconomic characteristics: households may sort into neighborhoods with better infrastructure, and utilities may prioritize service to economically important areas. Similar challenges have been documented in studies of electricity shortages, where both data and identification are key barriers to causal inference (Allcott et al., 2016).

I construct a novel proxy for exposure to piped water shortages at the city-block level, which I validate using billing data on residential water consumption. The proxy interacts weekly changes in external reservoir storage—driven by upstream rainfall—with each of the 40,000 blocks' location in Mexico City's gravity-fed pipeline network. Because water enters the city through a single mountain entry point, and pressure declines with distance due to gravity-fed flow and elevation loss, areas farther downstream are more likely to receive reduced supply when storage is low. This approach yields a fine-grained, spatiotemporal measure of shortage exposure, enabling detection of localized labor supply responses that would be obscured in coarser data. In the subset of years where billing data are available, the proxy significantly predicts declines in residential water use.

I estimate a two-way fixed effects model with city-block and week-by-year fixed effects, which account for stable differences across blocks and city-wide shocks. The identifying assumption is that, conditional on these fixed effects, water shortages are uncorrelated with other time-varying determinants of local labor outcomes or water use—such as changes in block-level demographic composition over time. This assumption is supported by institutional and hydraulic constraints: reservoir storage is determined by rainfall outside the city, and volumes delivered to the city closely track available supply (Figure A.1)—suggesting limited scope for discretionary allocation at the city level. To further address sorting concerns, I conduct two empirical tests. First, I regress individual and household characteristics on the shortage proxy and find estimates near zero and statistically insignificant. Second, I use predicted hours worked from demographics as the outcome and again find no relationship with water shortages. Together, these results suggest that labor supply effects are not driven by compositional shifts or unobserved household sorting.

Mexico City provides an ideal setting to study the labor market impacts of piped water shortages. As the largest metropolis in North America, it faces rising water stress due to declining precipitation, over-extraction of groundwater, and aging infrastructure. Service disruptions are frequent and unequally distributed across neighborhoods, and reliance on emergency trucked water has grown in recent years. At the same time, nearly half of the city's employed population works in the informal sector without job protections, and gender gaps in labor supply remain wide. These features—combined with the availability of detailed infrastructure and labor data—make Mexico City a

critical case for understanding how climate-driven infrastructure stress affects labor supply, particularly along gender and job informality lines.

I find that piped water shortages significantly reduce hours worked across the employed population in Mexico City. A drop in reservoir levels from the median to the fifth percentile reduces weekly hours worked by about one hour, on average.[1] The magnitude of this effect is surprisingly large, given that (i) the majority of households in Mexico City have some form of water storage (e.g., rooftop tanks or cisterns) to buffer against service interruptions, and (ii) external reservoirs account for only about one-quarter of the city's total water supply.[2] These short-run effects of water shortages are consistent with the hypothesis that water-related disruptions impose time costs that reduce labor supply.

I assess the robustness of the results to a variety of alternative specifications. The estimated reductions in hours worked persist when using log transformations of the outcome, binary indicators for low reservoir levels, and when estimating separate effects for the dry and rainy seasons.[3] Aggregating the panel to monthly or quarterly frequency yields consistent but less precise results, and a quadratic specification of the treatment effect confirms the same directional pattern. While adding individual fixed effects leads to imprecise estimates, the pattern of results remains consistent across specifications: water shortages reduce hours worked.

In terms of heterogeneity, I find that while both men and women reduce hours worked in similar magnitudes in response to shortages, the percentage decline is larger for women due to their lower baseline hours—widening the gender gap in labor supply during shortages. The effects vary substantially across female employees. Those in the formal sector reduce hours worked, while those in the informal sector—who lack job protections—work more. For example, when reservoir levels fall from the median to the fifth percentile, formal female employees living at the median pipeline distance work about 1.1 fewer hours per week, while informal female employees work 1.6 more hours per week. These results suggest that job formality likely shapes responses to

[1] Based on data from 2004 to 2019, this scenario reflects a typical seasonal pattern during dry years: a starting level around the 10th percentile of observed peaks (73%) and an ending level around the 25th percentile of troughs (49%). The implied 24 percentage point drop is also close to the 25th percentile of observed seasonal declines.

[2] According to the water utility this is a key water source and when reservoir levels are critically low, water supply is disrupted across the whole city, as observed in 2024.

[3] The magnitude of the effects are larger during the dry season and when reservoir levels are in the lowest quartile.

water shortages for female employees.

The heterogeneous effects of piped water shortages on female employees' hours worked reflect the dual pressures that water-related disruptions place on households: increased time demands and added financial strain. Women are often primarily responsible for managing household water needs (Huberts et al., 2023; Corona Pantoja and Miranda Caso Luengo, 2023). Moreover, job formality likely shapes how workers are affected by water shortages, through differences in pay structure, flexibility, and contract protections—with informal female employees facing the greatest disadvantages. Thus, investigating how gender and informality mediate these effects is essential for assessing the labor market consequences of infrastructure stress and its policy implications.

Several patterns suggest that gendered roles and job characteristics shape how workers cope with water-related disruptions. Formal female employees— particularly older, educated household heads with children—reduce hours worked, suggesting that the time burden dominates for this group. I find that female formal employees reallocate time toward caregiving and running errands, possibly enabled by job protections or stable income. In contrast, informal female employees—especially those who are unmarried or without young children—increase hours worked and reduce time spent on household chores, suggesting that financial constraints dominate time constraints. Although I find no significant change in total household labor supply, partners of informal female employees reduce their hours worked, suggesting some intra-household time reallocation. These findings highlight how gender and informality jointly mediate the labor market consequences of infrastructure stress in cities.

This paper contributes to several strands of literature. First, it introduces a new question to the literature on infrastructure and environmental shocks: How do short-run piped water shortages affect urban labor markets? While extensive research has examined the effects of improved water access on health, expenditures, and labor outcomes (Galiani et al., 2009; Devoto et al., 2012; Meeks, 2017; Alsan and Goldin, 2019), much less is known about the immediate labor market consequences of losing access to piped water—even temporarily. Labor supply is a critical yet overlooked outcome, especially in urban contexts where most households are already connected to the water grid but face growing exposure to intermittent service which imposes additional time and financial constraints. I show that these disruptions—often unannounced—lead to

sizable adjustments in labor supply, even in a large and relatively developed megacity where most households are connected to the pipeline infrastructure.

Second, the paper shifts the focus from extensive-margin access to the intensive margin of water infrastructure reliability. While a growing body of work has documented the benefits of gaining piped water access, much less is known about the consequences of intermittent supply among already-connected urban households. Much of the existing literature on water scarcity has concentrated on rural settings or drought exposure, often focusing on groundwater depletion or household well-digging (Sekhri, 2014; Sekhri and Hossain, 2023; Blakeslee et al., 2020; Abajian et al., 2025). Notable exceptions include Ashraf et al. (2021), who study the effects of water service complaints on health, financial transactions, and time use in Zambia's capital, and Baisa et al. (2010), who estimate the welfare costs of unreliable supply calibrating a model with cross-sectional data from Mexico City. I contribute to this literature by providing causal evidence on labor market impacts using high-frequency panel data and a novel proxy for short-run piped water shortages. My setting—an already-connected megacity facing rising climate stress—highlights that even where infrastructure coverage is high, unreliability can impose meaningful costs on time use and labor supply.

Third, this paper contributes to the literature on environmental shocks and short-run labor supply. Recent work has analyzed the impacts of air pollution (Hoffmann and Rud, 2024), extreme heat (Somanathan et al., 2021), hurricanes (Deryugina et al., 2018), and power outages (Allcott et al., 2016; Hardy and McCasland, 2021) on labor outcomes, but the effects of water disruptions remain largely unexplored. This omission is notable given that piped water is one of the most essential yet vulnerable urban services under climate stress. The results show that water insecurity—like other environmental shocks—can disrupt labor supply in meaningful and unequal ways, underscoring water stress as a critical but understudied climate risk for urban labor markets.

Fourth, the paper documents that gender and labor market informality are key dimensions shaping how workers respond to infrastructure stress. I find that female formal and informal employees adjust hours worked significantly in opposite directions, while most male workers do not make significant adjustments to their short-term labor supply. These findings contribute to broader discussions on the unequal impacts of climate-related disruptions (Carleton and Hsiang, 2016; Abajian et al., 2025)—and point to a labor market channel through which infrastructure shocks may reinforce

existing inequalities. While I do not estimate welfare effects directly, the evidence highlights the need for future research on how these unequal adjustments affect worker well-being. At the same time, gender and informality are policy-relevant margins since governments can strengthen labor protections and support mechanisms for the most vulnerable workers.

The rest of the paper is organized as follows. Section 2 introduces a brief conceptual framework. Section 3 describes the background of water supply in Mexico City. Section 4 describes the data collected and descriptive statistics. Section 5 presents the empirical strategy. Section 6 describes the results, and Section 7 discusses potential mechanisms.

2. Conceptual Framework

2.1. Coping with water shortages

When piped water supply is disrupted, households in water-scarce cities must adapt through a variety of coping strategies, each with distinct implications for time allocation, spending, and health. These strategies vary in both feasibility and cost and are shaped by the availability of alternative water sources, the reliability of public service delivery, and the household's own resources and constraints.

Most households in Mexico City have access to at least some type of storage at home (e.g. rooftop tanks, cisterns), which helps them buffer service interruptions (Baisa et al., 2010). However, storing water is costly: it requires up-front investments in infrastructure, regular maintenance, and time spent managing stored water. According to data from the National Household Income and Expenditure Survey, 59% of households in the bottom income quintile report having a rooftop tank and 38% a cistern, compared to 90% and 74%, respectively, among households in the top quintile (Table A.1). Thus, buffering capacity is limited for many low-income households.

When shortages are worse than usual, households often run out of stored water and must seek alternatives. A common first response is to call the water utility to report the outage, but resolution is uncertain. Households do not know when piped service will resume or whether they will receive free emergency deliveries via public tanker trucks–these deliveries often fall short of demand (Soto et al., 2012). Both are subject to delays and availability constraints. Even when public deliveries are accessible, they often require someone to remain at home to wait—sometimes for hours or even days.

When these options fail or delays become untenable, households—regardless of income—may be forced to purchase bottled water or hire private tanker trucks as a last resort. These alternatives are expensive, especially for low-income families, and require time to arrange. In such cases, severe shortages can impose significant and regressive financial burdens.

Households may also adapt by outsourcing basic water-dependent activities, such as eating out more often, using laundromats, or bathing outside the home. While these strategies can reduce the home time burden, they typically increase expenditures and require coordination and travel. Others may rely on disposable products to reduce water usage at home. In more severe cases, households reduce hygiene behaviors or use lower-quality water, increasing the risk of illness and downstream caregiving needs. These coping strategies disrupt household routines and impose additional demands on time and money.

Water-related responsibilities also disproportionately fall on women, who are typically responsible for household water management tasks. In many neighborhoods, women wait in shifts—sometimes overnight—for irregular truck deliveries (Corona Pantoja and Miranda Caso Luengo, 2023; Bosch et al., 2021; NYT, 2017). These obligations displace time that might otherwise be spent on paid work, caregiving, rest, or education (Antonopoulos and Memis, 2010; Gammage, 2010). National time-use statistics show that women spend roughly twice as much time as men collecting or storing water—regardless of whether the household has daily piped supply (Table A.2).

2.2. Labor supply responses

Whether and how workers adjust their labor supply in response depends on several household and job-specific factors. First, some individuals may increase their labor supply to cover unexpected expenses related to water purchases or outsourced services. This behavior is more likely among informal workers, who tend to lack access to savings or credit and are often paid based on hours worked.

Second, when household tasks become more time-intensive, families may reallocate responsibilities. If one member—often a woman—takes on more non-market work, her labor supply may decrease, while other members' work hours remain unchanged.

Third, job characteristics may shape labor supply responses. Workers with rigid schedules or job protections may be more able to reduce hours in favor of household

responsibilities. In contrast, informal workers without contracts or with irregular pay may need to maintain or even increase their labor supply to stabilize earnings. Finally, water shortages may affect labor demand in specific service subsectors. For example, reduced in-home water use could increase demand for food vendors, laundromats, or hygiene-related services, potentially shifting labor needs in the informal sector.

This paper focuses on the time allocation channel, due to limited data on household expenditures and health outcomes. Nonetheless, the evidence suggests that labor supply responses likely reflect a combination of time constraints and financial pressures. These responses vary systematically by gender, household structure, and employment type. Understanding this heterogeneity is critical to assessing the full economic burden of intermittent water service in urban settings—particularly in large, water-stressed cities like Mexico City.

3. Background

3.1. Mexico City's water sources and supply

Sistema de Aguas de la Ciudad de México (SACMEX) is the public water utility that was in charge of Mexico City's water supply and sanitation during the entire study period (2005–2019). SACMEX operated in one of the most complex urban water contexts, given the city's large population and the geographic distribution of its water sources (SACMEX, 2018). In February 2025, SACMEX was replaced by a new entity—the *Secretaría de Gestión Integral del Agua* (SEGIAGUA), created by the Mexico City Congress to oversee water management in a more integrated and autonomous way. However, because SEGIAGUA was not in operation during the years covered in this study, I refer throughout the paper to SACMEX as the public water utility.

Mexico City's local wells currently provide around two thirds of the total water supply. Since the mid-20th century, the city's government began building infrastructure to obtain water from external sources, as declining aquifer levels proved insufficient to meet growing demand. Today, about one third of the city's water supply comes from the Lerma and Cutzamala basins, located in neighboring western states (SACMEX, 2018). The Lerma system provides groundwater from an aquifer 57 km away, while the Cutzamala system transports surface water from reservoirs located 140 km away, across the western mountain range known as the *Sierra de las Cruces* (Lerner et al., 2018;

Palma et al., 2022).

3.2. Piped water shortages

In Mexico City, over 90% of dwellings have piped water access (INEGI, 2021), but this does not guarantee a continuous water flow. For example, in 2016 and 2018, 12% of households received piped water less than twice a week (Table A.1).[4] In 2018, SACMEX reported that 70% of users received a continuous supply and projected this share would decline to 28% by 2030 (SACMEX, 2018). Although my study period predates the COVID-19 pandemic and the 2023-2024 drought, recent data illustrate the system's increasing stress: by early 2024, the average neighborhood received piped water for only 12 hours per day.[5]

The city's water supply system faces multiple structural challenges. A central concern is the decreasing availability of surface water from the Cutzamala system, which accounts for roughly 25% of Mexico City's total water supply. Figure 1 shows that reservoir levels in the system have been on a downward trend since 2017, primarily due to declining precipitation in the basin (CONAGUA, 2024). These reservoirs are fed exclusively by surface water, so current precipitation shocks affect them directly, whereas the underground aquifers—another major source—are less sensitive to short-term rainfall patterns. Despite providing only a quarter of total water, reductions in Cutzamala's supply can have broad city-wide consequences because Mexico City's piped water distribution system is highly interconnected. When surface water availability declines, SACMEX redistributes pressure and volume across the network, affecting even neighborhoods that are not directly supplied by the Cutzamala system.

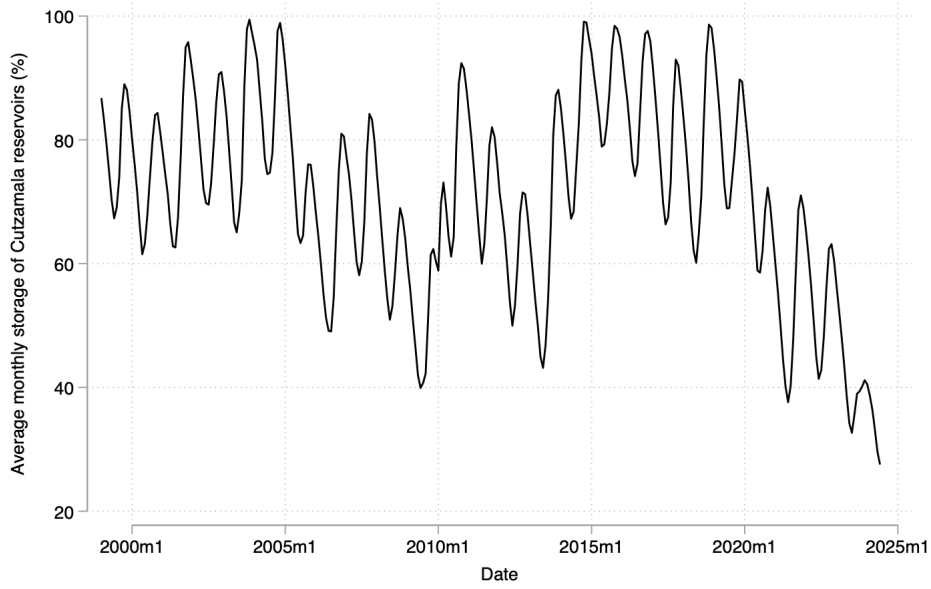
Seasonal rainfall patterns also shape the dynamics of water availability. The Mexico City basin has a well-defined rainy season from May to October and a dry season from November to April. Consequently, water supply often decreases during the dry months when reservoirs levels decline, and this seasonality is visible in Figure 1. However, long periods of low rainfall—such as the one affecting the region since 2021—can lead to critically low reservoir levels even during the rainy season. Other structural issues exacerbate supply challenges, including aging infrastructure—with an estimated 40%

[4]Table A.1 is based on data from the ENIGH survey (2016 and 2018). While these data are not used in the main empirical analysis, they offer valuable background on patterns of piped water access.

[5]Calculated with scraped data from SACMEX's website (*Agua en tu colonia*) on February 1, 2024.

of water lost due to pipe leaks (SACMEX, 2018)—and high demand from over 23 million residents in both the city and its metropolitan area.

Figure 1: Total average monthly storage of Cutzamala reservoirs (%)



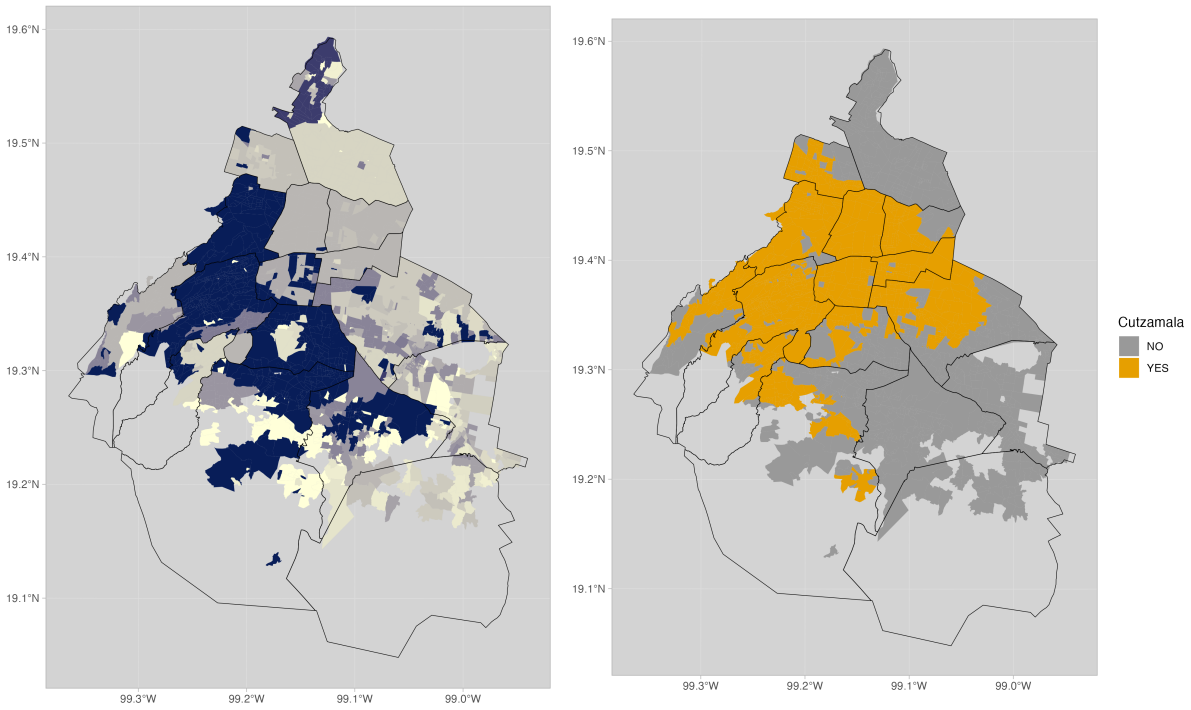
Source: Created with data from CONAGUA for the period January 1, 1999- June 7, 2024.

One key feature of Mexico City's water system is the highly unequal spatial distribution of supply, which reflects both topography and the layout of the city's aging infrastructure. Water rationing is the primary policy response to scarcity, and since November 2023, SACMEX has published neighborhood-level rationing schedules. Figure 2a shows that western neighborhoods tend to receive continuous supply, while eastern and peripheral areas often face intermittent service or depend on tanker trucks. This spatial inequality is closely linked to the structure of the city's water sources: the Cutzamala reservoir system, which supplies roughly a quarter of the city's water, serves 12 of the city's 16 boroughs (Figure 2b). Yet because water from Cutzamala enters the city through a single point in the western mountains and travels downhill through the pipeline network, neighborhoods farther from this entry point tend to be more affected by supply reductions—especially when reservoir levels are low.

This institutional and geographic structure motivates my proxy for water shortages. Using only temporal variation in reservoir storage would not capture the spatially heterogeneous exposure to shortages created by the city's distribution system. Therefore, I interact time variation in reservoir storage with spatial variation in distance to the reservoir entry point to construct a proxy that reflects both the intensity and reach of

water shortages across the city (see Section 5).

Figure 2: Piped water supply in Mexico City



(a) Water supply schedule – hours per week (%)

(b) Cutzamala reservoirs' service areas

Source: Created with scraped data from SACMEX's website (*Agua en tu colonia*) from February 1, 2024.

4. Data

I construct two spatially detailed panel datasets for Mexico City that merge information on Cutzamala reservoir storage and proximity to the water source with either household labor survey data or administrative water billing records. This paper focuses only on Mexico City because a single water utility manages the whole city's water supply (areas shown in Figure 2). While several municipal water utilities manage water supply in Mexico City's metropolitan area–which made data collection infeasible.[6]

4.1. Labor market data

I obtain detailed labor data from the National Survey of Occupation and Employment (ENOE, in Spanish) administered by the National Institute of Statistics and Geography

[6]Mexico City's metropolitan area includes Mexico City proper and 59 surrounding municipalities across the State of Mexico and Hidalgo. While SACMEX manages water distribution within Mexico City itself, the surrounding municipalities each operate their own local utilities, making regional coordination more complex.

(INEGI, in Spanish). ENOE is a quarterly rotating panel representative at the city level where households remain in the sample for five consecutive quarters. At any given quarter, 80% of the sample is observed the previous period, and the rest enters the sample (INEGI, 2024).

The main outcome of interest is total hours worked during the reference week – i.e., the week before the interview (Monday through Friday). While ENOE is a quarterly survey, it is possible to identify the randomly selected week in which the household was interviewed. INEGI collects demographic data for all household members, along with detailed labor information for those aged 15 and older. Using this data, I construct a weekly individual-level panel of working-age individuals (ages 15-65) in Mexico City from 2005 Q3 to 2019 Q4 (n=391,708).[7] I focus on the pre COVID-19 period to avoid the confounding effects of the pandemic on labor market outcomes and data collection challenges during 2020-2021.

A key feature of Mexico City's labor market– common in other developing countries– is its large informal sector, representing 49% of the employed population (Figure 3 and Appendix Table A.3). Informal workers are either self-employed in unregistered economic units or wage and salary workers without access to labor rights such as social security (see Table 1 for more details). The majority (77%) of the city's employed population are employees – i.e. wage and salary workers (Figure 3 and Table A.3).

To provide context on the main outcome of interest, Appendix Table A.4 reports average weekly hours worked across key subgroups. The average employed individual works 42.4 hours per week. Employed men and those employed in the formal sector tend to work more hours than their counterparts, with 46.0 and 43.1 hours per week, respectively. When dividing the sample into employees and self-employed, we observe that employees work longer hours, on average. These patterns motivate the heterogeneity analyses by sex, sector, and worker type presented in Section 6.4.

[7] I excluded the first two quarters of 2005 because the block-level location of the household is not available and that is key to build my proxy of water shortages. Future drafts will try to recover the location of the households in those two rounds.

Figure 3: Structure of the Employed Population by Sector and Worker Type (Mexico City, ENOE 2005–2019)

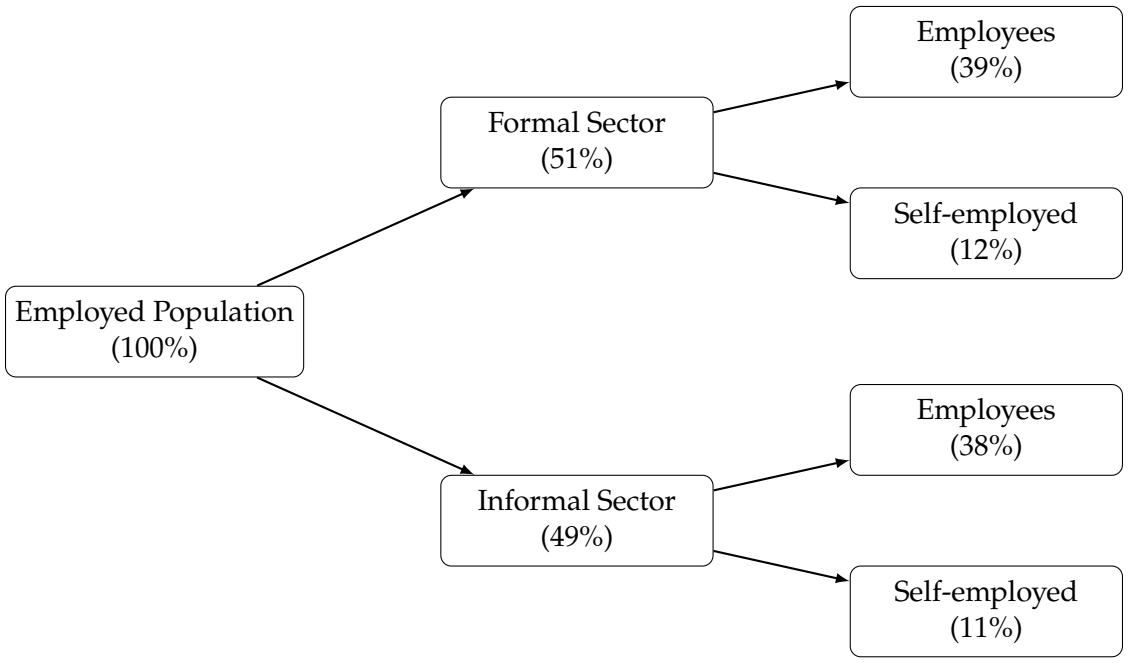


Table 1: Definitions of Employed Worker Groups

Group	**Definition**
Formal Employees	Wage and salary workers in registered economic units with access to social security and labor protections. Typically pay income taxes through payroll deductions.
Informal Employees	Wage and salary workers in unregistered economic units or without social security, even if employed in registered firms.
Formal Self-Employed	Individuals who run registered businesses or are registered professionals and contribute to the tax and social security system.
Informal Self-Employed	Workers who operate outside the formal sector, often in microenterprises, street vending, or personal services, without access to labor protections or regular tax contributions.

Note: Created based on INEGI definitions.

Table A.5 highlights a substantial gender gap in work outside the labor market. On average, women spend more time than men doing household chores, taking care of others, and running errands – all differences are statistically significant at the 1% level.[8] These statistics further motivate the analysis of the effects of water shortages on time use by gender to analyze potential mechanisms.

[8]The question on time spent in non-market activities appears at the end of the survey and has substantial missing data, except for household chores.

4.1.1. Characteristics of Worker Groups

To motivate the heterogeneity analyses in Section 6.4, I characterize four key groups of employed individuals in Mexico City's labor market: formal employees, informal employees, formal self-employed, and informal self-employed (see definitions in Table 1). Each group includes both women and men, whose experiences often differ in important ways. Overall, this typology shows how gender and informality interact to shape labor market vulnerability. Informal female workers experience the lowest pay, most unstable schedules, and highest unpaid time burdens—highlighting the need to examine labor impacts of water shortages through a gendered and occupational lens.

Formal Employees. Formal employees tend to work in structured, professional environments. Table A.8 shows that both men and women are concentrated in public administration, education, technical services, and office jobs. Over 95% have written contracts, and many are paid weekly or biweekly– i.e. every two weeks (Table A.6). Their payment patterns—regular schedules and high rates of permanent contracts—are consistent with Goldin's (2014) notion of jobs with *nonlinear pay*, where time constraints may carry high opportunity costs.

Hours worked are tightly clustered around full-time (Figure A.2, Panels A.2a and Table A.6): women average 40 hours and men 45 hours per week, with little variation. Involuntary part-time work is rare. Monthly labor income is moderate (Figure A.3, Panel A.3a). Most earn between two and five minimum wages, and only 2% fall below one minimum wage (Table A.6).

In terms of demographics, formal employees are more educated (12–13 years of schooling on average), less likely to be household heads, and live in slightly smaller households than other groups (Table A.7). Women in this group spend, on average, about 15 hours/week on chores and 18 hours on caregiving, while men report 6 and 11 hours, respectively (Table A.10).

Informal Employees. Informal employees—especially women—are concentrated in potentially vulnerable occupations such as domestic work, food preparation, and ambulant retail (Table A.8). Over 80% lack written contracts and are more likely to be paid daily or biweekly (Table A.6), with a greater incidence of part-time and unstable schedules. These characteristics suggest higher exposure to *linear pay*, where time

worked is more directly tied to earnings.

They exhibit wide variation in hours worked (Figure A.2, Panel A.2c). Informal male employees work around 46 hours on average, but with multiple peaks (e.g., 50 and 60 hours), while women average 36 hours, with a sizable share working part time. About 39% of informal female employees work fewer than 35 hours/week, and 5% are involuntarily part-time.

Income levels of informal employees are low. Women earn half of what their counterparts earn in the formal sector, while men earn around 60% of their counterparts in the formal sector (Table A.6). Over half of women earn below two minimum wages (MW), and 20% of women earn less than one. Men earn slightly more, the majority earns between one and three MW.

Informal employees are younger, have fewer years of schooling, and are more likely to head households than their formal counterparts (Table A.7). They also live in larger households with more children and dependents. Women in this group spend about 17 hours/week on chores and 18 on caregiving, again far more than men and two more hours on chores than their counterparts in the formal sector (Table A.10).

Formal Self-Employed. The formal self-employed—though a small group—are primarily engaged in professional services, food businesses, or managerial roles (Table A.8). They are the group with the highest reported incomes (Table A.6) with greater dispersion, reflecting varied occupations and business sizes (Panel A.3b).

They work long hours—over 46 hours/week on average for men and around 41 for women—with moderate heterogeneity (Figure A.2, Panel A.2b). They are more likely than employees to be paid monthly, and their schedules suggest a mix of flexibility and structure. Their income distribution suggests a blend of linear and nonlinear pay structures, depending on the nature of their work.

This group is relatively older and highly educated (Table A.7). The gender gap in unpaid time is still present, even if formal self-employed women do fewer chores on average than any other group of female workers (Table A.10).

Informal Self-Employed. Informal self-employed workers operate in highly varied occupations, often involving commerce, street vending, or artisan services (Table A.8). They report the lowest and most unequal incomes, with a large share earning below 2 MW (Table A.8 and Fig. A.3, Panel A.3d). About 40% of women earn below one MW.

Hours worked are highly dispersed (Figure A.2, Panel A.2d). Many men work 50–70 hours/week, while women are clustered between 0 and 40 hours. Nearly 60% of women in this group work under 35 hours/week, and this is the group with the largest proportion of involuntary part-time workers (Table A.6).

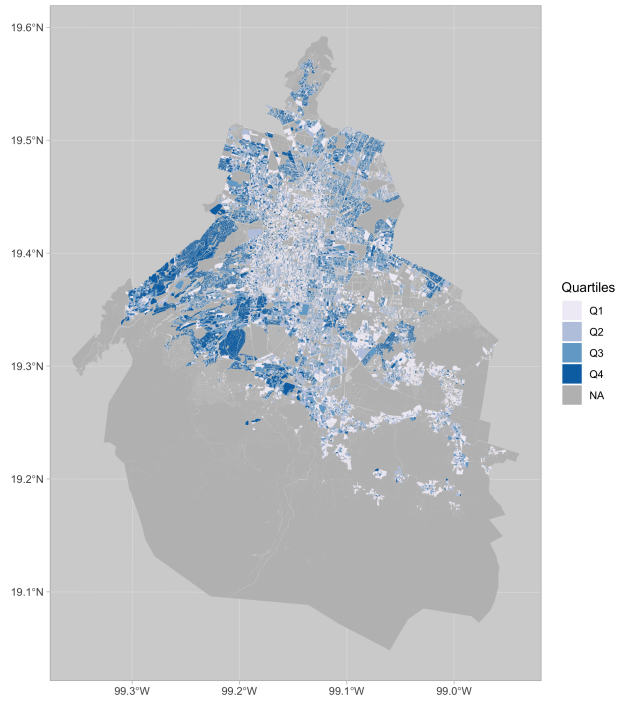
This group faces the highest unpaid time burdens: women average over 22 hours/week of housework and 20 hours of caregiving (Table A.10). They also tend to live in larger households and are more likely to be household heads. These dual burdens—low, unstable income and high household demands—make informal self-employed women particularly vulnerable to disruptions like water shortages.

4.2. Water data

Mexico City's public water utility (SACMEX) provided administrative records on metered residential water consumption and the number of accounts at the city-block level for every 2-month billing period from January 2013 to June 2023. The data cover over 40,000 blocks citywide. I end this panel before the COVID-19 pandemic to avoid confounding the effects and water measurement disruption. I include blocks with at least one residential account that recorded measured consumption in at least one billing period. This restriction ensures that the data reflect actual variations in water supply rather than administrative imputation. The resulting dataset is an unbalanced panel of 1,400,509 block-period observations from January 2013 to February 2020. Figure 4 shows that blocks in the top quartile of residential water consumption per account are concentrated in the western part of the city, which generally has more reliable water supply (see also Figure 2a).

I supplement this dataset with two additional sources. First, I use monthly end-of-period storage levels for the three reservoirs in the Cutzamala basin, obtained from the National Water Commission (CONAGUA). Second, I incorporate the geolocation of SACMEX's primary water pipeline infrastructure. These two sources allow me to construct a proxy for block-level exposure to piped water shortages from the Cutzamala system (details in Section 4.2).

Figure 4: Residential water consumption per account (quartiles)



Source: Constructed with 2019 block-level data of metered accounts from SACMEX. The figure shows an average over the six billing periods in 2019.

4.3. Merging labor and water data

I merge the ENOE labor survey with the water data using the city block where each household is located. While ENOE is publicly available, access to block-level geographic identifiers required the confidential version of the survey, which I obtained through INEGI's data lab in Mexico City.

5. Empirical Strategy

5.1. Identification problem

The main objective of this paper is to estimate the effects of water shortages on hours worked. However, the location and occurrence of water shortages may be influenced by political or economic considerations, socioeconomic characteristics, geographic factors (e.g. slope), and supply-side constraints – e.g. distance to water sources, and maintenance costs. In addition, households may sort into neighborhoods based on amenities such as water availability. Another challenge is the lack of direct data on when and where water shortages occur.

5.2. Proxy of water shortages

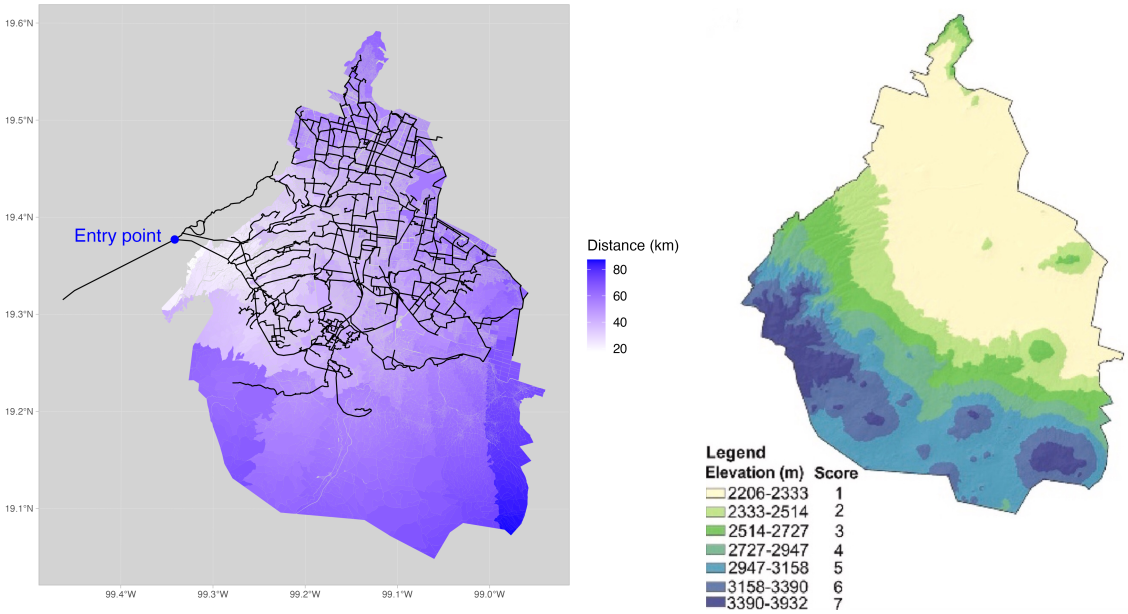
To address these identification challenges, I construct a plausibly exogenous proxy of water shortages that leverages two sources of variation. First, I use temporal variation in the total storage of the Cutzamala reservoir system, which depends on precipitation in two neighboring states. The Cutzamala system is one of Mexico City's main water sources (see Section 2), and the historically low storage levels during the 2023-2024 dry season led to significant disruptions in the city's water supply (NYT, 2024).

Second, I exploit spatial variation in neighborhood access to water from the Cutzamala system. The National Water Commission (CONAGUA) manages the Cutzamala reservoirs and delivers that water to Mexico City's water utility (SACMEX) at a single entry point located in the mountainous west of the city (Figure **??** and 5b) [9] From there, SACMEX distributes water to neighborhoods through a large primary infrastructure network. As water travels downstream via gravity through this network, it loses volume and pressure due to pipeline leaks and topography (decreasing slope and elevation, see Figure 5b). Around 40% of the water supply is lost along the way due to aging water infrastructure and illegal connections (SACMEX, 2018). Once the water reaches the low-elevation central area, the water is pumped up towards the east, where the most densely populated boroughs are located. Thus, neighborhoods located farther from the entry point or main pipelines tend to receive less water from this source— especially when reservoirs levels are low.

While residents may not know the specific location of the entry point or technical details about water sources in each neighborhood, they may have a general perception that western areas receive more reliable water supply. Thus, using the Euclidean distance from the entry point as a proxy for water supply could introduce bias if it captures other differences across neighborhoods. In addition, the location of water infrastructure may reflect historical decisions influenced by socioeconomic or political considerations.

[9] CONAGUA allocates water between Mexico City and neighboring states based on precipitation and rules defined around the end of the 20th century.

Figure 5: Distance to the Cutzamala entry point and elevation in Mexico City



(a) Shortest path to entry point

(b) Elevation

Notes: The shortest path distance through the pipeline network from the Cutzamala System's entry point and each block's centroid was constructed with spatial data from SACMEX. Panel B was obtained from Medina-Rivas et al. (2022).

To better isolate plausibly exogenous variation in water supply, I calculate the shortest path from the entry point to each block (D_b) using Dijkstra's algorithm (Figure 5a).[10] This measure is inspired by the least-cost path instruments used in the transport and infrastructure literature (e.g., Faber (2014)).

My proxy for water shortages in block b and time t is the interaction between the Cutzamala reservoirs' depletion–defined as the inverse of their total storage ($Depletion_t = 1 - Storage_t$) in period t, and the shortest path distance, $Distance_b$ (equation 1). Intuitively, when reservoirs are low and a block is far from the entry point, water supply is more constrained, increasing the likelihood of shortages.

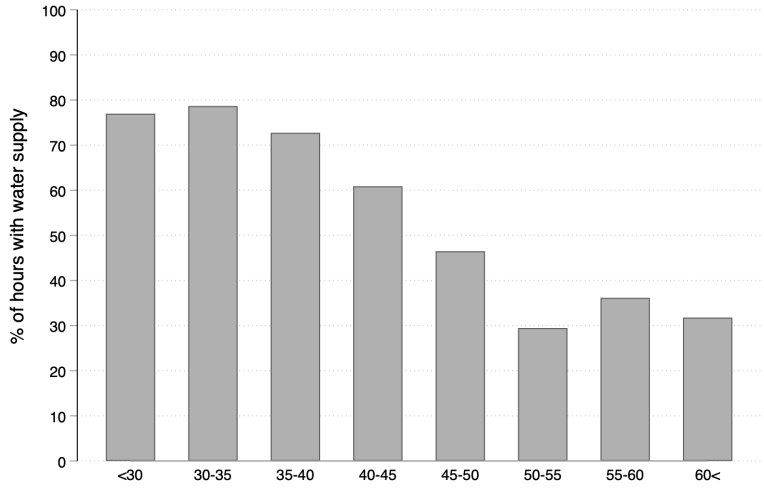
$$S_{bt} = (1 - Storage_t) \times Distance_b = Depletion_t \times Distance_b \tag{1}$$

Figure 6 shows that for a cross-section of neighborhoods on February 1, 2024, water supply (% of hours per week) decreases, on average, with the shortest path from the entry point. Neighborhoods located less than 30 km away from the entry point on average receive piped water 80% of the week, while neighborhoods located more

[10] I first created a network from the pipeline shapefile. Then, I used Dijkstra's algorithm to calculate the shortest distance from the entry point to each node (d_1). I matched each block centroid to its nearest node and calculated the distance between them (d_2). I define the total shortest-path distance as $D_b = d_1 + d_2$.

than 60 km away receive piped water around a third of the week. This descriptive evidence supports my hypothesis of the existence of a negative relationship between water supply and the shortest path to the entry point through the pipeline network.

Figure 6: Average water supply (% of hours) by distance to entry point (km)



Source: Water supply was calculated using a cross-section of neighborhood-level data from SACMEX for February 1, 2024. The distance to the entry point was calculated with the pipeline network from SACMEX and Dijkstra's shortest path algorithm.

5.3. Estimation Strategy

5.3.1. Residential water consumption

I estimate the effect of water shortages on average residential water consumption by block with the following two-way fixed effects (TWFE) regression:

$$C_{bt} = \beta_0 + \beta_1\{Depletion_t \times Distance_b\} + \gamma_b + \mu_t + \varepsilon_{bt} \tag{2}$$

where C_{bt} is the average residential water consumption in block b during 2-month billing period t (e.g. Jan-Feb 2015). $Depletion_t$ denotes the inverse of the average total storage level (as a share of total capacity) of the Cutzamala reservoir system in period t, and $Distance_b$ is the shortest-path distance (in kilometers) from the entry point to the centroid of block b. The terms γ_b and μ_t are block and billing period fixed effects, respectively, and ε_{bt} is the error term. Standard errors are clustered at the block level.

the coefficient of interest, β_1, captures the interaction between storage levels and distance. The water shortages proxy is higher in magnitude when reservoir levels are

low and blocks are farther from the entry point. Thus, I expect water shortages to have a negative effect on average residential water consumption, conditional on block and period fixed effects ($\beta < 0$).

In terms of identification, block fixed effects control for time-invariant block characteristics— including determinants of labor supply— while billing period fixed effects control for time-varying shocks common to all blocks.

Note that the main source of exogenous variation comes from precipitation shocks in the Cutzamala basin, which influence reservoir storage levels. While I use storage rather than precipitation directly, storage reflects hydrological inputs and operational rules, and is unlikely to respond to labor market conditions in Mexico City.

Conditional on time and block fixed effects, the proxy simulates water flowing from the entry point to blocks through a network based only on cost considerations. In practice, SACMEX can adjust water volume and pressure using pump stations and valve controls, potentially based on factors beyond cost considerations— some of which may be correlated with my outcomes of interest.

Finally, note that water consumption is an equilibrium outcome and not a perfect measure of water supply. Since it reflects both supply and demand for water by households. This specification assumes that shortages are exogenous to water demand, conditional on period and block fixed effects.

5.3.2. Hours worked

I estimate the effects of water shortages on hours worked using the following TWFE regression:

$$Y_{ibt} = \alpha_0 + \alpha_1\{Depletion_t \times Distance_b\} + \psi_b + \delta_t + \nu_{ibt} \tag{3}$$

Where Y_{ibt} denotes either hours worked by individual i in block b during the reference week of quarter-by-year t. The remaining variables are defined as in Equation 2. The terms ψ_b and δ_t are block and period fixed effects, respectively, and ν_{ibt} is the error term. Standard errors are also clustered at the block level.

The coefficient of interest is α_1, which captures the effect of water shortages on hours worked, Y_{ibt}. For the labor outcome, I expect $\alpha_1 < 0$, as greater water shortages may reduce hours worked if individuals are required to spend more time managing

these shortages or coping with their effects.

6. Results

6.1. Effects of water shortages on residential water consumption

I start by analyzing whether the water shortages proxy is a good predictor of average residential water consumption at the city block level. The proxy of water shortages interacts the reservoir depletion, i.e. the inverse of storage levels, with the distance of each block to the city's reservoir entry point, such that shortages are more severe when storage is lower and households are farther from the entry point.

Table 2: Effects of Water Shortages on Residential Water Consumption

	Levels (1)	Logs (2)
Depletion × Distance	-0.474***	-0.008***
	(0.088)	(0.001)
N	1,400,509	1,400,509
N of clusters	39,594	39,594
Adj. R^2	0.66	0.67
Mean	35.84	3.47
F-stat	29.30	236.50

Standard errors in parentheses and clustered at the block level.
All columns include block and billing-period fixed effects.
Water consumption is measured in cubic meters.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2 shows that water shortages significantly reduce residential water consumption, conditional on block and period fixed effects (statistically significant at the 1% level). The log specification implies that a one standard deviation increase in the water shortages proxy leads to a 5.3% decline in residential water consumption. The proxy exhibits strong predictive power, particularly for the log specification (F-stat = 236.5).

To interpret the magnitude of the effect, consider a drop in reservoir levels from 73% (median) to 49% (5th percentile), which is a relatively typical change between the rainy and dry seasons.[11] For blocks located at the median distance of 48.7 km from

[11] Based on data from 2004 to 2019, this scenario reflects a typical seasonal pattern: a starting level around the 10th percentile of observed peaks (73%) and an ending level around the 25th percentile of troughs (49%). The implied 24 percentage point drop is also close to the 25th percentile of observed seasonal declines.

the entry point, the interaction term increases by 11.7 units, implying a reduction of approximately 9.4% in monthly residential water consumption. For blocks located at the 90th percentile distance of 57.9 km, the corresponding decline is 11.1%. In absolute terms, these effects translate to reductions of 3.35 to 3.99 cubic meters per month (see Appendix A for full details). These results indicate that water shortages significantly reduce residential water use, with larger impacts for households located farther from the reservoir entry point. Because the data measure only metered piped water use, these results do not capture potential increases in water from alternative sources during shortages. Still, they reflect clear reductions in piped supply and usage.

Table 3: Effects of water shortages on hours worked by sex

	All	Women	Men
	(1)	(2)	(3)
Depletion × Distance	-0.087**	-0.091*	-0.083**
	(0.034)	(0.051)	(0.042)
N	230,580	101,173	129,152
Clusters	5,209	4,794	4,955
Adj. R^2	0.075	0.110	0.091
Mean dep. var.	41.35	37.16	44.65
Estimated effect (hours/week)	-1.02	-1.06	-0.97

Notes: Standard errors in parentheses and clustered at the block level.
All specifications include block and week-by-year fixed effects.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6.2. Effects of water shortages on hours worked

I find that piped water shortages significantly reduce hours worked across the employed population in Mexico City. As shown in Table 3, a one standard deviation increase in the water shortages proxy (SD = 6.67) leads to a reduction of approximately 35 minutes of work per week, a decline that is statistically significant at the 5% level.

To interpret the magnitude, consider a household located at the median distance from the entry point (48.7 km). For this household, a drop in reservoir storage from the median (73%) to the fifth percentile (49%) increases the shortages proxy by 11.7 units and leads to a predicted reduction of 1.02 hours of work per week. These are economically meaningful effects, especially in a setting where many households are exposed to service disruptions and must adjust their hours—whether by reducing

work time or reallocating it across the week.

Figure 7: Estimated effects of water shortages on hours worked

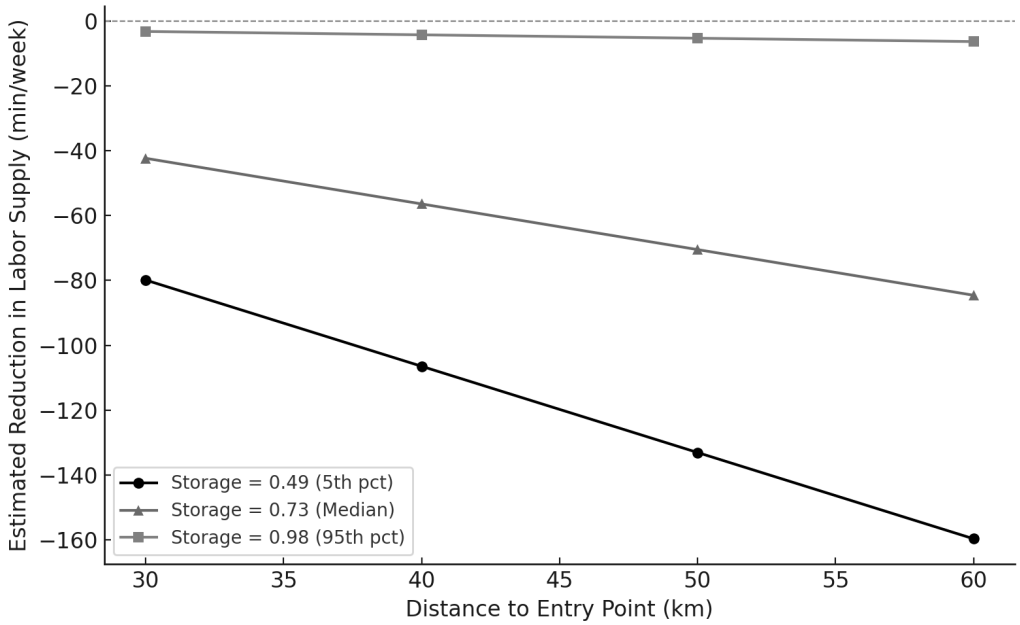


Figure 7 plots the predicted reductions in short-term labor supply for varying levels of reservoir storage (5th, 50th, and 95th percentiles) and household distances to the entry point based on the main regression results (Table 3). The reductions are larger for households located farther from the reservoir entry point and during periods of lower reservoir storage. For example, at the median storage level, estimated effects range from about 40 minutes per week for households 30 km away to approximately 80 minutes for those 60 km away. When reservoir storage reaches the fifth percentile, these effects roughly double—up to 160 minutes (2.7 hours) for the most distant households. Moreover, when storage levels are high, distance to the entry point has little impact on hours worked—the effects are negligible across all distances, with predicted reductions of less than 5 minutes per week. These estimates are consistent with the idea that households farther from the water source tend to face more acute service disruptions during periods of low reservoir levels, which adds time constraints.

6.3. Empirical validation tests & robustness checks

6.3.1. Validation tests

To support the validity of my empirical design, I conduct a couple of tests to assess whether the water shortages proxy is correlated with changes in demographic or

socioeconomic characteristics that might themselves influence hours worked.

I estimate my main two-way fixed effects specification using individual and household-level characteristics (e.g., age, education, household size) as outcomes. These tests evaluate whether compositional changes at the block level—such as shifts in the types of households or workers living there—could be confounding the main results. As shown in Table 4, the estimated coefficients are all close to zero and not statistically significant, suggesting that such changes are unlikely to be driving the observed labor supply effects.

I run another test of the empirical design consisting of two steps. First, I predict hours worked using the same set of demographic characteristics as in the first test with a linear regression excluding all fixed effects (Table C.1, Panel A, Appendix **??**). Second, I use the predicted values from that model—i.e., the portion of hours worked explained by observables—as the outcome in my main two-way fixed effects regression. The idea is that if the water shortages proxy were correlated with these demographic characteristics, it would show up here. However, as shown in Table C.1, Panel B, the coefficient on the shortages proxy is small and not statistically significant, indicating that water shortages do not predict the component of hours worked explained by demographic characteristics alone.

Together, these tests support the interpretation that the effects of water shortages on hours worked are not being driven by changes in household composition or other time-varying characteristics at the block level.

Table 4: Main specification using covariates as outcome variables

Panel A: Individual Characteristics				
	Age	Female	Married	Some College
	(1)	(2)	(3)	(4)
Depletion × Distance	-0.020	0.000	0.000	0.001
	(0.027)	(0.001)	(0.001)	(0.001)
N	241,260	241,329	241,329	241,329
N of clusters	5,245	5,245	5,245	5,245
Adj. R^2	0.076	0.037	0.100	0.262
Mean	40.24	0.44	0.55	0.29

Panel B: Household Characteristics					
	HH Size	Head Female	Kid < 12	Kid < 5	Elderly
	(5)	(6)	(7)	(8)	(9)
Depletion × Distance	-0.000	-0.001	-0.001	-0.001	-0.001
	(0.005)	(0.001)	(0.001)	(0.001)	(0.001)
N	239,356	241,329	241,329	241,329	241,329
N of clusters	5,245	5,245	5,245	5,245	5,245
Adj. R^2	0.242	0.187	0.197	0.173	0.208
Mean	4.12	0.29	0.42	0.21	0.20

Notes: Standard errors in parentheses and clustered at the block level. All specifications include block and period fixed effects. These regressions also include members of the household outside the working age population. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6.3.2. Robustness checks

This section presents several robustness checks of the main specification, using alternative functional forms and treatment definitions. I begin by estimating the model separately for the dry and rainy seasons. During the dry season—when reservoir levels are typically more depleted—the estimated effect of water shortages on hours worked is similar in magnitude to the main specification (Table 5). In contrast, the estimated reduction during the rainy season is approximately 40% smaller. Although neither coefficient is statistically significant, the directional patterns are consistent with expectations.

Columns 3 and 4 of Table 5 use binary indicators for low reservoir storage—equal to one when storage levels fall below the 25th percentile (lowest quartile) or 33rd percentile (lowest tertile), respectively. Both specifications yield statistically significant reductions in hours worked during low-storage periods. The magnitude of the effect is

larger when using the lowest quartile threshold, suggesting that labor supply responses are more pronounced under more severe water scarcity.

Table 5: Effects of Water Shortages on Hours Worked: Seasonal and Low-Storage Specifications

	(1) Dry	(2) Rainy	(3) Low storage (Q1)	(4) Low storage (T1)
Depletion × Distance	-0.089	-0.053		
	(0.063)	(0.045)		
$\mathbb{1}\{\text{Storage (Q1)}\} \times$ Distance			-0.026***	
			(0.010)	
$\mathbb{1}\{\text{Storage (T1)}\} \times$ Distance				-0.018**
				(0.009)
N	111,905	118,480	230,580	230,580
N of clusters	5,016	5,082	5,209	5,209
Adj. R^2	0.097	0.047	0.075	0.075
Mean	40.72	41.95	41.35	41.35

Standard errors in parentheses and clustered at the block level. Depletion is a continuous variable defined as $1 - Storage$. $\mathbb{1}\{\text{Storage (Q1)}\}$ and $\mathbb{1}\{\text{Storage (T1)}\}$ are indicators equal to one when reservoir storage levels are at the lowest quartile or tertile, respectively. All specifications include block and week-by-year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6 presents additional robustness checks of the main specification, which uses a weekly panel and includes block and week-by-year fixed effects. Column 1 estimates a log-hours specification, which also shows a statistically significant decline in labor supply (significant at the 1% level).

Column 2 adds individual fixed effects, allowing for within-person estimation. This reduces the magnitude of the coefficient and renders the estimate statistically insignificant, likely because of reduced variation within individuals and smaller sample size. In ENOE, individuals are observed only once per quarter, so many respondents do not contribute sufficient variation to identify within-person effects over the weekly reservoir cycles. In contrast, my preferred specification includes block fixed effects, since water shortages vary at the block level, and this specification retains the full sample of employed individuals across all weeks, even those who were interviewed only once.

Columns 3 and 4 use lower-frequency variation in reservoir depletion by aggregating to monthly and quarterly panels, respectively. In both cases, the point estimates

remain negative but are smaller in magnitude and not statistically significant. Column 5 also uses the quarterly panel, but instead models reservoir depletion as a quadratic function of distance. The results remain consistent with a negative—though imprecise—effect of water shortages on hours worked.

Table 6: Robustness Checks: Effects of Water Shortages on Hours Worked

	Log Hours (1)	Hours (2)	Hours (3)	Hours (4)	Hours (5)
Depletion × Distance	-0.005***	-0.042	-0.044	-0.048	-0.245
	(0.002)	(0.030)	(0.037)	(0.042)	(0.321)
Depletion × Distance^2	–	–	–	–	0.002
					(0.003)
N	230,580	213,994	235,515	235,515	235,515
N of clusters	5,209	5,123	5,210	5,210	5,210
Adj. R^2	0.076	0.463	0.052	0.049	0.049
Time variation	Weekly	Weekly	Monthly	Quarterly	Quarterly
Time FE	Week-Year	Week-Year	Month-Year	Quarter-Year	Quarter-Year
Group FE	Block	Individual	Block	Block	Block

Notes: Each column shows a variation of the main specification for the full working-age employed population. The outcome is weekly hours worked (in logs for column 1, levels for the rest). Column 1 is estimated using a weekly panel with block and week-year fixed effects, like the main specification. Column 2 includes individual and week-year fixed effects using a weekly panel. Column 3 uses a monthly panel with block and month-year fixed effects. Columns 4–5 use quarterly panels with block and quarter-year fixed effects, modeling distance linearly or quadratically. Standard errors in parentheses, clustered at the block level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

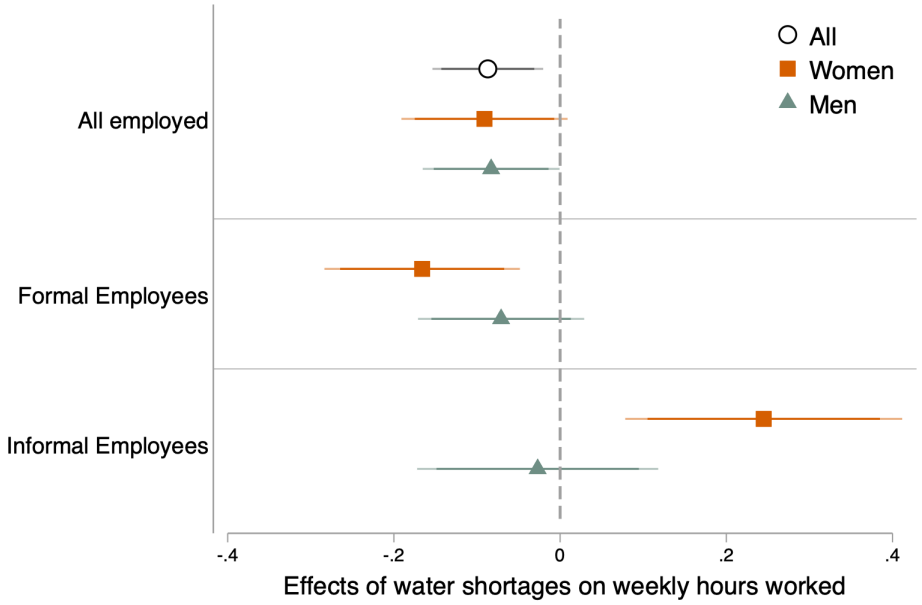
6.4. Heterogeneous effects on hours worked

I next explore treatment effect heterogeneity by sex, worker type (employee vs. self-employed), and sector (formal vs. informal). While average effects are negative and similar in magnitude for both men and women (Table 3), these aggregate patterns mask important differences across subgroups—particularly among women.

Figure 8 and Table 7 show that female employees respond differently depending on their sector of employment. Female formal employees significantly reduce hours worked in response to water shortages, while female informal employees significantly increase their hours. For example, when reservoir storage drops from the median to the fifth percentile for those living at the median distance (48.7 km), formal female employees reduce their weekly hours by 1.94 (significant at the 1% level), while informal female employees increase their hours by 2.86 (also significant at the 1% level).

This divergence is consistent with differences in job protections, flexibility, and the financial burden of coping with service disruptions. In contrast, formal and informal self-employed women exhibit noisier patterns: formal self-employed women increase their hours (4.98), but the estimate is imprecise and not statistically significant, while informal self-employed women reduce their hours significantly (–3.2, significant at the 10% level). Note that I am underpowered for the heterogeneity analyses within the self-employed since they represent a small fraction (23%) of the employed population.

Figure 8: Effects of water shortages on hours worked by sector and sex



Note: 95% confidence intervals shown in dark color and 90% confidence intervals shown in light color. The graph shows the effects of water shortages on hours worked (in levels) for the whole employed population, by sex and by sector (formal or informal).

Among men, all subgroup estimates are negative, but relatively small and not statistically significant—except for informal self-employed men, who reduce hours by a larger margin (significant at the 10% level). These patterns suggest that the labor supply effects of water shortages are more pronounced and heterogeneous among women, especially among employees, where formal–informal differences are most salient. As discussed further in the Mechanisms section, these divergent responses may reflect differences in job protections, constraints, and household responsibilities.

Table 7: Effects of Water Shortages on Hours Worked by Worker Type & Sex

	Employees				**Self-employed**			
	Formal		Informal		Formal		Informal	
	Women	Men	Women	Men	Women	Men	Women	Men
Depletion × Distance	-0.166***	-0.071	0.245***	-0.027	0.426	-0.031	-0.274*	-0.231*
	(0.060)	(0.051)	(0.085)	(0.074)	(0.399)	(0.178)	(0.149)	(0.120)
N	47,400	57,348	29,168	37,449	2,780	7,975	15,260	22,206
N of clusters	3,804	4,137	3,303	3,526	784	1,650	2,513	2,915
Adj. R^2	0.205	0.157	0.175	0.116	0.324	0.238	0.209	0.153
Mean hours/ week	40.15	44.65	36.52	45.98	40.64	46.25	29.88	42.94
Estimated effect (hrs)	-1.94	-0.83	2.86	-0.32	4.98	-0.36	-3.20	-2.70

Notes: Standard errors in parentheses, clustered at the block level. Outcome is weekly hours worked. All regressions include block and period fixed effects. Sample restricted to working-age population. Estimated effects in hours per week shown in the last row are computed for a storage decline from 73% to 49% (median to 5th percentile) at a median block distance of 48.7 km from the entry point.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

7. Mechanisms for adjustments in female employees' hours worked

This section explores why female formal and informal employees adjust their hours worked in opposite directions in response to water shortages. Overall, the evidence points to a shared source of disruption—household-level time and financial burdens—but divergent coping strategies shaped by sectoral constraints and household dynamics. Both groups reallocate their non-market time in response to shortages, but in opposite directions: formal employees shift toward home production and reduce paid work, while informal employees reduce home production and work more hours in the labor market. While I do not find consistent evidence of reallocation of paid work among other household members, time-use and partner data suggest that intra-household dynamics differ across groups. Formal employees appear to absorb most of the household adjustment themselves, aided by job protections that allow them to reduce hours without income loss. In contrast, informal employees increase labor supply even in the absence of earnings gains—likely to cope with added household costs and earnings volatility. These findings underscore how gendered responsibilities and job formality jointly shape labor market responses to infrastructure shocks.

7.1. Female Formal Employees: Reductions in Hours Worked

Female formal employees significantly reduce their hours worked in response to water shortages. A plausible mechanism is that these workers absorb additional caregiving and home-management duties when water is scarce. Supporting this interpretation, Table E.4 shows significant increases in time spent on caregiving and errands among this group (both significant at the 10% level). These non-market adjustments likely crowd out time available for paid work.

Heterogeneity analyses within female formal employees show that reductions in hours worked are concentrated among household heads, women aged 45–65, those with some college education, and those living with children under age 12 (Table E.1). These patterns further support a shift toward home production as a plausible channel through which water shortages reduce labor supply.

Importantly, there is no evidence that other household members compensate for the respondent's reduced work hours. Table E.3 shows no significant changes in total hours worked by other household members (excluding the respondent), and Table E.6 finds similarly small and non-significant reductions in partners' labor supply. These results suggest that formal female employees may be absorbing much of the time burden associated with water-related disruptions.

Labor market protections likely facilitate this adjustment. Table A.6 shows that nearly all formal female employees have written contracts and are paid on a regular schedule—most often weekly or biweekly. Their earnings are less sensitive to marginal changes in hours worked, making it more feasible to temporarily reduce labor supply without incurring financial losses. This interpretation is supported by Table D.1, which shows no significant effect of water shortages on labor income for this group.

Taken together, the evidence suggests that reductions in hours worked among female formal employees are likely driven by a reallocation of time toward household responsibilities during water shortages facilitated by job protections in the formal sector. These findings underscore the role of job protections and intra-household dynamics in shaping how women and their households adapt to infrastructure shocks.

7.2. Female Informal Employees: Increases in Hours Worked

In sharp contrast to their formal-sector counterparts, informal female employees significantly increase their hours worked in response to water shortages. Time-use data suggest that this adjustment is driven in part by a reallocation of time away from home production and toward paid work. Table E.4 shows that informal female employees significantly reduce time spent on household chores (at the 10% level), indicating a shift from non-market to market labor. This is consistent with the broader pattern observed across female workers: both formal and informal employees are the only worker group to adjust their non-market time use in response to shortages, but in opposite directions.

Table E.1 shows that the effect is concentrated among household heads, women who are not married or cohabiting, those without college education, and those without young children. These women are likely to work out of necessity and lack a partner who could help buffer the shock. Table A.6 further shows that informal female employees are among the lowest-paid workers, with nearly 60% earning less than two minimum wages. They also rarely have contracts and are typically paid daily or biweekly, reflecting high earnings volatility. Consequently, the opportunity cost of missing work is particularly high for this group.

Household-level patterns offer mixed evidence of intra-household reallocation. Table E.3 shows no statistically significant change in the total hours worked by other household members (excluding the respondent), even though the coefficient is positive and similar in magnitude. While partners of informal female employees reduce their hours worked significantly during water shortages (Table E.6), recall that the positive effect on hours worked is concentrated among those women who are not married or cohabiting. Taken together, these findings suggest that informal female employees appear to absorb much of the adjustment in hours worked themselves.

Despite working more, Table D.1 shows no statistically significant change in labor income for this group. This may reflect underreporting (29% of informal female workers do not report income), irregular pay schedules, or limited returns to marginal increases in labor supply.

I also explore whether this increase reflects a shift in labor demand for certain occupations that may become more essential during water shortages. One third of informal female employees work in domestic services, and nearly one quarter work in

food preparation or hygiene services—sectors that could plausibly experience rising demand when households reduce in-home cooking or cleaning. However, Table E.10 shows that the increase in hours worked is not driven by these occupations: point estimates are small and imprecise for domestic and food/hygiene sectors, while the effect is largest and most precisely estimated for those working in all other sectors. These findings do not support demand-driven increases in short-term labor supply.

Taken together, the evidence suggests that female informal employees increase labor supply to offset household disruptions and financial pressures—not because of rising demand or income gains. This adjustment occurs in a context of precarity, with few job protections. These findings seem to highlight the fragility of informal work and the disproportionate burden placed on some low-income women when essential infrastructure fails.

8. Conclusion

This paper provides new evidence on how short-run water shortages shape urban labor supply. Using a novel proxy for piped water shortages and weekly individual-level panel data for Mexico City, I find that a one standard deviation increase in shortages leads to a 3.3% decline in weekly hours worked across the employed population. Effects are highly heterogeneous: female employees are the only group to significantly adjust their labor supply, but in opposite directions depending on employment type. Formal female employees reduce hours worked, while informal female employees increase them. These patterns suggest that gendered responsibilities and employment conditions jointly mediate the labor market consequences of infrastructure shocks.

The study highlights an overlooked dimension of water insecurity: the impact of water shortages on labor supply, even when households are already connected to the piped water network. Previous research has documented welfare gains from improved water access, but little was known about how short-term piped water service disruptions affect time allocation and economic activity. This paper shows that rainfall-driven infrastructure shocks—common in water-scarce cities—trigger meaningful labor market responses, particularly among women. Importantly, these adjustments occur even in a middle-income megacity with relatively high infrastructure coverage, pointing to the persistent vulnerability of urban households to intermittent service—an issue that

is expected to intensify under climate change.

This paper finds that even small, short-term service disruptions in cities with existing infrastructure coverage can lead to measurable and unequal labor market impacts. Formal female employees—especially older, educated household heads with children—appear to reduce hours worked in favor of caregiving and errands, likely facilitated by stable pay and job protections. In contrast, informal female employees—particularly those who are unmarried or without young children—appear to reallocate time away from household chores and toward market work, possibly to cope with added financial pressures. The evidence does not support a strong role for intra-household reallocation of labor. The adjustment appears to be borne primarily by female employees. Together, these patterns underscore how gender, job protections, and pay structures shape coping strategies to household shocks.

From a policy perspective, the findings suggest that even temporary disruptions in piped water service can carry real economic costs that are not evenly distributed across the population. The labor supply responses observed here vary by gender and employment type, pointing to the role of household responsibilities and job protections in shaping how individuals adapt to infrastructure stress. These patterns underscore the importance of considering not just infrastructure access, but also service reliability and labor market structure—especially in developing country contexts where informal employment is widespread and social protections are limited. More broadly, the results highlight the need to integrate urban service delivery, labor market dynamics, and climate adaptation into policy discussions. Understanding who bears the burden when essential services fail is key to designing more equitable and resilient systems.

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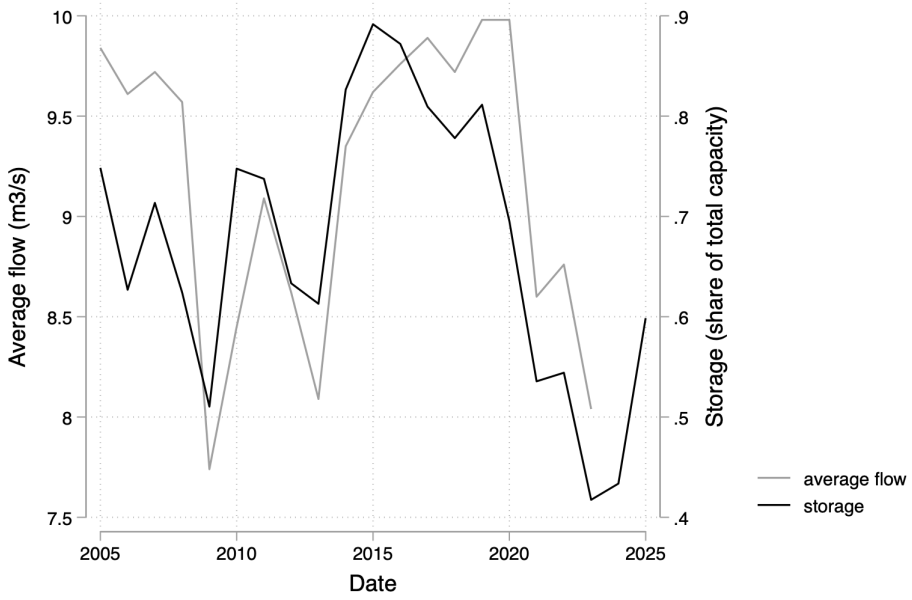
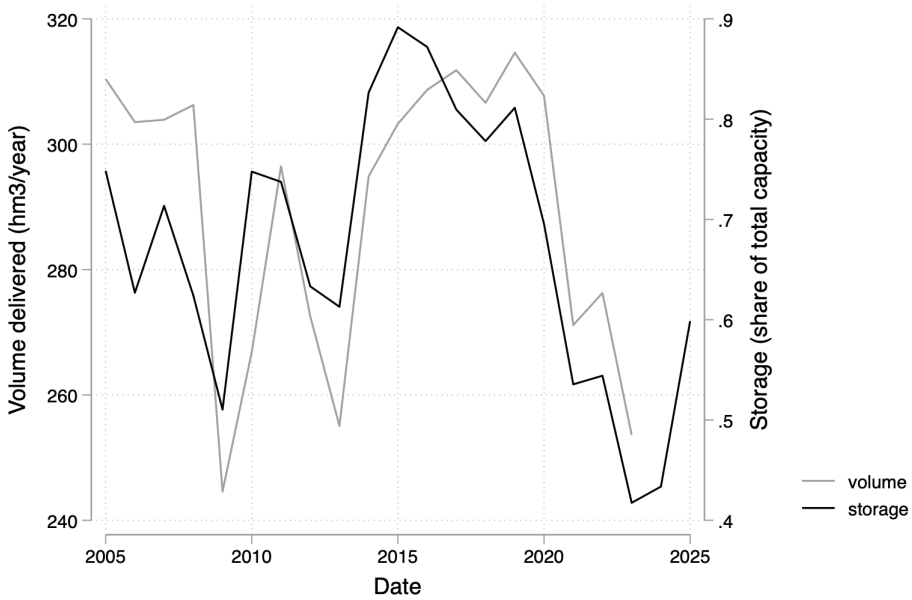
A. Descriptive statistics

Figure A.1: Evolution of Cutzamala System's total reservoir storage and water deliveries to Mexico City



(a) Average flow at entry point



(b) Total volume delivered

Source: Constructed with data from CONAGUA
Note: For water deliveries only annual time series data is available up to 2023. Storage is the annual average total storage of the Cutzmala System's reservoirs.

Table A.1: Mexico City household characteristics by income quintiles

	Total	Q1	Q2	Q3	Q4	Q5
Water Access and Infrastructure						
Piped water inside home (%)	0.81	0.62	0.75	0.81	0.90	0.96
	(0.39)	(0.48)	(0.44)	(0.39)	(0.31)	(0.19)
Water from truck only (%)	0.06	0.09	0.08	0.08	0.05	0.02
	(0.24)	(0.28)	(0.28)	(0.27)	(0.22)	(0.13)
Has water tank (%)	0.77	0.59	0.71	0.79	0.84	0.90
	(0.42)	(0.49)	(0.45)	(0.40)	(0.37)	(0.30)
Has cistern (%)	0.55	0.38	0.46	0.54	0.62	0.74
	(0.50)	(0.49)	(0.50)	(0.50)	(0.49)	(0.44)
Has any water storage (%)	0.91	0.81	0.88	0.93	0.95	0.99
	(0.29)	(0.40)	(0.32)	(0.26)	(0.21)	(0.12)
Has water pump (%)	0.62	0.41	0.52	0.63	0.71	0.84
	(0.49)	(0.49)	(0.50)	(0.48)	(0.46)	(0.37)
Water Supply Frequency						
Daily water supply (%)	0.75	0.67	0.69	0.75	0.79	0.86
	(0.43)	(0.47)	(0.46)	(0.43)	(0.41)	(0.34)
Water supply $\leq$ 2 days (%)	0.12	0.17	0.14	0.13	0.11	0.05
	(0.32)	(0.37)	(0.35)	(0.34)	(0.31)	(0.22)
Income and Expenditure						
Quarterly income (MXN)	66,615	18,971	32,186	45,715	67,547	168,891
	(78,705)	(5,155)	(3,673)	(4,536)	(8,983)	(128,598)
Quarterly water bill (MXN)	237.43	121.64	206.07	190.13	262.08	407.62
	(438.88)	(221.99)	(626.33)	(263.41)	(390.99)	(504.03)
N (general variables)	*3,902*	*781*	*781*	*780*	*781*	*779*
N (water supply variables)	*3,616*	*694*	*707*	*713*	*740*	*762*

Notes: Table constructed with the 2016 and 2018 samples of the National Income and Expenditure Survey (ENIGH) that are representative for Mexico City. The table shows means and standard deviations (in parentheses) by household income quintile. Frequency of water supply is shown only for the subsample of households with piped water. Income and water bills are quarterly and shown in current MXN.

Table A.2: Summary statistics- Weekly minutes spent on water-related activities

	Total	Men	Women
Panel A: Non-daily water supply			
Collect or store water	28.55	19.18	37.55
	(103.72)	(64.26)	(130.38)
	437	214	223
Wait for water truck or other services	4.65	3.50	5.74
	(19.02)	(10.67)	(24.46)
	437	214	223
Panel B: Daily water supply			
Collect or store water	11.43	8.03	14.51
	(83.21)	(66.78)	(95.63)
	1,550	737	813
Wait for water truck or other services	3.63	2.76	4.41
	(33.05)	(13.18)	(43.87)
	1,550	737	813

Notes: The table shows the mean, standard deviation (in parentheses) and sample size of weekly hours spent on each activity for all the sample and by sex. Constructed with the 2019 National Time Use Survey's (ENUT) Mexico City sample that includes individuals aged 12-97.

Table A.3: Individual characteristics of ENOE's Mexico City sample

	N	Mean	Std. Dev.	Min	Max
Age	391,708	37.15	13.99	15	65
Female (%)	391,708	0.53	0.50	0	1
Years of schooling	390,839	10.81	3.92	0	24
Labor participation (%)	391,708	0.67	0.47	0	1
Unemployed (%)	261,210	0.06	0.24	0	1
Formal sector workers (%)	238,801	0.51	0.50	0	1
Employees (%)	238,801	0.77	0.42	0	1
Self-employed (%)	238,801	0.23	0.42	0	1

Notes: Note that N varies across rows because unemployment is a proportion of the labor force, while the formal workers, employees and self-employed workers are shown as a proportion of the employed population. Constructed with ENOE survey during the study period: 2005 Q3- 2019 Q4. The sample is restricted to the working-age population (aged 15-65) in Mexico City.

Table A.4: Summary statistics- Weekly hours worked

	N	Mean	Std. Dev.	Min	Max
All	391,708	26.56	24.82	0	140
All women	207,935	19.15	22.35	0	126
All men	183,773	34.94	24.80	0	140
Employed	245,563	42.37	17.68	0	140
Employed women	106,047	37.54	16.98	0	126
Employed men	139,516	46.03	17.32	0	140
Employed - formal	122,545	43.60	15.00	0	140
Employed - informal	116,256	41.54	19.82	0	140
Employees	183,398	43.07	16.09	0	140
Self-employed	55,403	41.04	21.61	0	140

Notes: This table shows total hours worked during the survey's reference week– the main outcome of interest– for different groups of the employed population. Constructed with ENOE survey during the study period: 2005 Q3- 2019 Q4. The sample is restricted to the working-age population (aged 15-65) in Mexico City.

Table A.5: Summary statistics- Weekly hours spent on non-labor market activities

	All	Men	Women
Household chores	15.22	6.75	20.59
	(12.79)	(5.79)	(13.10)
	326,971	126,890	200,081
Bills, errands, & purchases	3.74	2.80	4.21
	(2.88)	(2.14)	(3.09)
	111,123	37,007	74,116
Caregiving	19.02	11.38	22.30
	(13.53)	(8.55)	(13.95)
	106,145	31,893	74,252

Notes: The table shows the mean, standard deviation (in parentheses) and sample size of weekly hours spent on each activity for all the sample and by sex. All differences in means by sex are statistically significant at the 1% level. Constructed with ENOE survey during the study period: 2005 Q3- 2019 Q4. Sample restricted to people aged 15-65.

A.1. Characterizing the employed population

Table A.6: Average Work Characteristics by Worker Type, Formality, and Sex

	Salaried				**Self-employed**			
	Formal		Informal		Formal		Informal	
	Women	Men	Women	Men	Women	Men	Women	Men
Monthly income (MXN)	7,378	8,367	3,737	4,910	9,555	12,846	3,162	5,570
	(7,947)	(8,266)	(3,207)	(4,088)	(10,279)	(14,150)	(3,501)	(4,474)
$\leq$ 1 MW (%)	0.02	0.02	0.20	0.11	0.06	0.03	0.39	0.14
1–2 MW (%)	0.21	0.17	0.38	0.31	0.15	0.10	0.29	0.24
2–3 MW (%)	0.23	0.23	0.20	0.27	0.16	0.14	0.13	0.23
3–5 MW (%)	0.21	0.22	0.07	0.14	0.16	0.18	0.06	0.18
>5 MW (%)	0.14	0.17	0.03	0.05	0.21	0.28	0.03	0.08
Hours worked/week	40.1	44.7	36.3	46.0	40.6	46.4	29.8	43.0
	(13.1)	(13.4)	(16.8)	(16.3)	(18.1)	(16.6)	(19.8)	(19.0)
<15 hrs (%)	0.06	0.04	0.12	0.06	0.09	0.05	0.27	0.10
<35 hrs (%)	0.19	0.12	0.39	0.18	0.33	0.18	0.59	0.28
Involuntary part-time (%)	0.01	0.01	0.05	0.04	0.04	0.04	0.13	0.10
Paid monthly (%)	0.05	0.05	0.05	0.04	0.24	0.24	0.12	0.08
Paid biweekly (%)	0.10	0.14	0.33	0.41	0.15	0.14	0.26	0.30
Paid weekly (%)	0.42	0.37	0.12	0.08	0.03	0.03	0.05	0.01
Paid daily (%)	0.00	0.00	0.23	0.18	0.08	0.05	0.30	0.27
Has contract (%)	0.96	0.95	0.16	0.14	–	–	–	–
N (income)	27,928	33,580	22,998	28,692	1,823	4,175	12,152	16,084
N (others)	48,836	59,360	31,408	40,675	3,575	8,943	16,712	24,138

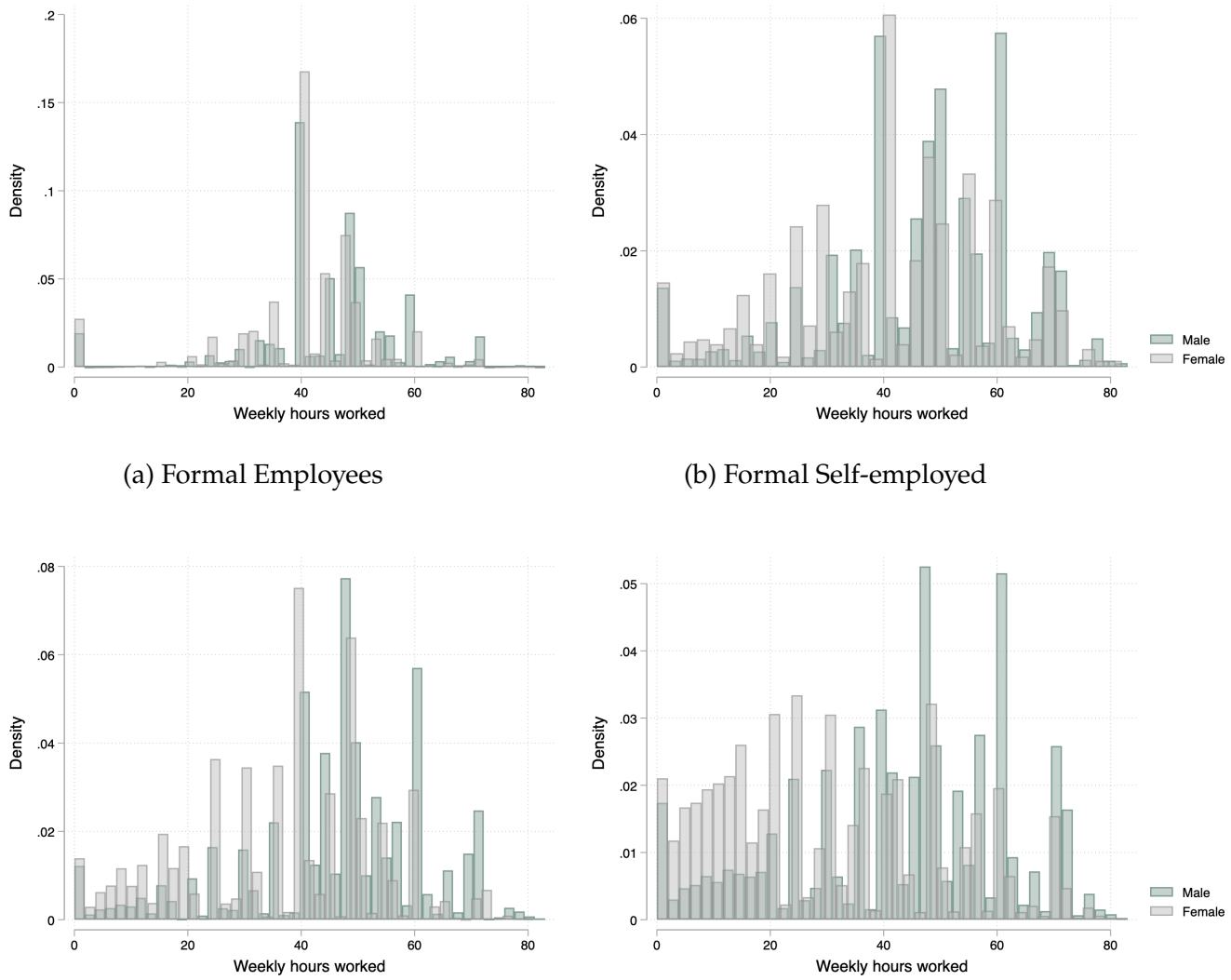
Notes: All values are means. Standard deviations appear in parentheses. All variables are binary indicators except for monthly income and hours worked per week. Nominal gross monthly income is shown. "MW" refers to minimum wage.

Table A.7: Individual and Household Characteristics by Worker Type, Formality, and Sex

	Salaried				**Self-employed**			
	Formal		Informal		Formal		Informal	
	Women	Men	Women	Men	Women	Men	Women	Men
Age (years)	38.68	38.74	37.15	35.02	43.64	45.11	43.44	43.49
	(11.01)	(11.48)	(12.46)	(12.72)	(10.66)	(10.76)	(11.77)	(11.79)
Schooling (years)	12.85	12.46	9.61	9.82	13.75	13.72	9.43	9.52
	(3.55)	(3.69)	(4.01)	(3.62)	(3.85)	(3.69)	(3.90)	(3.70)
Married/cohabiting (%)	0.42	0.65	0.42	0.56	0.54	0.73	0.57	0.71
	(0.49)	(0.48)	(0.49)	(0.50)	(0.50)	(0.44)	(0.50)	(0.45)
Household head (%)	0.23	0.59	0.24	0.48	0.31	0.76	0.30	0.69
	(0.42)	(0.49)	(0.43)	(0.50)	(0.46)	(0.43)	(0.46)	(0.46)
# own children	1.29	–	1.72	–	1.62	–	2.36	–
	(1.30)		(1.66)		(1.42)		(1.75)	
# infants (0–1) in HH	0.04	0.05	0.05	0.06	0.03	0.03	0.04	0.05
	(0.20)	(0.22)	(0.22)	(0.25)	(0.17)	(0.19)	(0.21)	(0.22)
# children <5 in HH	0.23	0.27	0.29	0.33	0.17	0.21	0.28	0.28
	(0.50)	(0.55)	(0.58)	(0.62)	(0.43)	(0.49)	(0.57)	(0.58)
# persons 65+ in HH	0.25	0.18	0.19	0.17	0.21	0.17	0.18	0.18
	(0.53)	(0.46)	(0.47)	(0.45)	(0.50)	(0.45)	(0.45)	(0.46)
# unemployed in HH	0.09	0.08	0.11	0.10	0.06	0.06	0.09	0.08
	(0.31)	(0.30)	(0.33)	(0.33)	(0.25)	(0.25)	(0.32)	(0.29)
# employed in HH	2.31	2.17	2.48	2.37	2.35	2.14	2.44	2.25
	(1.07)	(1.09)	(1.14)	(1.22)	(1.07)	(1.08)	(1.14)	(1.16)
N (vars with values)	48,836	59,360	31,408	40,675	3,575	8,943	16,712	24,138
N (schooling)	48,724	59,254	31,324	40,571	3,571	8,935	16,680	24,090
N (# own children)	48,835	–	31,407	–	3,573	–	16,712	–

Notes: All values are means. Standard deviations appear in parentheses. All variables are indicator or count variables except for age and schooling. The variable for own children is only defined for women. "HH" = household.

Figure A.2: Distribution of hours worked by sex, sector, and type of worker



(a) Formal Employees

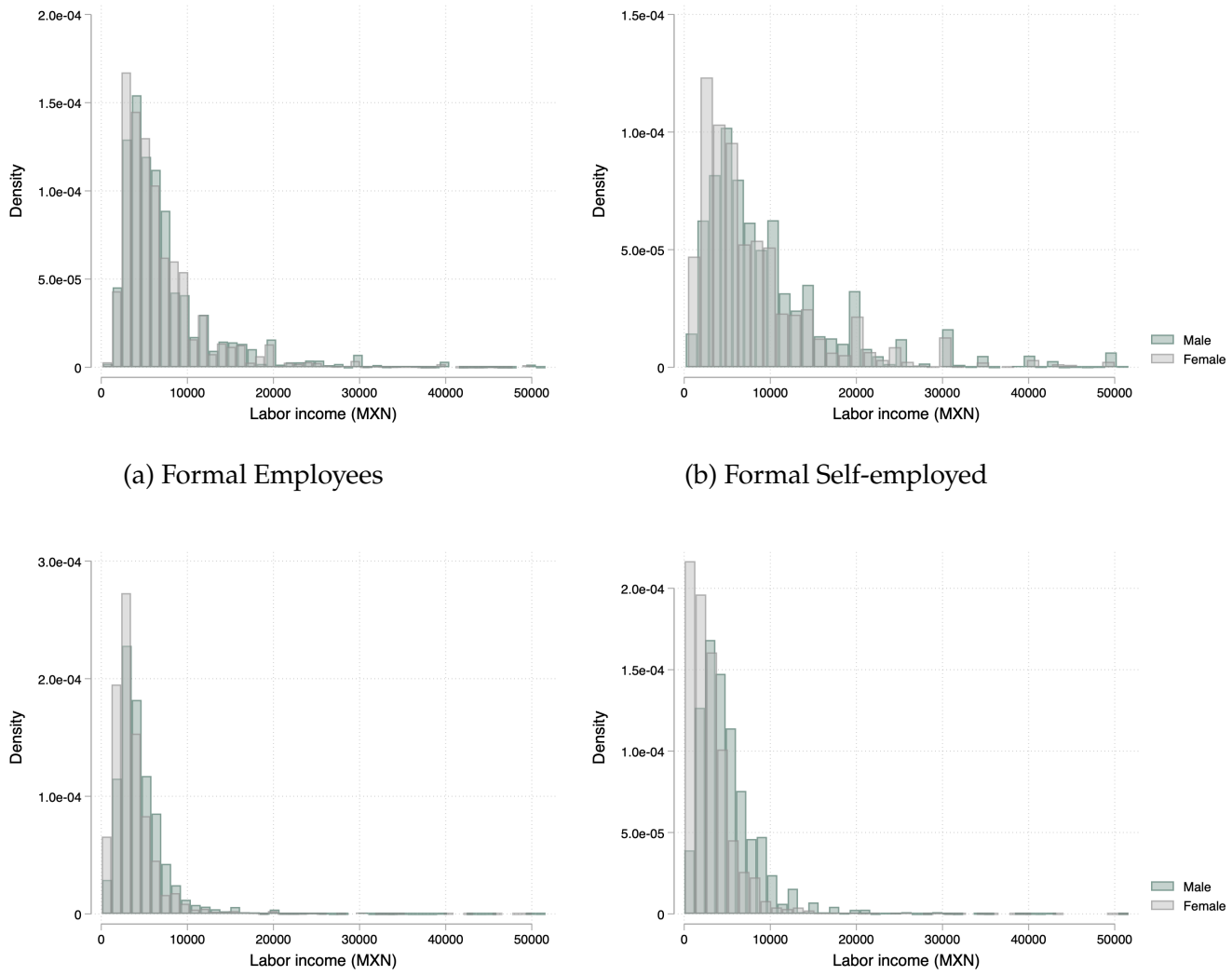
(b) Formal Self-employed

(c) Informal Employees

(d) Informal Self-employed

Notes: These graphs show the distribution of hours worked below the 99th percentile for the whole sample of the employed population (around 80 hours worked). "Employees" refers to wage and salary workers, i.e. non-self-employed workers. You can see more details about the definition of these four types of workers in Table 1.

Figure A.3: Distribution of monthly labor income (in MXN) by sex and type of worker



(a) Formal Employees

(b) Formal Self-employed

(c) Informal Employees

(d) Informal Self-employed

Notes: These graphs show the distribution of monthly labor income for employed individuals by sex, across formal and informal sectors and by worker type (salaried vs. self-employed). Values are not adjusted for inflation and include extreme values up to 50,000 MXN.

Table A.8: Summary of Top Occupations by Group

Group	Top Occupations (SCIAN)	Top Occupational Categories (ENOE)
Formal Employees - Women	Public administration, education (public/private), technical and food services	Office workers; Education workers; Professionals; Personal services
Formal Employees - Men	Public administration, education, food services, technical fields, transport	Professionals; Office workers; Industrial/artisan workers; Transport operators
Formal Self-Employed Women	Technical/professional services, retail (stationery, clothing), food	Professionals; Commerce; Managers/directors
Formal Self-Employed Men	Professional/technical services, construction, repair, food, transport	Professionals; Managers/directors; Industrial/artisan workers
Informal Employees - Women	Domestic work, food preparation, ambulant retail (clothing, stationery), personal services	Personal services; Commerce; Industrial/artisan workers
Informal Employees - Men	Construction, repair, food, transport, ambulant retail	Industrial/artisan workers; Commerce; Transport operators
Informal Self-Employed Women	Street vending (food, clothing), personal services, artisan trades	Commerce; Personal services; Industrial/artisan workers
Informal Self-Employed Men	Construction, transport, street vending, repair, retail (food)	Industrial/artisan workers; Commerce; Transport operators

Notes: Used based on ENOE 2013Q1 data. Future drafts will include information based on the whole study period, but this information is unlikely to change significantly across years.

Table A.9: Type of Contract by Type of Employees (not Self-Employed)

Contract Type	Formal Women	Formal Men	Informal Women	Informal Men
Permanent	82.48%	81.88%	5.58%	5.37%
Temporary	13.14%	13.41%	9.90%	8.48%
No Written Contract	3.94%	4.18%	83.96%	85.51%
Unspecified Type	0.19%	0.19%	0.11%	0.11%
Missing value	0.25%	0.34%	0.46%	0.53%
Total	100.00%	100.00%	100.00%	100.00%

Notes: Used based on ENOE 2013Q1 data. Future drafts will include information based on the whole study period, but this information is unlikely to change significantly across years.

Table A.10: Non-Labor Time Use by Worker Type, Sector, and Sex (hours/week)

	Employees				**Self-employed**			
	Formal		Informal		Formal		Informal	
	Women	Men	Women	Men	Women	Men	Women	Men
Chores	15.38	6.03	17.40	5.95	14.68	6.33	22.13	6.97
	(9.41)	(5.11)	(10.40)	(5.09)	(9.13)	(5.38)	(11.72)	(5.67)
	46,535	40,033	30,286	25,930	3,303	5,173	16,399	15,510
Caregiving	18.08	11.08	18.44	10.31	19.61	12.25	20.52	11.16
	(10.71)	(7.70)	(11.17)	(7.22)	(12.06)	(8.70)	(12.85)	(8.33)
	15,066	13,251	10,355	7,521	1,020	1,807	6,311	4,403
Bill paying	3.60	2.78	3.68	2.63	3.57	2.97	4.50	3.04
	(2.57)	(1.88)	(2.65)	(1.92)	(2.97)	(2.16)	(3.22)	(2.38)
	18,121	13,642	11,702	7,155	1,376	2,092	7,284	5,622

Notes: The table shows the mean, standard deviation (in parentheses), and sample size (non-missing values) for each time-use variable (hours/week) and worker group. Constructed with ENOE survey during the study period: 2005 Q3- 2019 Q4. The sample is restricted to the working-age population (aged 15-65) in Mexico City.

B. Illustrative Calculations for Effects on Water Consumption

Assume a drop in reservoir storage levels from 73% (median) to 49% (5th percentile).

Outcome in logs (residential water consumption):

$$\text{Effect (\%)} = \hat{\beta} \times \Delta((1 - \text{Storage}) \times \text{Distance})$$

$$\text{Effect (m}^3\text{)} = \text{Effect (\%)} \times \text{Mean Consumption}$$

Where $\hat{\beta} = -0.008$ (from the log specification), and mean residential water consumption per account is approximately 35.84 m^3.

For a block 48.7 km from the entry point (median):

$$\text{Change in interaction term: } (1 - 0.49) \times 48.7 - (1 - 0.73) \times 48.7 = 24.837 - 13.149 = 11.688$$

$$\text{Effect (\%)} = -0.008 \times 11.688 = -0.0935 = -9.35\%$$

$$\text{Absolute change} = 0.0935 \times 35.84 = -3.35 \text{ m}^3\text{/2-month billing period}$$

For a block 57.9 km from the entry point (90th percentile):

$$\text{Change in interaction term: } (1 - 0.49) \times 57.9 - (1 - 0.73) \times 57.9 = 29.529 - 15.633 = 13.896$$

$$\text{Effect (\%)} = -0.008 \times 13.896 = -0.1112 = -11.12\%$$

$$\text{Absolute change} = 0.1112 \times 35.84 = -3.99 \text{ m}^3\text{/2-month billing period}$$

These calculations indicate that a drop in reservoir storage from the median to the 5th percentile leads to a reduction in monthly residential water consumption of approximately 3.35 to 3.99 cubic meters—corresponding to 9.4% to 11.1% declines for blocks located at the median and 90th percentile distances from the entry point, respectively.

C. Testing empirical design

Table C.1: Regression of actual and predicted hours worked

Panel A: Hours worked on individual and household characteristics

	Hours worked
Age	-0.068***
	(0.004)
Female	-7.623***
	(0.102)
Married	0.870***
	(0.122)
Some college	-2.073***
	(0.117)
HH size	0.250***
	(0.036)
Female head of HH	1.337***
	(0.129)
Has kid under 12	-0.015
	(0.145)
Has kid under5	0.426***
	(0.154)
Has elderly	-1.175***
	(0.145)
N	249,182
N of clusters	5,529
Adj. R^2	0.061
Mean	40.979
Block FE	No
Period FE	No

Panel B: Predicted hours worked on water shortages proxy

	Predicted hours worked
(1 - Storage) $\times$ Distance	-0.002
	(0.007)
N	239,287
N of clusters	5,245
Adj. R^2	0.085
Mean	40.925
Block FE	Yes
Period FE	Yes

Standard errors in parentheses and clustered at the block level.

Regressions include members of the household outside the working age population.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

D. The role of labor income

Table D.1: Effects of Water Shortages on Log Labor Income by Worker Type and Sex

	Employees				**Self-employed**			
	Formal		Informal		Formal		Informal	
	Women	Men	Women	Men	Women	Men	Women	Men
Depletion × Distance	0.004	0.002	0.000	0.002	0.003	0.031*	-0.006	0.004
	(0.003)	(0.003)	(0.004)	(0.003)	(0.040)	(0.017)	(0.009)	(0.008)
N	26,525	31,701	20,843	25,742	899	3,126	10,793	14,329
N of clusters	3,086	3,343	2,792	2,947	308	867	2,063	2,350
Adj. R^2	0.332	0.334	0.238	0.174	0.388	0.324	0.197	0.169
Mean log income	8.96	9.06	8.26	8.58	9.14	9.45	7.94	8.64

Notes: Standard errors in parentheses, clustered at the block level. All specifications include block and period fixed effects. The outcome is log real labor income.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.2: Heterogeneous effects of water shortages on hours worked by income group of informal female employees

Panel A: Individual labor income

	Bottom 20%	Top 80%	Bottom 50%	Top 50%
	(1)	(2)	(3)	(4)
Depletion × Distance	0.303	0.145	0.260***	0.274
	(0.188)	(0.088)	(0.094)	(0.215)
N	5,936	22,351	23,981	4,182
N of clusters	1,339	3,035	3,075	1,138
Adj. R^2	0.234	0.179	0.183	0.242
Mean	23.605	40.283	35.468	41.422

Panel B: Household labor income

	Bottom 20%	Top 80%	Bottom 50%	Top 50%	Bottom 80%	Top 20%
	(5)	(6)	(7)	(8)	(9)	(10)
Depletion × Distance	0.145	0.244**	0.283**	0.225*	0.217**	0.093
	(0.252)	(0.096)	(0.139)	(0.115)	(0.094)	(0.191)
N	4,384	23,662	11,416	16,739	22,359	5,878
N of clusters	1,250	2,968	2,252	2,622	3,004	1,454
Adj. R^2	0.242	0.174	0.211	0.177	0.185	0.235
Mean	39.786	35.847	35.534	37.235	35.979	38.483

Panel C: Household labor income per capita

	Bottom 20%	Top 80%
	(11)	(12)
Depletion × Distance	0.119	0.246**
	(0.258)	(0.095)
N	4,286	23,744
N of clusters	1,225	2,971
Adj. R^2	0.236	0.174
Mean	39.932	35.826

Notes: Standard errors in parentheses and clustered at the block level. All specifications include block and week-by-year fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

E. Investigating mechanisms for employed women

Table E.1: Effects of water shortages on hours worked by female worker group and individual characteristics

	Employees				Self-employed			
	Formal		Informal		Formal		Informal	
	Yes	No	Yes	No	Yes	No	Yes	No
Panel A: Household Head								
Depletion × Distance	-0.267**	-0.130*	0.399**	0.107	-0.993	1.635***	-0.333	-0.014
	(0.119)	(0.067)	(0.176)	(0.098)	(1.047)	(0.590)	(0.344)	(0.164)
N	10,885	36,116	6,632	21,956	439	1,615	4,375	10,351
Clusters	1,755	3,444	1,380	2,946	157	506	1,054	2,029
Adj. R^2	0.317	0.217	0.321	0.192	0.349	0.323	0.346	0.252
Mean	40.17	40.14	36.78	36.47	42.45	40.11	32.52	28.82
Panel B: Married or Cohabiting								
Depletion × Distance	-0.188**	-0.160**	0.000	0.291***	0.630	0.276	0.036	-0.422*
	(0.092)	(0.072)	(0.139)	(0.104)	(0.649)	(0.970)	(0.193)	(0.245)
N	19,440	27,477	11,511	16,897	1,100	950	8,296	6,360
Clusters	2,574	3,017	2,065	2,513	360	312	1,775	1,387
Adj. R^2	0.277	0.222	0.243	0.214	0.341	0.413	0.266	0.307
Mean	38.53	41.28	33.48	38.66	39.70	41.39	28.76	31.53
Panel C: Some College Education								
Depletion × Distance	-0.163*	-0.089	-0.165	0.254***	1.059**	1.531	-0.636	-0.276*
	(0.096)	(0.072)	(0.239)	(0.093)	(0.535)	(1.137)	(0.528)	(0.162)
N	19,861	27,112	4,340	24,176	1,499	574	1,414	13,165
Clusters	2,447	2,905	1,107	2,894	440	226	447	2,224
Adj. R^2	0.285	0.227	0.300	0.194	0.305	0.206	0.345	0.228
Mean	38.39	41.43	34.83	36.88	36.30	49.36	25.69	30.58
Panel D: Child Under Age 5 in Household								
Depletion × Distance	-0.140	-0.148**	-0.027	0.277***	-1.436	0.213	0.631*	-0.387**
	(0.136)	(0.066)	(0.168)	(0.097)	(2.149)	(0.453)	(0.340)	(0.175)
N	8,546	38,430	6,341	22,314	59	2,273	2,905	11,752
Clusters	1,472	3,513	1,283	2,971	21	668	755	2,171
Adj. R^2	0.288	0.227	0.291	0.198	-0.390	0.357	0.338	0.233
Mean	40.64	40.04	36.94	36.44	42.39	40.76	29.84	30.11
Panel E: Child Under Age 12 in Household								
Depletion × Distance	-0.195**	-0.094	0.156	0.261**	0.078	0.275	0.154	-0.840***
	(0.091)	(0.076)	(0.126)	(0.114)	(0.943)	(0.556)	(0.199)	(0.223)
N	18,415	28,505	13,497	15,068	447	1,637	6,751	7,892
Clusters	2,360	3,051	2,090	2,444	158	503	1,408	1,722
Adj. R^2	0.251	0.245	0.215	0.242	0.273	0.370	0.314	0.269
Mean	40.35	40.01	36.15	36.95	40.57	40.67	29.46	30.51

Notes: Each column corresponds to a subgroup of female workers. Columns labeled "Yes"/"No" indicate whether the subgroup satisfies the characteristic listed in the corresponding panel title. Standard errors in parentheses, clustered at the block level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table E.2: Effects of water shortages on hours worked by female worker group and age

	Formal			Informal		
	15–24	25–44	45–65	15–24	25–44	45–65
Panel A: Employees						
Depletion × Distance	0.049	-0.125	-0.208**	0.261	0.105	0.189
	(0.191)	(0.076)	(0.106)	(0.215)	(0.121)	(0.146)
N	4,179	27,458	14,860	5,019	14,280	8,458
Clusters	987	3,067	2,213	1,177	2,364	1,713
Adj. R^2	0.276	0.227	0.329	0.256	0.238	0.296
Mean Hours	42.81	40.58	38.52	38.20	37.38	34.38
Panel B: Self-employed						
Depletion × Distance	–	-0.415	0.849	-0.917	0.300	-0.500**
	–	(0.795)	(0.666)	(0.875)	(0.211)	(0.215)
N	–	903	950	247	6,481	7,197
Clusters	–	308	322	96	1,458	1,602
Adj. R^2	–	0.391	0.364	0.253	0.286	0.301
Mean Hours	–	38.99	41.18	29.05	29.78	30.70

Notes: Each column corresponds to a subgroup of female workers by age group. Standard errors in parentheses, clustered at the block level.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table E.3: Effects of water shortages on other household members' hours worked–grouped by female respondent's employment types

	Employees		Self-employed	
	Formal	Informal	Formal	Informal
	(1)	(2)	(3)	(4)
Depletion × Distance	-0.037	0.235	-0.570	0.265
	(0.278)	(0.305)	(1.118)	(0.375)
N	47,400	29,168	2,780	15,260
N of clusters	3,804	3,303	784	2,513
Adj. R2	0.301	0.279	0.488	0.314
Mean	55.53	63.78	56.82	61.80

Notes: Standard errors in parentheses and clustered at the block level. All specifications include block and period fixed effects. Outcome is total weekly hours worked by other household members (excluding the female respondent). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table E.4: Effects of water shortages on time use, by worker type and sex

	Employees				Self-employed			
	Formal		Informal		Formal		Informal	
	Women	Men	Women	Men	Women	Men	Women	Men
Panel A: Caregiving								
Empty × distance	0.010*	-0.004	-0.007	-0.009	0.025	0.048	-0.007	-0.003
	(0.005)	(0.005)	(0.006)	(0.008)	(0.065)	(0.031)	(0.009)	(0.013)
N	14,020	12,158	8,968	6,243	272	871	5,201	3,323
Adj. R^2	0.133	0.095	0.096	0.085	-0.604	0.018	0.151	0.086
Mean	2.791	2.315	2.807	2.257	2.917	2.451	2.889	2.308
Panel B: Chores								
Empty × distance	-0.004	0.001	-0.006*	0.001	-0.018	0.003	0.004	-0.007
	(0.003)	(0.003)	(0.003)	(0.004)	(0.018)	(0.013)	(0.004)	(0.006)
N	45,130	38,422	28,064	23,626	2,484	4,245	14,950	13,924
Adj. R^2	0.159	0.094	0.167	0.094	0.191	0.159	0.172	0.110
Mean	2.607	1.737	2.721	1.723	2.548	1.769	2.993	1.860
Panel C: Paying Bills and Running Errands								
Empty × distance	0.006*	0.003	-0.000	-0.002	-0.019	0.002	0.010*	0.003
	(0.003)	(0.004)	(0.004)	(0.005)	(0.020)	(0.013)	(0.006)	(0.006)
N	17,425	12,873	10,544	6,229	852	1,550	6,418	4,760
Adj. R^2	0.124	0.090	0.133	0.126	0.029	0.128	0.158	0.144
Mean	1.416	1.241	1.418	1.188	1.382	1.260	1.568	1.276

Notes: Standard errors in parentheses and clustered at the block level. All specifications include block and period fixed effects. All dependent variables are log weekly hours spent on each activity due to the highly skewed distributions. Means are also shown in log hours. Sample includes the working-age employed population.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table E.5: Effects of Water Shortages on Time Use by Sex (Working-Age Population)

	All	Women	Men
	(1)	(2)	(3)
Panel A: Caregiving			
(1 - Storage) × Distance	-0.006***	-0.006***	-0.006*
	(0.002)	(0.002)	(0.003)
N	99,888	69,920	29,321
Clusters	4,378	4,237	3,365
Adjusted R^2	0.043	0.085	0.089
Mean dep. var.	2.768	2.959	2.323
Panel B: Chores			
(1 - Storage) × Distance	-0.003**	-0.004***	-0.002
	(0.001)	(0.001)	(0.002)
N	311,367	191,317	119,853
Clusters	5,261	5,127	4,917
Adjusted R^2	0.049	0.116	0.083
Mean dep. var.	2.455	2.853	1.821
Panel C: Paying Bills and Running Errands			
(1 - Storage) × Distance	0.004***	0.004**	0.005*
	(0.002)	(0.002)	(0.002)
N	107,196	71,333	35,369
Clusters	3,867	3,658	3,174
Adjusted R^2	0.105	0.132	0.091
Mean dep. var.	1.421	1.516	1.231

Notes: Standard errors in parentheses and clustered at the block level. All specifications include block and period fixed effects. All dependent variables are log weekly hours spent on each activity due to the highly skewed distributions. Means are also log weekly hours. Sample includes the working-age population (employed and not employed). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table E.6: Effects of water shortages on partners' hours worked by type of female worker

	Employees		Self-employed	
	Formal	Informal	Formal	Informal
	(1)	(2)	(3)	(4)
Panel A: Without Covariates				
Depletion × Distance	-0.234	-0.546***	1.345	0.587**
	(0.143)	(0.209)	(1.043)	(0.259)
Panel B: With Covariates				
Depletion × Distance	-0.076	-0.190	1.466*	0.485***
	(0.113)	(0.167)	(0.881)	(0.183)
Female (partner)	1.845	5.154	0.000	-3.018
	(2.637)	(4.000)	(.)	(11.157)
Employed (partner)	41.508***	45.486***	38.853***	44.315***
	(0.519)	(0.684)	(4.741)	(0.909)
Age (partner)	-0.133***	-0.165***	-0.253	-0.225***
	(0.025)	(0.025)	(0.229)	(0.036)
Informality (partner)	1.350***	-1.200**	-1.264	-1.064
	(0.498)	(0.564)	(3.320)	(0.756)
Household head (partner)	-0.353	-1.122	3.138	0.252
	(0.903)	(1.096)	(6.057)	(1.443)
N	15,993	9,191	844	7,069
N of clusters	2,289	1,770	282	1,613
Adj. R^2 (Panel A / B)	0.278 / 0.554	0.241 / 0.563	0.267 / 0.414	0.241 / 0.547
Mean hours worked (partner)	40.26	42.29	42.34	41.57

Notes: Each column corresponds to a group of female workers; the outcome is the hours worked of their partners. All regressions include block and period fixed effects. Standard errors in parentheses and clustered at the block level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table E.7: Partner characteristics of female workers by worker type

	Employees		Self-employed	
	Formal	Informal	Formal	Informal
	(1)	(2)	(3)	(4)
Demographics				
Age (years)	44.49	44.26	47.91	47.60
	(10.52)	(11.33)	(10.98)	(11.50)
Household head (%)	0.91	0.92	0.91	0.91
	(0.28)	(0.28)	(0.29)	(0.28)
Employment Status				
Employed (%)	0.87	0.84	0.88	0.85
	(0.34)	(0.36)	(0.32)	(0.36)
Formal employee (%)	0.54	0.28	0.31	0.29
	(0.50)	(0.45)	(0.46)	(0.46)
Informal employee (%)	0.13	0.34	0.09	0.22
	(0.34)	(0.47)	(0.28)	(0.41)
Formal self-empl. (%)	0.07	0.05	0.37	0.04
	(0.26)	(0.22)	(0.48)	(0.20)
Informal self-empl. (%)	0.12	0.18	0.08	0.26
	(0.33)	(0.38)	(0.27)	(0.44)
Labor Outcomes (partner)				
Hours worked/week	40.45	42.34	42.97	41.70
	(20.78)	(22.66)	(21.03)	(23.27)
Monthly income (MXN)	5,442.65	3,961.90	6,082.94	3,897.76
	(8,494.85)	(5,990.50)	(11,768.92)	(6,337.47)
Own Labor Outcomes (female worker)				
Own hours/week	38.34	32.70	40.89	29.26
	(13.65)	(17.14)	(19.17)	(20.85)
Own income (MXN)	5,181.86	2,929.97	5,158.09	2,311.38
	(6,891.71)	(3,504.36)	(9,145.18)	(3,108.24)
N (partner characteristics)	16,873	10,721	1,735	8,315
N (own outcomes)	17,467	11,232	1,819	8,652

Notes: Means and standard deviations (in parentheses) shown for each variable by worker group. Partner characteristics refer to the spouse or cohabiting partner of each female worker. "Own" outcomes refer to the female worker. Sample constructed from the ENOE survey (2005 Q3–2019 Q4), restricted to working-age individuals (15–65) residing in Mexico City.

Table E.8: Effects of water shortages on partners' hours worked by type of male worker

	Employees		Self-employed	
	Formal	Informal	Formal	Informal
	(1)	(2)	(3)	(4)
Panel A: Without Covariates				
Depletion × Distance	-0.127	-0.375**	-0.264	-0.182
	(0.101)	(0.157)	(0.301)	(0.161)
Panel B: With Covariates				
Depletion × Distance	-0.040	-0.164	-0.213	-0.082
	(0.056)	(0.102)	(0.182)	(0.098)
Female (partner)	-3.327	-12.697***	-4.941	-18.965***
	(3.199)	(3.817)	(5.987)	(5.578)
Employed (partner)	37.554***	39.194***	36.242***	38.509***
	(0.254)	(0.457)	(0.669)	(0.519)
Age (partner)	-0.018*	-0.025*	0.051	-0.014
	(0.011)	(0.014)	(0.034)	(0.017)
Informality (partner)	-10.053***	-8.454***	-4.582***	-5.579***
	(0.394)	(0.541)	(0.840)	(0.588)
Household head (partner)	1.626***	2.301***	4.563***	-0.343
	(0.504)	(0.713)	(1.562)	(0.774)
N	30,650	15,886	5,099	13,476
N of clusters	3,269	2,415	1,189	2,202
Adj. R^2 (Panel A / B)	0.254 / 0.767	0.218 / 0.725	0.334 / 0.748	0.236 / 0.715
Mean hours worked (partner)	16.73	14.97	19.64	18.28

Notes: Each column corresponds to a group of male workers; the outcome is the hours worked of their partners. All regressions include block and period fixed effects. Standard errors in parentheses and clustered at the block level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table E.9: Partner characteristics of male workers by worker type

	Employees		Self-employed	
	Formal	Informal	Formal	Informal
	(1)	(2)	(3)	(4)
Demographics				
Age (years)	41.17	39.62	43.96	43.52
	(10.05)	(11.22)	(9.97)	(10.58)
Household head (%)	0.06	0.07	0.05	0.06
	(0.23)	(0.26)	(0.22)	(0.24)
Employment Status				
Employed (%)	0.48	0.44	0.55	0.52
	(0.50)	(0.50)	(0.50)	(0.50)
Formal employee (%)	0.29	0.12	0.20	0.13
	(0.45)	(0.33)	(0.40)	(0.34)
Informal employee (%)	0.09	0.20	0.09	0.12
	(0.29)	(0.40)	(0.28)	(0.33)
Formal self-empl. (%)	0.02	0.01	0.10	0.01
	(0.13)	(0.09)	(0.31)	(0.09)
Informal self-empl. (%)	0.08	0.10	0.06	0.14
	(0.27)	(0.30)	(0.24)	(0.35)
Labor Outcomes (partner)				
Hours worked/week	16.69	14.80	19.98	18.66
	(20.78)	(20.72)	(22.12)	(22.32)
Monthly income (MXN)	2,196.15	1,379.54	2,386.87	1,254.11
	(4,970.45)	(3,171.90)	(6,396.60)	(2,796.86)
Own Labor Outcomes (male worker)				
Own hours/week	45.14	49.64	48.64	45.98
	(14.52)	(16.62)	(17.59)	(19.57)
Own income (MXN)	5,514.98	4,171.96	6,195.25	3,997.77
	(8,172.88)	(4,546.65)	(11,890.23)	(4,512.81)
N (all variables)	32,438	18,502	6,158	15,595

Notes: Means and standard deviations (in parentheses) shown for each variable by worker group. Partner characteristics refer to the spouse or cohabiting partner of each male worker. "Own" outcomes refer to the male worker. Sample constructed from the ENOE survey (2005 Q3–2019 Q4), restricted to working-age individuals (15–65) residing in Mexico City.

Table E.10: Effects of Water Shortages on Hours Worked by Informal Female Employees, by Sector

	(1) Domestic	(2) Food/hygiene	(3) Other
Depletion × Distance	0.136	0.160	0.229
	(0.137)	(0.207)	(0.141)
N	9,478	5,968	12,290
N of clusters	1,594	1,302	2,246
Adj. R2	0.344	0.287	0.222
Mean	31.66	42.59	37.49

Notes: Standard errors in parentheses and clustered at the block level. All specifications include block and period fixed effects. Column 1 includes domestic workers, while column 2 includes workers in sectors related to food and hygiene that are likely to experience increased demand during water shortages. Categorization was based on INEGI's SCIAN occupation descriptions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.