Let the Water Do the Work:

Climate Adaptation Policies and Labor Market Outcomes*

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Abstract

The provision of clean water is a key factor for poverty reduction and economic development. This study uses a difference-in-differences research design to evaluate the impact of a water policy in Brazil that distributed cisterns for water storage to poor families in rural areas on labor market outcomes. Our findings show that receiving a cistern had a positive impact on the probability of getting formal jobs and increased the wages of beneficiaries. The effect was stronger for jobs with longer commuting times, indicating that access to clean water can help reduce time spent on daily chores and increase labor force participation. Our results provide evidence of the important role that water policies can play in reducing poverty and promoting economic development, particularly in rural areas with limited access to clean water.

JEL codes: Q54, Q25, Q58, J01.

Keywords: climate, adaptation, labor market, cisterns, water

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1 Introduction

Access to clean water is a crucial factor for development. In fact, ensuring the availability and sustainable management of water and sanitation for all is one of the 17 Sustainable Development Goals of the United Nations. Still, water stress is a phenomenon experienced by billions of people worldwide, particularly in developing countries (Organization et al., 2021). A large body of the literature has shown how improving access and quality of water can benefit the health outcomes of individuals (Kremer et al., 2011; Bhalotra et al., 2021) and even improve school outcomes of children (Zhang, 2012). However, little is known about how and whether these benefits can translate into the labor market and job opportunities.

At first, the literature has shown that the absence of clean water sources can impose a time-consuming burden on families that have to go long distances to fetch water (Meeks, 2017). Therefore, access to water can affect labor supply in the formal sector through how it interacts with individuals' time allocation. One first channel of action operates through the impacts of access to water on the increase in productivity of family farming and, consequently, the returns from domestic production. This can result in an increase in the cost of migrating work in agriculture to work in the market, keeping individuals away from job opportunities in the formal labor market. The second channel of action is associated with reducing the time spent collecting and transporting water for human consumption, which increases the time available both to offer work in the formal market and the time available for leisure and well-being.

In this paper, we investigate the causal effect of a large-scale government program, the First Water Cistern (hereafter, FWC), that distributed, from 2003 to 2017, more than 800 thousand cisterns to rural households in the Brazilian semiarid region to provide clean water for consumption, drinking, and cooking. The semiarid region is one of the poorest Brazilian regions hosting 28 million individuals, whose main economic activities are subsistence agriculture and livestock farming, and is historically affected by recurring droughts.[1] The cisterns distributed by the FWC program can capture rainwater and have a storage mechanism for the dry seasons. In addition to the cistern, beneficiaries receive training on how to maintain the quality of the stored water.

By utilizing micro-data on the universe of beneficiaries and combining it with detailed registry datasets, we traced the families of the beneficiaries and obtained information on the labor market outcomes of their household members. This allowed us to estimate the

[1]The gdp per capita (PPP) in the Semi-arid was about $3,458, similar to that of Ethiopia ($2,599), Ghana ($6,178), and Zambia ($3,623) in the same period (2021).

impact of the FWC program on labor market outcomes at the individual level having a panel sample with more than 635 thousand individuals, from whom we were able to track labor market outcomes over time. Our sample considers only family members (men and women) that could legally be in the formal labor market, that is, with more than 18 years old. To estimate these effects we exploit the staggered distribution of the cisterns in a difference-in-difference research design. Our main specification utilizes the estimator proposed by Callaway and Sant'Anna (2021), comparing individuals who received the treatment early with those who received it late.

Our findings show that individuals who received a cistern had a higher probability of obtaining a formal job than those who received the cistern at a later time. We also find that beneficiaries who were already in the formal labor market increased their earnings. Specifically, we estimate that receiving a cistern increases the probability of getting a job by 16% relative to the sample average, and also increases wages by 8% relative to the sample mean. The main results are robust to a number of robustness exercises and sample restrictions. Also, event study specifications demonstrate that these results are not driven by differential trends prior to the treatment.

The results of our study are consistent with the time-saving mechanism. We found that facilitating people's access to water saves time, which can be used in other productive activities (SILVA, 2009; Meeks, 2017). Our estimates demonstrate that the FWC resulted in increased employment opportunities for jobs with longer commuting times outside of the individual's municipality of residence without causing outward migration. We also show that the effect on employment is primarily driven by off-farm jobs in non-agricultural sectors. Furthermore, heterogeneity analysis of treatment effects reveals that the positive impact of the FWC is stronger for men, more educated and younger individuals who are more prone to accept longer commuting times. Additionally, we observed higher treatment effects for individuals in households with at least one child aged 14 years or younger. This result is also consistent with the time-saving mechanism, as households with children tend to have higher workloads, making time-saving a more significant benefit.

This paper makes multiple contributions to the literature. Our primary contribution is to investigate strategies that developing countries can adopt to address the challenges of climate change in climate-vulnerable areas. Previous research shows that climate shocks, such as droughts or climate fluctuations, can have adverse effects on the welfare of individuals (Dell, Jones and Olken, 2014; Rocha and Soares, 2015; Dinkelman, 2017; Carrillo, 2020; Blakeslee, Fishman and Srinivasan, 2020). We add to this branch of literature showing how technology adoption can be used to mitigate these effects.

This paper also adds to the literature on the welfare effects of providing water infras-

tructure. Many papers have primarily focused on the health benefits of improving access to water, such as Galiani, Gertler and Schargrodsky (2005), Kremer et al. (2011), Zhang (2012), Bhalotra et al. (2021), Marcus (2021). Furthermore, a study conducted by Da Mata et al. (2023) evaluated the same program and concluded that the availability of cisterns during the initial phase of pregnancy enhanced the health outcomes of childbirth. Additionally, Zhang and Xu (2016) demonstrates how access to water can generate positive long-term impacts on education. The current study adds to this body of literature by offering credible empirical evidence of the effects of cisterns in a new dimension, specifically the labor market.

Our third contribution is that, to the best of our knowledge, we are the first to use fine-grained individual-level data to measure the impact of low-cost climate adaptation policies on the labor market. Our data allow us to track individuals over time, and also control for individual fixed-effects. Therefore we can compare individuals in the same municipality that received a cistern at a different time, contrary to other studies such as Meeks (2017), and Li, Xi and Zhou (2021), which use village-level data and estimate panel regressions showing that a water program in China increased off-farm employment.

Finally, our paper is also connected to the existing literature exploring the effects of improved infrastructure on development outcomes. For instance, Dinkelman (2011) and Vidart (2023) discovered that providing households with electricity increased labor force participation. Additionally, Asher and Novosad (2020) demonstrated how access to roads increased off-farm employment in rural India. Our contribution lies in demonstrating the impact of enhancing water infrastructure on creating additional employment opportunities.

2 The First Water Cisterns Program

The First Water Cistern program (FWC) has as its main goal the provision of access to clean and safe water for families living in rural areas in Brazil. The program builds cisterns, with concrete slabs, next to the houses to store rainwater, which is collected through gutters installed on the roofs. Each tank has a standard storage capacity of 16,000 liters, enough volume for domestic use (drinking and cooking) for a family of up to six people during the dry season, which can last up to eight months. The cisterns are built with precast concrete slabs — a simple, low-cost technology, easy to scale, and suitable for dry conditions.[2] To start implementing the program in a region, implementers rely on the local workforce

[2]Similar rainwater harvesting technologies have been adopted in various regions of the world (see **?**). **?** argue that "decentralized approaches to making drinking water safer, including chemical and solar disinfection at the point of use, safe storage and behavior changes deserve high priority for rapid implementation".

to build the cisterns. Before the construction of the cisterns, families usually relied on alternative sources to obtain water, such as small lakes and reservoirs, which are often vulnerable to contamination by pathogens.

The cisterns were distributed on the Brazilian semi-arid region. The place is home to approximately 28 million people and occupies about 12% of the national territory, covering 1,262 municipalities, it constitutes a territory prone to irregular rainfall, low soil water retention and severe droughts. The semi-arid climate imposes an arduous water *deficit* on the region, marked by the scarcity of rainfall, concentrated in a few months of the year and irregularly distributed.[3]

The program provided training on disinfection (sodium hypochlorite) for the beneficiary families, to ensure good quality of the water stored in the reservoir. In addition, families are instructed to remove gutters during droughts, set aside a bucket of water to exclusively handle the water in the pond, cover the exterior walls with lime, and clean the pond annually using the first rain of the season added with bleach. (Palmeira, 2006). The training received by the beneficiary families is pointed out by Da Mata et al. (2023) as being directly related to the quality of the water in the reservoirs, reinforcing the importance of this stage of the program.

Private non-profit entities (selected through public calls) and the state government in partnership with the Ministry of Citizenship of Brazil are the responsibles for the execution of the program. These partners are responsible for identifying and selecting families based on criteria established by the federal government (Brasil, 2018).[4] To be eligible to participate in the program, families living in rural areas without regular access to water must be registered with the Federal Government's Cadastro Único para Programas Sociais (CadÚnico). The selection process prioritizes families with the following characteristics: (i) low income; (ii) headed by women; (iii) large number of children under six or school-age children; (iv) families with people with special needs and (v) families with elderly people (Brasil, 2018).

[3]The average annual rainfall in the Brazilian semi-arid region varies between 200 and 800 mm, making it one of the rainiest semi-arid regions on the planet, however, as a characteristic of such regions, the evaporation rate in the Brazilian semi-arid region is 3,000 mm per year, which configures a challenging scenario for families who live from agriculture and animal husbandry in the (Asa Brasil, 2017) region.

[4]The process of locating eligible families is carried out in local meetings involving different entities, such as local public authorities, civil society organizations civil society, and social assistance councils, among others.

3 Data and Reserach Design

3.1 Data

This section provides an overwiew of the data sources, variable definitions, and analysis sample.

Beneficiaries. Our data on the beneficiaries is based on both administrative data from the Cisternas First Water Program (FWC), and data from CadÚnico, an integrated registry of about 80 million people in poverty and extreme poverty. Administrative data for the FWC includes detailed records of all heads of households benefiting from the program. The data identifies each beneficiary by name, date of birth, municipality of residence, and registration number in the Cadastro de Pessoas Físicas (CPF). In addition to the data used to identify users, the Cisterns Program dataset also includes data on the exact start and end dates of the construction process of each cistern, which lasts around two to three days, this makes it possible to identify the *timing* from the start of exposure to the FWC program for each beneficiary family.

CadÚnico records gather all individuals from all families benefiting from some federal government social assistance program, such as the Bolsa Família Program. From the CadÚnico dataset, it is possible to obtain information on the date of birth, sex, education, the registration number in the Individual Taxpayer Registry (CPF), address, and income profile of the registered individuals. Therefore, Cadúnico provides a direct link between the beneficiary and the members of their respective family, allowing us to identify all beneficiaries within families.

Employment. Data on the labor market are derived from the Annual Social Information List (RAIS), which consists of a set of microdata, with an annual frequency, with restricted access, relating employers and employees, covering the universe of workers and formal firms in Brazil to the period 2002-2018. This dataset is based on socioeconomic information requested by the Brazilian Ministry of Labor from legal entities and other employers annually.

RAIS data are organized by employment relationship level, defined as each combination between an employee and an employer/firm for each year, containing all employments declared active and non-active on 12/31 of each year. The information provided by the RAIS database represents the universe of the formal labor market in Brazil, providing, for each employment relationship, detailed information about each employment contract, including, among other things, the CPF of each individual (employer and employee), the

type of contract, the start and end dates of each contract, contractual working hours, type of occupation, sex, race, age group, average monthly income, level of education, size of establishment, region, and economic sector, among others.

Analysis Sample. The process of building up our sample is straightforward. First, we match by the unique CPF individuals on the administrative data with each wave of Cadúnico from 2012 to 2020. By doing this we were able to map all individuals living at the house that received the cistern, instead of only the chief of the household registered in the Cisterns First Water administrative data. We identified 72% (approximately 635,000 individuals) of beneficiaries on Cadúnico. From this list of individuals we restricted the sample to the ones that had at least 18 years old, and at most 55 years old in 2002.

Having the list of adults in the family, the next step is, for each year from 2002 to 2017, look if we can found them in the RAIS data. Since RAIS represent the universe of Brazilian formal workers, not being in the RAIS in a given year means that the individual was not employed in the formal sector in that year. This procedure resulted in a panel data of 606,901 individuals who received the cistern between 2003 and 2017 from were we can know employment status and wages for each year.

3.2 Research Design

To estimate the effect of receiving a cistern on the labor market outcomes of beneficiaries, we exploit variation in the *timing* of distribution of cisterns among treated individuals in a difference-in-difference research design. Recent developments on the difference-in-differences literature have shown that when treatment varies over time, results from Two-Way Fixed Effects (TWFE) regressions might be biased, specially when there is no never-treated units (Goodman-Bacon, 2021) in the sample. To avoid such problem, and since we only have treated units in our sample of individuals, in this paper we use the doubly-robust estimator proposed by Callaway and Sant'Anna (2021).

The procedure have two steps. The first step consists in estimate a different Average Treatment Effect among the Treated (ATT) for each group g and time t combination possible in our sample, calling these parameters as $ATT(g,t)$. Under the assumptions that in the counterfactual scenario where the treatment did not occurred, the outcomes for all adoption groups would have evolved in parallel (generalized parallel trends), and that there if a unit is untreated in period t, their outcome does not depend on what time period they will be treated in the future (no antecipation), the parameter $ATT(g,t)$ gives the average treatment effect at time t for the cohort first treated in time g (Roth et al., 2022). Also, under these assumptions, we can estimate $ATT(g,t)$s by comparing the expected

change in the outcome for cohort g between periods $g-1$ and t to that for a control group not-yet treated, what effectively absorbs unit and time fixed-effects.[5] This procedure will result in as many parameters as the possible group-time combinations in our data. Therefore, the second step is to summarise these parameters in meaningful ones. We use a dynamic event-study specification averaging the $ATT(g,t)$s in a single parameter for each relative event-time l, as shown in equation 1. Also, for inference, we follow Callaway and Sant'Anna (2021) bootstrapping procedure, adjusting for household clusters and, alternatively, for municipality clusters.[6]

$$ATT_l^w = \sum_g ATT(g, g+l) \tag{1}$$

It is important to note that the Doubly-Robust estimator is robust to treatment effect heterogeneity over time, reducing concerns raised by Sun and Abraham (2021) about bias in event-study designs with multiple treatment timing. Our panel ranges from 2002 to 2018, and the last year an individual received the cistern is 2017. Therefore, following Callaway and Sant'Anna (2021), we restricted our panel untill 2016, making the last group to be treated into a never-reated control group. We also use the not-yet-treated units as part of the control group. Note that this procedure make our control group similar to our treated group, since all units in the sample will receive a cistern at some point in time, reducing concerns about nonparallel pre-trends. Finally, the advantage of using an event-study specification as in equation 1, is that the researcher could look at each $ATT_{l<0}$ and empirically test if the parallel trends assumption holds.

4 Results

4.1 Employment and wages

Figure 2 presents our main empirical results on the effect of receiving a cistern on labor market outcomes. The dependent variable on Panel A is an indicator variable that equals one if the individual is employed in the formal sector in that year and zero otherwise. In Panel B, the dependent variable is the log of wages of employed individuals. All estimates were obtained using the Callaway and Sant'Anna (2021) proposed estimator, and inference procedures. Our main results show that receiving a cistern has positive effects on the labor market, increasing the probability of getting a job in the formal sector, as can be seen in panel A. Also, receiving a cistern raises the wages of beneficiaries. More precisely,

[5] For a comprehensive discussion, one may refer to Callaway and Sant'Anna (2021) and Roth et al. (2022).
[6] All estimates were obtained using the open-source R package *did*.

the average estimated positive effect of receiving a cistern on the probability of having a formal job is about to 16% of the mean sample, while the effect on wages represents approximately an increase of 8% relative to the mean, as can be seen in Table 1.

Moreover, results in both panels A and B of Figure 2 suggest that before the treatment, the treatment (individuals who received a cistern before 2016) and control (individuals who only received the cistern after 2016) groups are comparable in terms of trends. Prior to the treatment, there are no statistically significant differences between the groups indicating that the parallel trends assumption holds. The difference between both groups appears only after the treatment and holds over time, indicating a permanent long-run effect on the beneficiaries. In the appendix, we have also shown that there are no systematic differences in the treatment effect by treatment cohort, which reassures the robustness of our baseline estimates.

4.2 Off-farm work

Figure 3 illustrates that the positive impact of cisterns on the labor market affects both agriculture and non-agriculture jobs. However, the effect is much more significant for non-agriculture jobs, which aligns with the observed positive impact on wages, as off-farm jobs generally offer higher pay. Additionally, in the appendix, Figure A.4 presents the same results as Figure 3, but with a breakdown of off-farm jobs in three additional sectors. Industry and Construction are the two sectors where employment increased the most.

5 Mechanisms

We have shown that water infrastructure can lead to both long- and short-term benefits in terms of labor outcomes for individuals in climate-vulnerable areas, such as increased formal employment and wages. As discussed previously, improving water infrastructure can enhance individual labor market outcomes by reducing the amount of time spent on obtaining water. Indeed, SILVA (2009) conducted a survey with 1,328 beneficiaries of the Cisterns Program about the perception of the impact of the cistern on their lives. Table 2 shows that most beneficiaries on the survey declared that the cistern reduced significantly the time spent on fetching water. Based on the survey results, only 5.6% of respondents reported spending less than 15 minutes per day fetching water before receiving the cistern, while 35% spent an hour or more. Conversely, 66.6% of respondents spent less than 15 minutes fetching water after receiving the cistern, and only 0.2% reported spending an hour or more per day. As we do not have access to detailed information on the time

allocation of beneficiaries over time, we take multiple measures to verify the mechanism behind our findings and present the results in this section.

5.1 Heterogenous effects

First, we check where these new formal jobs are located. As discussed in previous sections, the beneficiaries live in rural areas of the Brazilian semiarid region, where there is a limited number of formal jobs and the existing ones involve long commuting times. The less time available within the household, the lower the willingness of individuals to accept jobs that require a long commuting time. Thus, if time allocation plays a significant role in explaining our results, the effect on employment should be higher for jobs located far away from households. To examine this, using the same empirical approach described in section 3.2, we estimate the effect of receiving a cistern on the probability of getting a job in the same and in a different municipality where the cistern is located. Results are shown in Figure 4.

The results displayed in Figure 4 are consistent with the time allocation mechanism. All the treatment effects come from jobs in municipalities distinct from the one where the cistern is located, with no statistically significant changes in the probability of obtaining a formal job in the same municipality where the individuals reside.

Our second step is to check which demographic groups are more affected by the policy. The idea behind this exercise is to test if the groups more prone to higher commuting times are the ones more affected, which would be a pattern consistent with the time-saving mechanism. We display the results in Figures 5 and 6. Our estimates show that the effect of receiving a cistern is stronger for young and more educated men, which strongly suggests that time allocation has a major role in explaining our results. These results are also consistent with the ones found by Da Mata et al. (2023), which demonstrate that pregnant women with higher levels of education are more likely to comply with the maintenance training offered by the Cisterns Program. Furthermore, there is no difference in the estimates for municipalities with populations above and below the median of the distribution.

5.2 Alternative sample and outcomes

As discussed in Section 3.2, the CadÚnico data, which we use to build family links, covers only the period from 2012 to 2017. Consequently, we lack high-frequency information on other dimensions, such as migration status, in addition to formal labor market outcomes. To overcome this limitation and continue to shed light on the mechanisms, we restricted our sample to only include individuals treated between 2013 and 2017, yielding a panel

from 2012 to 2016. Notably, the never-treated group, consisting of individuals who received the cistern in 2017, remains the same as our main sample. The advantage of using this restricted sample is that we can examine other outcomes that are unavailable at RAIS but accessible in Cadúnico.

Table 3 presents the results obtained using the new restricted sample. To assess their comparability with our baseline estimates, columns (1) and (2) estimate the effects of receiving a cistern on formal employment and wages for the restricted sample. The findings align with our baseline estimates presented in Table 1, suggesting that receiving a cistern increases the likelihood of having a formal job by 11% relative to the mean sample. Cadúnico data provides information on total employment status, which encompasses both formal and informal jobs. The wage measure in Cadúnico also includes wages earned from informal jobs and serves as the dependent variable in columns (3) and (4) of Table 3. The estimates indicate no significant impact of receiving a cistern on the total employment, yielding smaller and statistically indistinguishable from zero coefficients. On the other hand, we found a positive and statistically significant effect on the total wage variable with an increase of approximately 1.8% relative to the mean, as shown in column (4). This result suggests that improving water access for families resulted in a shift from informal to formal jobs, with longer commuting times for formal jobs. Since formal jobs are typically well-paid in Brazil, the effect on wages in column (4) is somewhat expected.

The dependent variable in column (5) of Table 3 is a dummy variable that equals one if the individual resides in a different municipality than the one where the cistern is located. The null effects of the program on outward migration, as shown in column (5), suggest that the program's impact on new formal jobs arises from jobs that require long commutes, rather than solely from individuals' migration. This finding reinforces the importance of the time-saving mechanism in explaining our baseline results.

Columns (6) and (7) of Table 3 utilize our baseline formal employment indicator as the dependent variable, but they split the sample into families with children under 14 years old living in the household one year before receiving the cistern (column (6)) and families without children (column (7)). Once again, the results consistently support the time-saving mechanism. Receiving a cistern has a positive and statistically significant effect on formal employment for households with a child. However, there is no statistically significant effect for households without a child. The rationale behind these results is that households with children generally have a much higher workload, and thus, saving time is more critical for them, leading to a higher marginal effect of the cistern on labor supply.

6 Conclusion

In this paper, we estimated the causal effect of water access on labor market outcomes. By utilizing detailed microdata and exploiting the varying timing of access to the First Water Cistern Program, we demonstrate that individuals who received cisterns experienced improvements in their labor market outcomes for both, men and women. Specifically, our findings reveal that the provision of cisterns led to an approximately 16% increase in the probability of securing a formal job. Additionally, we estimate an 8% increase in job earnings. Our analysis indicates that the time saved from fetching water enabled the beneficiaries to pursue off-farm job opportunities in municipalities other than their own residence. The results reinforce the fact that individuals residing in rural and climate-vulnerable areas encounter various constraints when attempting to access the formal labor market. Moreover, they highlight the crucial role that simple and low-cost policies can play in alleviating these constraints. Also, the paper presents the initial large-scale evidence of the impacts of water availability policies targeting households. Importantly, this is a low-cost and scalable policy that has already been extensively implemented in Brazil. We provide comprehensive evidence on the effectiveness of a program that has the potential to be applied on a large scale in many other countries, particularly in climate-vulnerable areas, facing similar issues.

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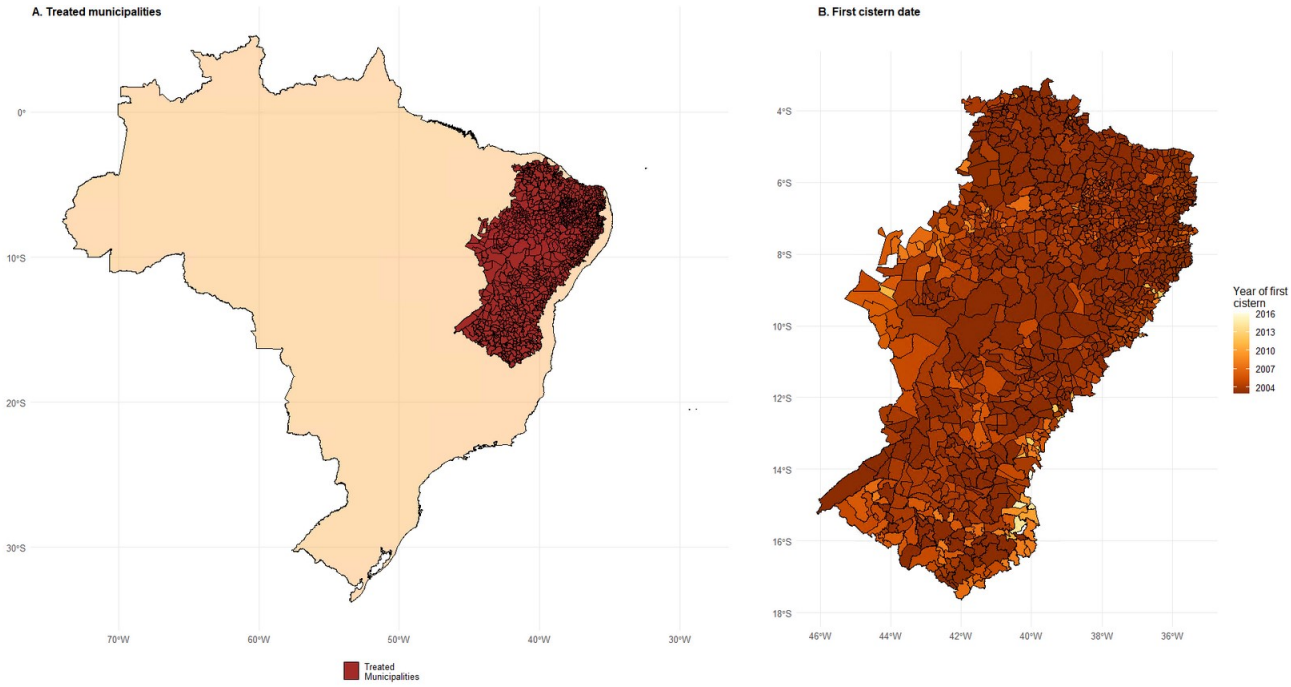
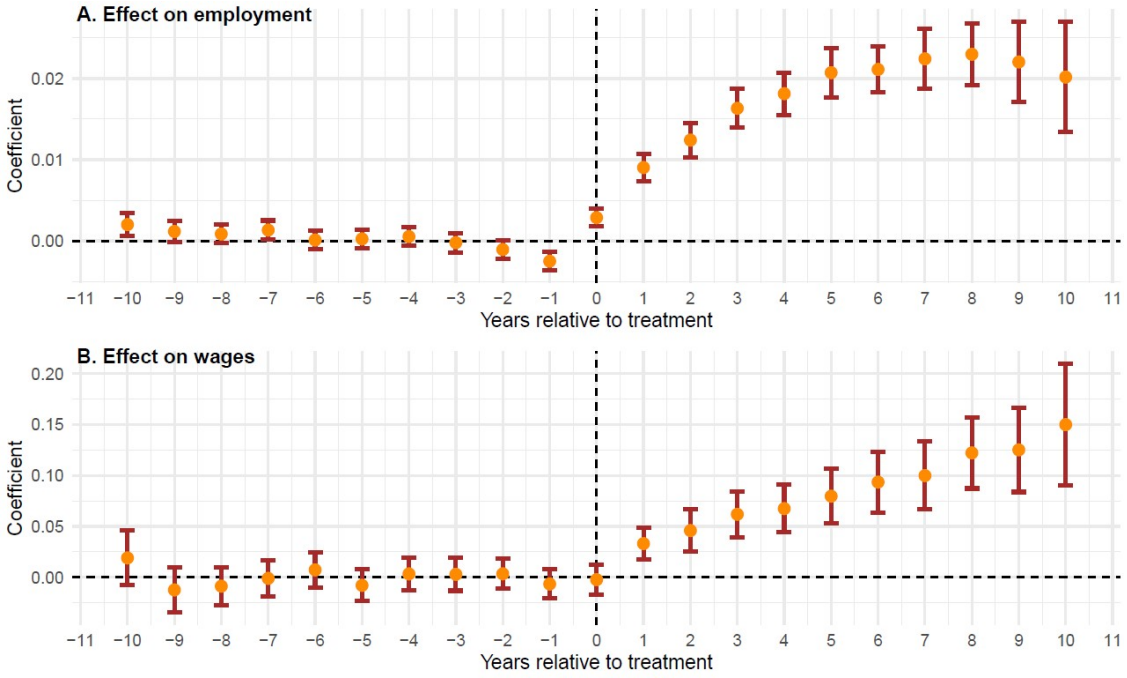
Figure 1: Spatial distribution of treated municipalities



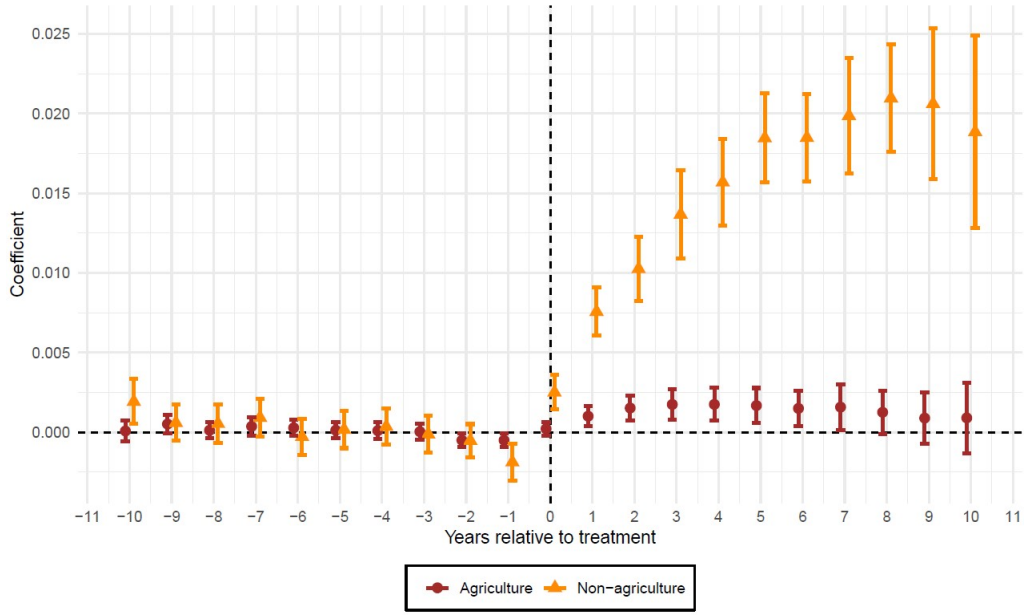
Notes. The map in Panel A highlights the Brazilian semiarid region and illustrates the municipalities that have received at least one cistern. The choropleth map in Panel B displays the respective years when each municipality received its first cistern.

Figure 2: The effect of receiving a Cistern on labor market outcomes



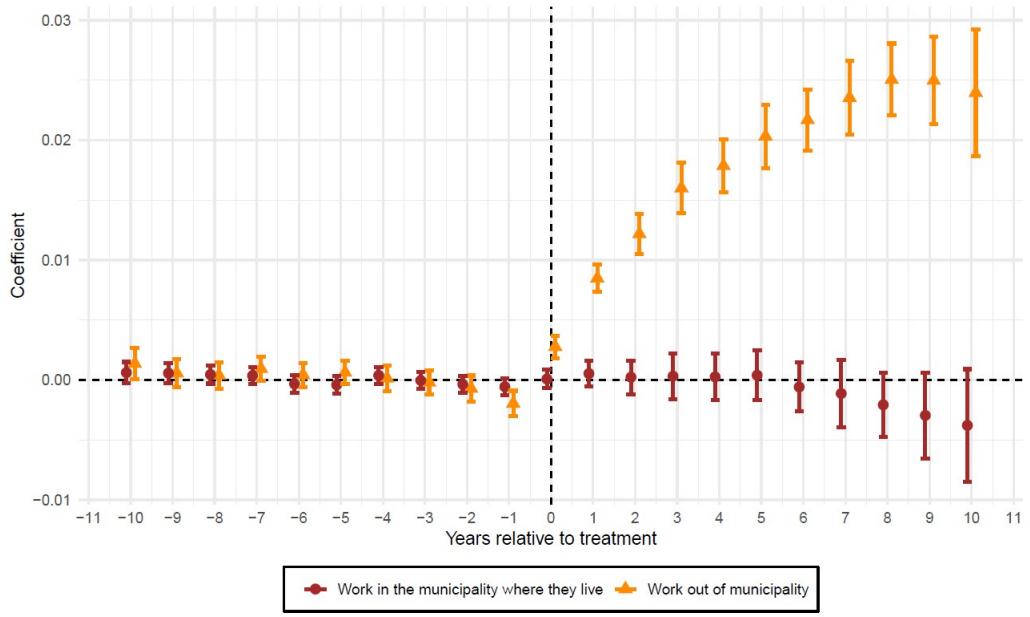
Notes.This figure presents the event-study estimates using the Callaway and Sant'Anna (2021) estimator with individual-level panel data spanning from 2002 to 2016. The control group consists of individuals who have not yet been treated, as well as those who received the cistern in 2017. In Panel A, the dependent variable is a binary variable indicating whether the individual has a formal job in a given year. In Panel B, the dependent variable is the natural logarithm of wages, and the sample is limited to employed individuals.

Figure 3: The effect of receiving a Cistern on formal employment by sector



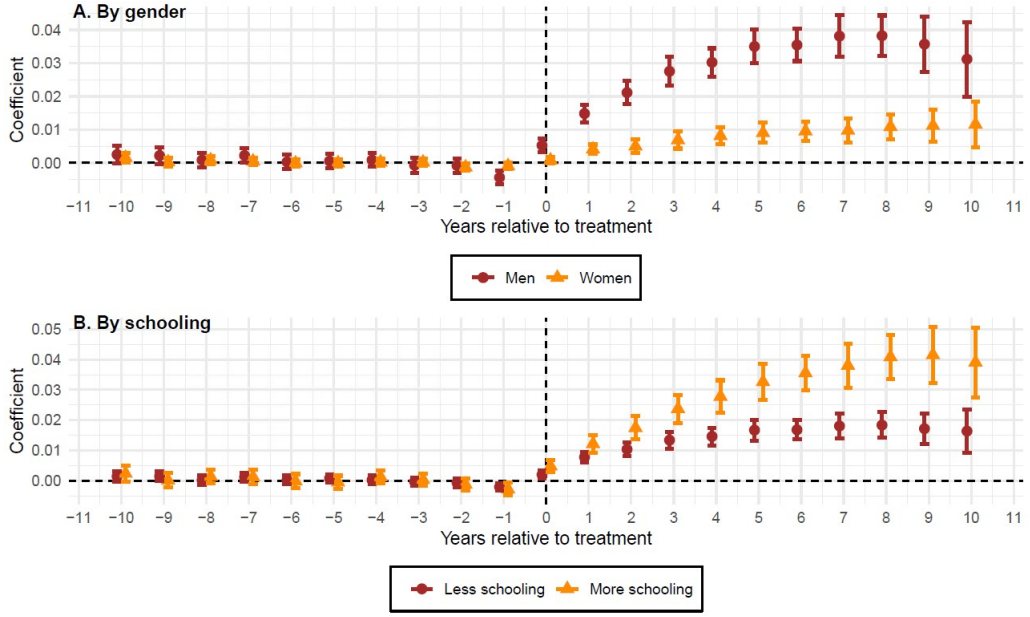
Notes. This figure presents the event-study estimates using the Callaway and Sant'Anna (2021) estimator with individual-level panel data spanning from 2002 to 2016. The control group consists of individuals who have not yet been treated, as well as those who received the cistern in 2017. In the yellow plot, the dependent variable is a binary variable indicating whether the individual has a formal job in a non-agriculture sector in a given year. In the red plot, the dependent variable is a binary variable indicating whether the individual has a formal job in the agriculture sector in a given year.

Figure 4: The effect of receiving a Cistern on formal employment location



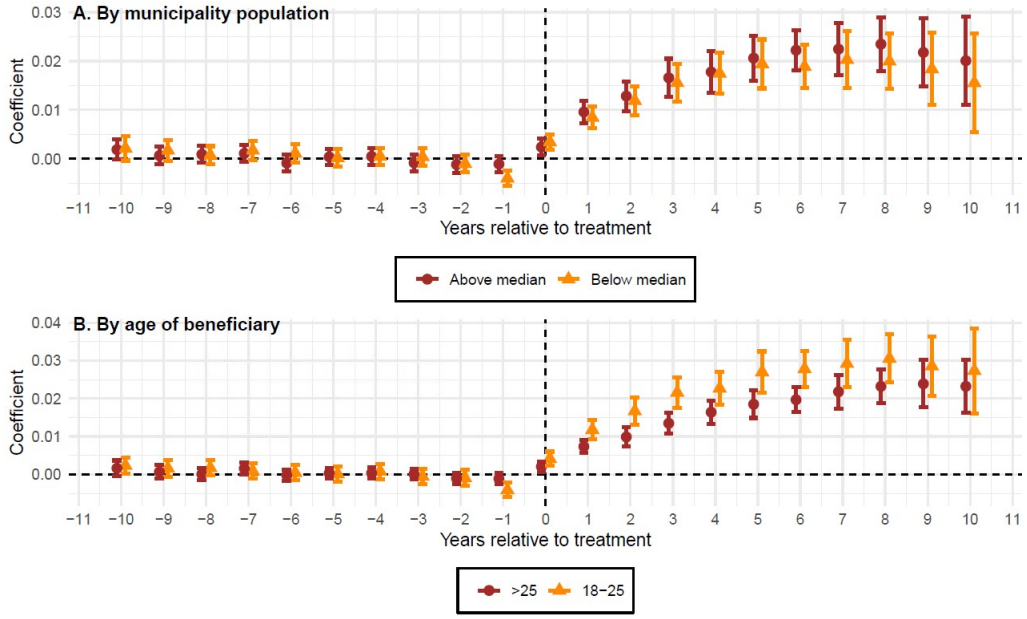
Notes. This figure presents the event-study estimates using the Callaway and Sant'Anna (2021) estimator with individual-level panel data spanning from 2002 to 2016. The control group consists of individuals who have not yet been treated, as well as those who received the cistern in 2017. In the yellow plot, the dependent variable is a binary variable indicating whether the individual has a formal job located in a municipality different from their place of residence in a given year. In the red plot, the dependent variable is a binary variable indicating whether the individual has a formal job located in the same municipality of residence in a given year.

Figure 5: The effect of receiving a Cistern on formal employment by gender and education



Notes. This figure presents the event-study estimates using the Callaway and Sant'Anna (2021) estimator for different samples with individual-level panel data spanning from 2002 to 2016. The control group consists of individuals who have not yet been treated, as well as those who received the cistern in 2017. The dependent variable in both Panel A and Panel B is a binary variable indicating whether the individual has a formal job in a given year. In Panel A, the results are presented for a sample that includes only men (red) and only women (yellow). In Panel B, the results are presented for a sample that includes individuals with different levels of schooling. The red plot represents individuals with less schooling, while the yellow plot represents individuals with more schooling.

Figure 6: The effect of receiving a Cistern on formal employment by population and age



Notes.This figure presents the event-study estimates using the Callaway and Sant'Anna (2021) estimator for different samples with individual-level panel data spanning from 2002 to 2016. The control group consists of individuals who have not yet been treated, as well as those who received the cistern in 2017. The dependent variable in both Panel A and Panel B is a binary variable indicating whether the individual has a formal job in a given year. In Panel A, the results are presented for a sample that includes only municipalities with above (red) and below (yellow) the median sample population. In Panel B, the results are presented for a sample that includes individuals with different ages. The red plot represents individuals with more than 25 years old, while the yellow plot represents individuals with 18 to 25 years old.

Table 1: The effect of cisterns on labor market outcomes

	(1)	(2)
	Employment	log(Wage)
DD	0.014	0.061
	(0.001)	(0.006)
N. Obs	9103515	1226021
N. Individuals	606901	204829
N. households	431412	182578
Mean dep. variable	0.087	8.528

Notes. Table shows the baseline results from Callaway and Sant'Anna (2021) difference-in-difference estimator. In columns (1) and (2) the dependent variables are an indicator of formal employment and the log of formal wages, respectively. Panel data covers 2012 to 2016.

Table 2: Time spent to fetch water before and after the cistern

	Before cistern		**After cistern**	
Time spent to fetch water	nº households	%	nº households	%
Up to 15 minutes	74	5.6	884	66.6
From 15 minutes to 1 hour	481	36.2	65	4.9
From 1 hour to 2 hours	233	17.5	2	0.2
More than 2 hours	235	17.7	0	0
Don't know	299	22.5	354	26.7
No answer	6	0.5	23	1.7

Notes. The table displays the findings of a survey carried out by SILVA (2009) on a representative sample of 1,328 households that were provided with a cistern. The survey aimed to assess the beneficiaries' perceptions of the impact of the cisterns on their lives.

Table 3: The effect of cisterns on employment - restricted sample

	RAIS		CadÚnico			Have children?	
	Employment	log(Wage)	Total Employment	log(wage)	Prob. Moved out	Yes	No
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DD	0.012	0.037	0.000	0.018	0.001	0.017	0.003
	(0.001)	(0.010)	(0.003)	(0.007)	(0.001)	(0.004)	(0.002)
N. Obs	1192220	191229	950596	494847	1039286	804430	231620
N. Individuals	238444	60130	219658	138540	229955	160886	46324
N. households	173263	55097	159981	117345	167759	110951	36713
Mean dep. variable	0.106	8.844	0.534	4.776	0.024	0.093	0.118

Notes. Table shows results from Callaway and Sant'Anna (2021) difference-in-difference estimator for the restricted sample. In columns (1) and (2) the dependent variables are an indicator of formal employment and the log of formal wages, respectively. Colunms (3) and (4) use a dummy for employment (formal and informal) and wages from Cadúnico. In column (5) the dependent variable is a dummy that equals one if the individual lives in a different municipality from the one where the cistern is located. Columns (6) and (7) uses the formal employment indicator as dependent variable for sub-samples of household that had and had not children with less than 14 years old one year before the cistern construction. Panel data covers 2012 to 2016.

Online Appendix to "Let the Water Do the Work: Climate Adaptation Policies and Labor Market Outcomes"

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July 26, 2023

A Appendix **2**

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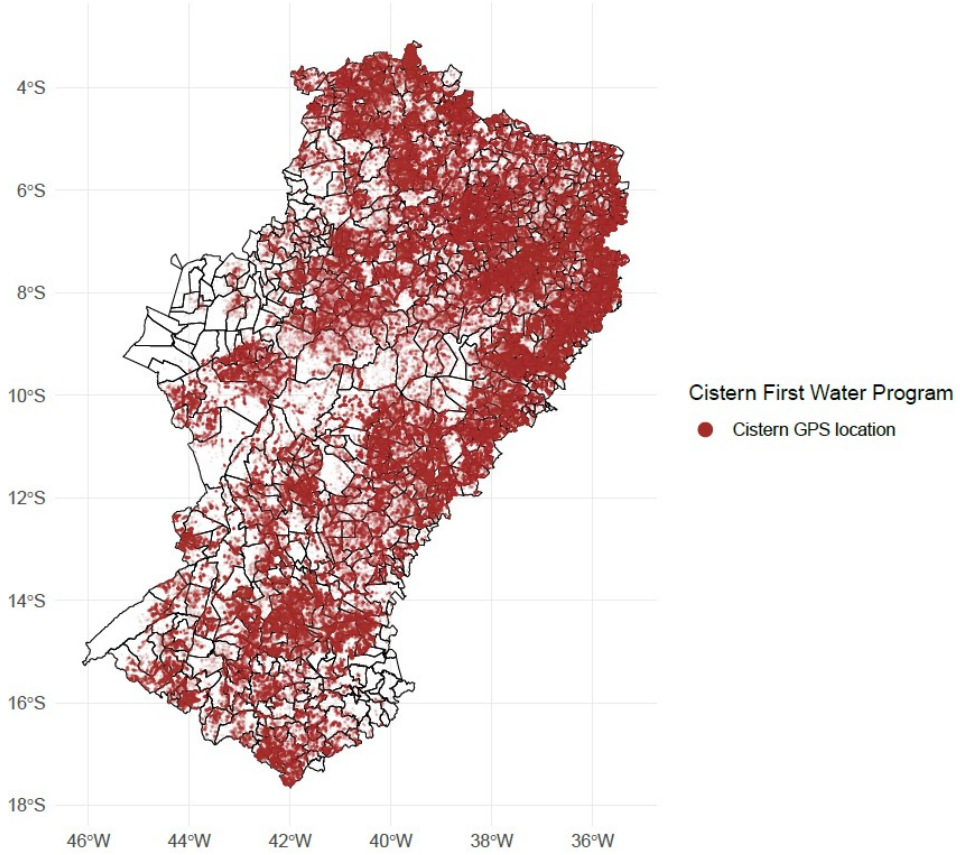
A Appendix

A.1 Cisterns geographical distribution

Figure A.1: Cisterns geographical distribution



Notes. The map shows the spatial distribution of the cisterns in the Brazilian semiarid. The plot uses data on the exact GPS location of the cisterns.

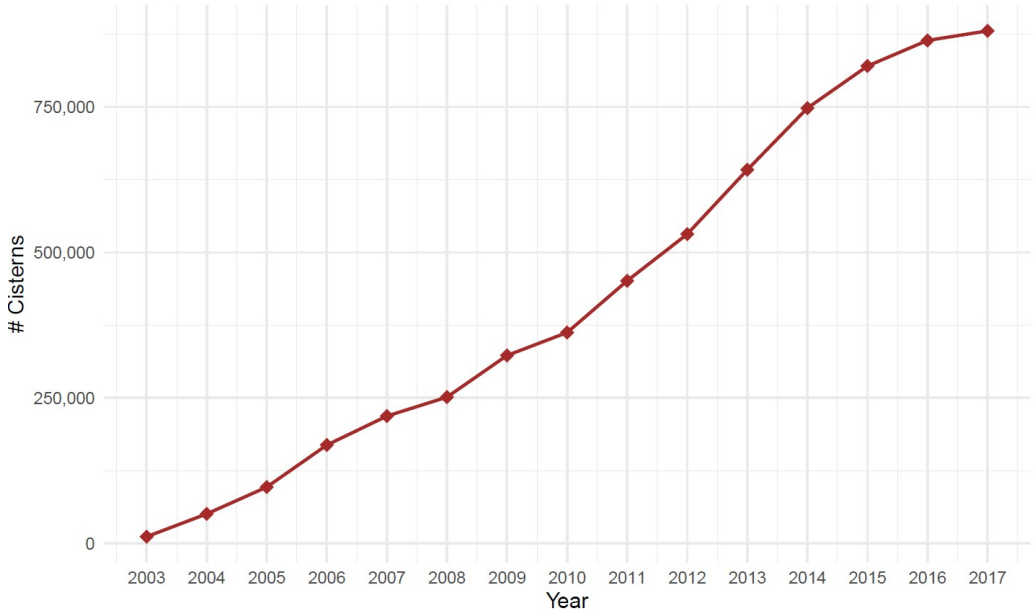
A.2 Cistern in the Brazilian semiarid

Figure A.2: Cistern in the Brazilian semiarid

Note. The picture displays a typical cistern distributed through the Cistern First Water Program.

A.3 First Water Cistern Program expansion over time

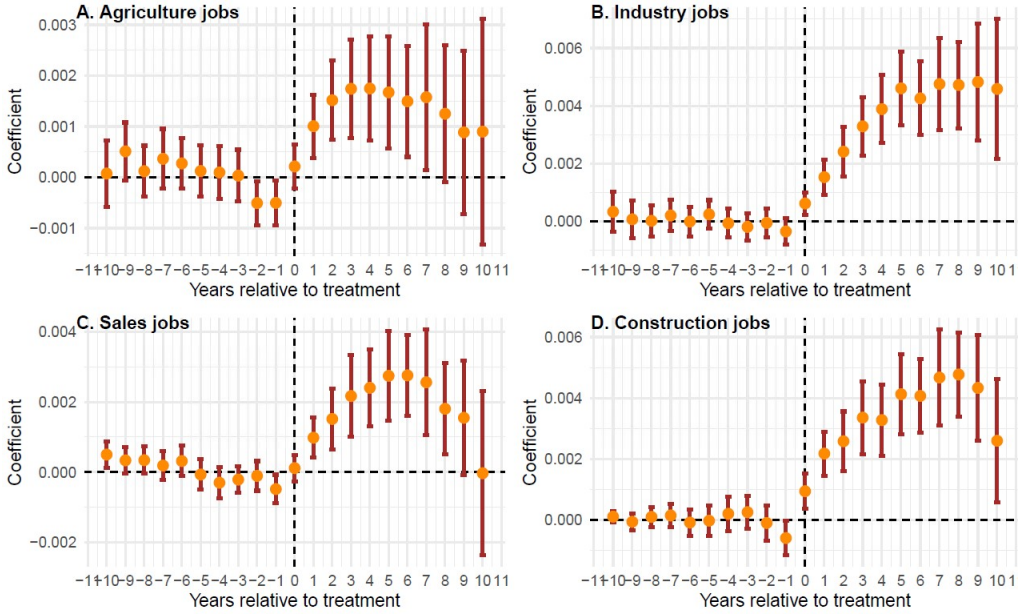
Figure A.3: First Water Cistern Program expansion over time



Notes. This figure plots the cumulative sum of the number of cisterns distributed over the years.

A.4 The effect of receiving a Cistern on formal employment by sector

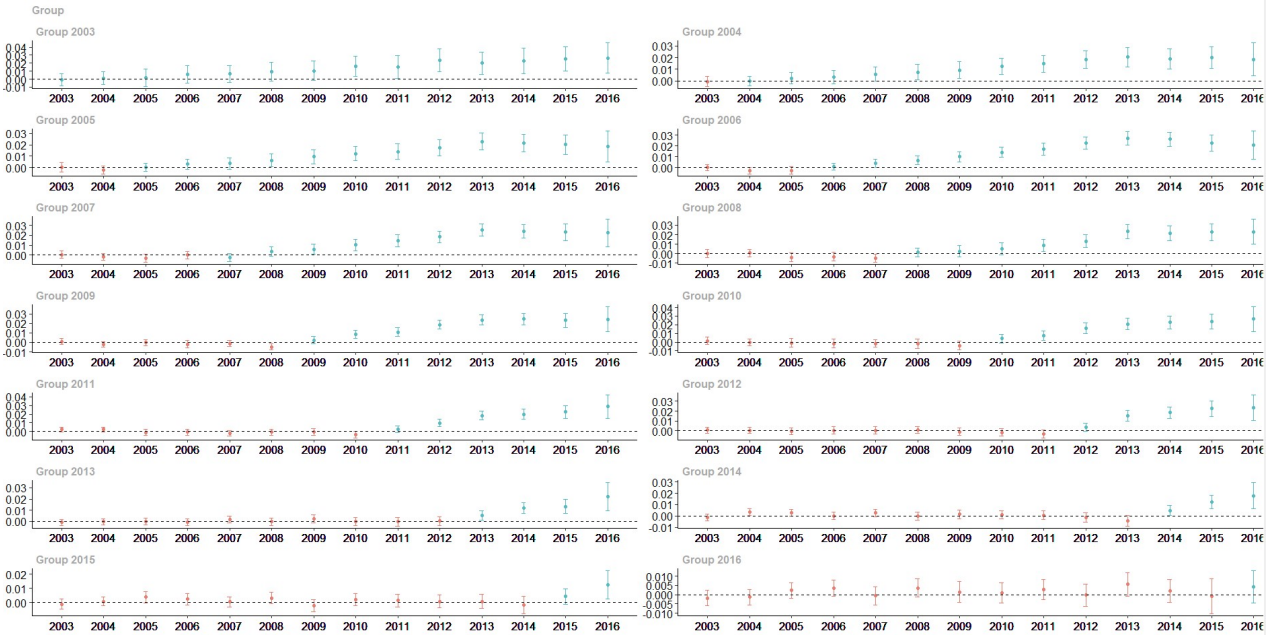
Figure A.4: The effect of receiving a Cistern on formal employment by sector



Notes. This figure presents the event-study estimates using the Callaway and Sant'Anna (2021) estimator with individual-level panel data spanning from 2002 to 2016. The control group consists of individuals who have not yet been treated, as well as those who received the cistern in 2017. In each panel the dependent variable is a dummy that equals one if the individual is employed in the formal sector in a given sector.

A.5 The effect of cisterns on formal employment by treatment date

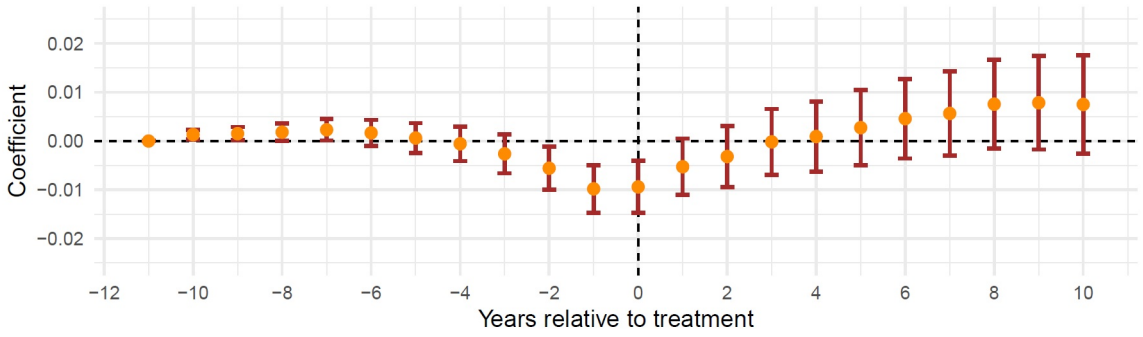
Figure A.5: The effect of cisterns on formal employment by treatment date



Notes. This figure presents the baseline results of the effect of cisterns on formal employment by treatment date using Callaway and Sant'Anna (2021) estimator. Results were obtained using the did package in R.

A.6 The effect of receiving a Cistern on formal employment - Two Way Fixed Effects estimate

Figure A.6: The effect of receiving a Cistern on formal employment - Two Way Fixed Effects estimate



Notes. This figure presents the event-study estimates using the Two-Way Fixed Effects estimator with individual-level panel data spanning from 2002 to 2016. The control group consists of individuals who have not yet been treated, as well as those who received the cistern in 2017. The dependent variable is a dummy that equals one if the individual is employed.