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PROGRAMA DE PÓS-GRADUAÇÃO EM ECONOMIA

Yuri Barreto Cabral de Oliveira

ESSAYS IN DEVELOPMENT ECONOMICS

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YURI BARRETO CABRAL DE OLIVEIRA

A Comissão Examinadora composta pelos professores abaixo, sob a presidência do primeiro, considera o Candidato Yuri Barreto Cabral de Oliveira **APROVADO**.

Recife, 03/08/2023

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O autor
Salvador, Agosto de 2023.

Abstract

This dissertation is related to the Development Economics literature, studying the short and long-run effects of historical events and public policies on several development outcomes. In the first chapter, I show that contemporary differences in domestic labor markets within Brazil trace their origins to female slavery's prevalence more than 120 years ago. I test the hypothesis that the colonial period culture of having enslaved women in the house doing domestic work persisted after slavery abolition until modern days. Consistent with existing hypotheses, leveraging detailed data on slave occupations, I document a positive and robust statistical association between the share of women domestic slaves in 1872 and the contemporary share of female labor force occupied as housemaids. I also show that these results cannot be fully explained by current development, inequality, or human capital accumulation levels and find suggestive evidence that culture may be an important channel of persistence. The second chapter studies the long-term effects of a long-lasting agricultural shock on Brazilian individuals' educational achievement and earnings. I explore the witches' broom outbreak in cocoa farms in the Bahia state in Brazil. I leverage information about people born in municipalities affected and not affected by the disease and explore the difference in educational attainments between cohorts older and younger than eighteen years old at the time of the witches' broom outbreak. The main results show that the witches' broom outbreak negatively impacted the long-term education and earnings of individuals living in affected municipalities. I show evidence that the increase in child labor may drive our results. I discuss that our setting provides a better test of the luxury axiom of child labor theory. The third chapter 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. The 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. The 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.

Keywords: Development Economics, Economic History, Applied Economics

Resumo

Esta tese aborda a questão da Economia do Desenvolvimento, estudando os efeitos de curto e longo prazo de eventos históricos e políticas públicas. O primeiro capítulo mostra que as diferenças contemporâneas nos mercados de trabalho doméstico no Brasil têm suas origens na prevalência da escravidão feminina há mais de 120 anos. O capítulo testa a hipótese de que a cultura do período colonial de ter mulheres escravizadas realizando trabalhos domésticos persistiu após a abolição da escravidão até os dias atuais. De acordo com as hipóteses existentes, utilizando dados detalhados sobre ocupações de escravos, documentamos uma associação estatística positiva e robusta entre a proporção de mulheres escravas domésticas em 1872 e a proporção contemporânea da força de trabalho feminina ocupada como empregadas domésticas. Os resultados não podem ser totalmente explicados pelos níveis atuais de desenvolvimento, desigualdade ou acumulação de capital humano, e existe evidências sugestivas de que a cultura pode ser um canal importante de persistência. O segundo capítulo estuda os efeitos de longo prazo de um choque agrícola duradouro sobre educação e salários de indivíduos afetados. Foi estudado o surto da vassoura-de-bruxa nas fazendas de cacau no estado da Bahia. Foram utilizadas informações sobre pessoas nascidas em municípios afetados e não afetados pela doença observando a diferença nas conquistas educacionais entre as coortes com mais de dezoito anos na época do surto da vassoura-de-bruxa. Os principais resultados mostram que o surto da vassoura-de-bruxa teve um impacto negativo na educação e nos salários de longo prazo das pessoas que viviam em municípios afetados. São apresentadas evidências de que o aumento do trabalho infantil pode ser o motivo por trás desses resultados. O terceiro capítulo utiliza um desenho de pesquisa de diferenças em diferenças para avaliar o impacto de uma política de água no Brasil que distribuiu cisternas para armazenamento de água para famílias pobres em áreas rurais nos resultados do mercado de trabalho. Os resultados mostram que receber uma cisterna teve um impacto positivo na probabilidade de conseguir empregos formais e aumentou os salários dos beneficiários. O efeito foi mais forte para empregos com maiores tempos de deslocamento, indicando que o acesso à água limpa pode ajudar a reduzir o tempo gasto em tarefas diárias e aumentar a participação na força de trabalho. Os resultados fornecem evidências do papel importante que as políticas de água podem desempenhar na redução da pobreza e na promoção do desenvolvimento econômico, especialmente em áreas rurais com acesso limitado à água limpa.

Palavras-chave: Desenvolvimento econômico, História Econômica, Economia Aplicada.

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CHAPTER 1

Women slavery and the roots of domestic labor

1.1 Introduction

Wherever it has been practiced, slavery has left scars that persist to this day. An increasing body of literature documents its enduring effects on modern societies, encompassing issues such as underdevelopment (NUNN, 2008; ACEMOGLU; GARCÍA-JIMENO; ROBINSON, 2012; BERTOCCHI; DIMICO, 2014), political beliefs, and cultural traits (NUNN; WANTCHEKON, 2011; ACHARYA; BLACKWELL; SEN, 2016b). In this paper, we investigate how past exposure to women's domestic slavery can manifest itself into the contemporary female occupations. To accomplish this, we focus on Brazil, a particularly compelling context due to its historical role as the primary destination for slaves exported from Africa during the Transatlantic Slave Trade. Additionally, during the 19th century, domestic slavery accounted for more than a quarter of enslaved women's occupations in the country.

In present times, domestic workers play an indispensable role in Brazilian households, both among the elite and the middle class. In 2013, they accounted for 15.3% of the occupied female labor force (FLF), surpassing the Latin American average of 14.3% (LEXARTZA; CHAVES; CARCEDO, 2016). This percentage is significantly higher than that of African countries (2.5% in 2010) and developed countries (1.3% in 2010) as reported by Luebker, Oelz e Simonovsky (2013). The prevalence of domestic service is so deeply ingrained in Brazilian society that it was considered an "essential activity" during the Covid-19 lockdown in the city of Belém (CNN, 2020). This prominence of domestic work is also reflected in Brazilian architecture, where middle-class homes often include a separate room close to the kitchen designated for domestic workers (LIMA; TOLEDO, 2018). Such a feature has become an attractive characteristic in properties purchased by Brazilians abroad (UOL, 2012; R7, 2018).

This paper aims to explain why domestic work is so relevant in Brazilian society and how it is related to women's slavery. We test the hypothesis that contemporary differences in domestic service labor markets within Brazil trace their origins to female slavery's prevalence more than 120 years ago. This hypothesis finds support in two distinct branches of literature in the fields of history and sociology. In the first branch, scholars such as Algranti (1997) and Cunha (2005) argue that slave societies exhibited a strong bias against manual labor, considering it as unworthy and primarily assigned to slaves. This characteristic was particularly prominent in Brazil, where slavery was widespread across the entire territory, and slaves were commonly employed in

households, even in the simplest ones, to perform all household tasks.[1][2]

In the second branch of literature, the work of Souza (2011, 2017) illustrates how domestic slaves were gradually replaced by freed slaves and free women following the abolition of slavery. Examining the early governmental efforts to regulate domestic services in Rio de Janeiro, Souza (2011) demonstrates that such concerns only emerged towards the end of the slavery era. Regulations were consequently enacted soon after abolition, primarily due to the words of a state council member in 1888, who stated: "Among us, there was never any concern with relation to domestic service; the very clear reason is that only on a small scale did it feel necessary in the regime of slavery." [3] Thus, after slavery's abolition, the demand for domestic services persisted, leading to the substitution of domestic slaves with free women and freed slaves who then took up salaried positions. However, these new working relationships still maintained many similarities to the previous slave labor arrangements, thus necessitating regulation (SOUZA, 2017).

Putting the historical evidence together, the combination of strong prejudice against manual work due to centuries of domestic slavery, a very unequal society, and the demand for re-qualification of domestic service just after the abolition of slavery suggests how Brazilian elites were traditionally dependent on having someone to do their housework. Our hypothesis is that this culture persisted over time and is reflected, nowadays, in the high share of domestic workers over FLF. Moraes Sarmento, a Brazilian congressman in the 19th century synthesize this argument when discussing the resistance of the elites to obey the law that prohibited the slave trade in 1831: "One can't change the state of a country so suddenly. Our habits of three centuries, during which slavery was maintained among us, the country's needs, all that needed more than one simply saying 'slave trafficking is abolished' with no preparation for it."[4] (CHALHOUB, 2012).

To test this hypothesis, we link historical census with modern census data. First, we build a data set at municipality-level based on the Census of 1872. Using this data, we calculated the proportion of the female enslaved population that was engaged in domestic work in 1872 for each municipality and matched these municipalities with the contemporary ones. We match this historical data with the Brazilian Census from 2010 and data on geography characteristics and income of municipalities from other official sources of the Brazilian government. Consistent with our hypothesis, we find that municipality exposure to women's domestic slavery in 1872 is

[1] According to Schwarcz e Gomes (2018), between 1550 and 1860, approximately 4.8 million African slaves arrived in Brazil, accounting for 40% of the 12 million slaves exported from Africa during the Transatlantic Slave Trade. This makes Brazil the principal destination for slaves in the Americas. It is important to note that Brazil was the last country on the continent to abolish slavery, which occurred only in 1888, despite numerous slave revolts that took place long before that date across the entire territory.

[2] For further insights into the roles of *criadas* and *mucamas* (housemaids) in Brazil, refer to works by Lima e Popinigis (2017) and Algranti (1997). Additionally, the works of Koutsoukos (2007) and Quintas (2009) provide detailed accounts of the presence of *amas-de-leite* (women slaves responsible for caring for and even breastfeeding their masters' children) within wealthier Brazilian families during the 19th century.

[3] Freely translated from: "Entre nós, nunca se cogitou de uma tal necessidade, com relação ao serviço doméstico (...) razão muito patente de que só em uma pequenena escala se fazia ela sentir no regime da escravidão." (SOUZA, 2011).

[4] On a free translation of: "Não se muda o estado de um país de um momento para o outro. Os nossos hábitos de três séculos, durante os quais foi mantida a escravidão entre nós, as necessidades do país, tudo enfim pedia que com um rasgo de pena não se dissesse - fica abolido o tráfico - sem que para isso nada se tivesse preparado.".

positively correlated with a share of the FLF occupied in domestic jobs in 2010.

Notwithstanding, it is still possible that omitted variable bias could explain away this correlation. If that is the case, an alternative explanation, for instance, could be that municipalities with lower income or lower human capital in 1872 were also the ones with higher domestic slave share and these characteristics persisted over time, creating a pool of poorer and less educated women that have no choice but to work as housemaids. We pursue several strategies to deal with the possibility of omitted variable bias.

Our first strategy is to use 1872-census data to control for several variables that may be correlated with the prevalence of domestic slaves in 1872 and the share of domestic workers on FLF in 2010, such as population density, literacy rates, an extensive set of geographic variables, such as distance to the coast, climate and soil characteristics. We find that, if anything, controlling for these observable characteristics slightly reduces the estimated effect of domestic women slaves share on the contemporary share of FLF on domestic occupations.

Our second strategy is to perform a falsification exercise using as the main explanatory variable the share of women slaves in different occupations unrelated to domestic services using the 1872 census classification. We found that other slaves occupations don't affect the contemporary share of women in domestic occupations. This exercise strongly suggests that we are indeed measuring the effect of domestic women's slavery prevalence, not just the effect of slavery by itself, or any omitted factor related only to it. In another similar falsification exercise, using the share of women slaves instead of the share of domestic women slaves as the main explanatory variable, we found no statistically significant coefficient, with point estimates being smaller. The same pattern is observed when using the share of total slaves (men and women) instead of our baseline measure of women's domestic slavery, enhancing the reliability of our baseline results.

Our third strategy is meant to deal with the possibility of our results being explained away by omitted variables bias. To do so, following (OSTER, 2019) we calculate, under different assumptions about the true model, how much greater the influence of unobservable factors would need to be, relative to observable factors, to completely explain away the positive relationship between the share of domestic women slaves in 1872 and the share of FLF on domestic occupations in 2010. We find that the influence of unobservable variables would have to be more than five times greater than observable factors to explain away our results, assuming an R^2 for the true model equals to 1.25 times the R^2 of the baseline specification. Therefore, it is unlikely that our estimates can be fully attributed to unobserved heterogeneity. We also use this analysis to estimate bounds to our coefficient of interest under different assumptions of unobservable variable bias.

After establishing a robust statistical association between domestic women slave prevalence in 1872 and the contemporary share of FLF in domestic occupations, we turn to the task of distinguishing between the mechanism behind our results. Our main hypothesis is the persistence of the demand for domestic workers, through the persistence of a prejudice against manual work. On the other hand, supply-side factors like poverty, inequality, and human capital can also be potential channels. If domestic slavery causes poverty and inequality in the long run as found by Acemoglu, García-Jimeno e Robinson (2012) in Colombia and by Bertocchi e Dimico (2014) in the US, the pool of women in low skill occupations should also be higher today in municipalities

with higher slave prevalence in the past, so our findings may represent only the effect of a higher supply of less-educated women and cannot be interpreted as culture persistence.

We address this concern in several ways. First, using 2010's census definitions of occupations, we estimate our baseline regressions and find that women's domestic slavery prevalence does not affect the contemporary share of the female labor force on other low-skill jobs indicating that our results are not driven by the supply-side mechanism. Also, following Acharya, Blackwell e Sen (2016a), we use sequential g-estimation to estimate the effect of domestic women slavery prevalence in 1872 on the contemporary share of FLF on domestic occupations net the effect of possible mediators. We find that our results hold even after accounting for the effect of contemporary GDP per capita, inequality, human development index, literacy rates, high school completion rates, and urbanization.

Finally, we also found suggestive evidence that culture can be an important mechanism behind our results. We explore data from the Discriminatory Actions in the School Survey - a project of the Ministry of Education that aims to measure discriminatory beliefs among the school community (parents, employees, students, teachers, and principals) of different municipalities - and found that historical exposure to women's domestic slavery correlates with discriminatory beliefs relating manual and domestic work to black women and black people in general.

This paper complements studies on the long-run effects of forced labor on institutions and political preferences within countries (DELL, 2010; SUMMERHILL, 2010; ACEMOGLU; GARCÍA-JIMENO; ROBINSON, 2012; BERTOCCHI; DIMICO, 2014; ACHARYA; BLACKWELL; SEN, 2016b) finding novel evidence that slavery can have lasting effects on the shape of labor markets. Our work is also related with previous cross-countries studies on the effects of slave trade (NUNN, 2008; NUNN; WANTCHEKON, 2011; SOARES; ASSUNÇÃO; GOULART, 2012; GERSHMAN, 2020) and with previous works on historical shocks and cultural persistence (VOIGTLÄNDER; VOTH, 2012; GUISO; SAPIENZA; ZINGALES, 2016). This work also contributes to the literature on the effects of historical shocks and culture on women's insertion in the labor market as Fernandez (2007), Alesina, Giuliano e Nunn (2013) and Teso (2019), focusing not on female labor force participation, but rather on the quality of this participation.

The paper proceeds as follows. In Section 1.2 we present a historical background on the development of domestic slavery in Brazil. Section 1.3 present our data. In Section 1.4 we detail our empirical strategy, identification challenges, and discuss our baseline estimates. In Section 1.5 we discuss identification issues and present results from a number of falsification and robustness exercises. In Section 1.6 we present an extensive discussion on the mechanisms. Section 1.7 concludes by summarizing our findings.

1.2 Historical Background: Domestic Slavery in Brazil

Any European traveler who visited Brazil in the 19th century became astonished with the number of slaves in the country, especially the ones responsible to do the housework. Souza (2017) described two remarkable examples of these surprised visitors. The first one was the German writer Ina von Bizen reporting her travel to Rio de Janeiro in 1880 pointed out that "All domestic

service are done by black people: it's a black coachman who leads us, a black woman who serves us, by the stove the cook is black, and the woman slave breastfeeds the white child". The second one was the French physician Louis Couty who came to Brazil to became a university professor in Rio de Janeiro in 1874 and wrote "The abundance of servants is one of the most remarkable characteristics of a rich Brazilian family. In a situation where a European would have four slaves, its neighbor country would have six or even more". The French painter Jean Baptiste Debret, who came to Brazil on the Artistic French Mission in the 19th-century, also illustrated this aspect of Brazilian society in many of his works.[5] In Figure 1.1 Debret painted a typical rich family in the 19th century at dinner surrounded by domestic slaves.

By the time of the German writer and the French painter's visits, the country counted with more than 1.5 million slaves and 283 thousand domestic slaves, 18% of the total, according to the 1872 Brazilian census. The majority of domestic slaves were women captives (66%) and domestic service was the second more common occupation among women slaves (26.5% of women captives) behind only to farm-work (29%). These women were responsible to do all housework activities like cook, clean, laundry, nanny, and even breastfeed the children of their masters (KOUTSOUKOS, 2007). Even the smaller and more simple houses counted with slaves to do their housework which was common in both rural and urbanized areas (ALGRANTI, 1997; SOUZA, 2017). Naturally, due to the perversity of the system of slavery, these women were also susceptible to all kinds of abuse by their masters, including violence and rape (FREYRE, 1986; SOUZA, 2017).

The high prevalence of slaves and domestic slaves created in the subjective imaginary of Brazilian society a crescent prejudice against manual work, since all this kind of work was done almost exclusively by slaves and, therefore, were seen as unworthy activities. As pointed out by Cunha (2005):

> *"In a society in which manual labor was destined for slaves, this characteristic 'contaminated' all the activities that were destined for them, those that required physical effort or the use of hands. Free men moved away from manual labor to leave no doubt about their own condition, striving to eliminate ambiguities of social classification."*

The stigmatization of manual and domestic labor, a result of centuries of slavery, led to high demand for domestic slaves in the second half of the 19th century. This was also confirmed by the high number of newspaper advertisements for the purchase and sale of domestic slaves most of which were about selling and buying domestic slaves (FREYRE, 2015). Analyzing a sample of 2,496 advertisements between the years of 1850 and 1870, in the *Jornal do Commercio*, one of the biggest newspapers in the city of Rio de Janeiro, Souza (2017) found that roughly 72% of ads were with respect of sale and purchase of domestic slaves, highlighting the high demand and supply for the service. Figure A.3 in the Online Appendix shows examples of one advertisement for purchase and another for sale of women domestic slaves in a newspaper from the city of Recife in the 19th century extracted by (FREYRE, 2015).

The late abolition of slavery in 1888 didn't change the demand for domestic services, but rather altered the supply which was gradually substituted by free workers, especially women.

[5] More on the painter's visit can be found on Lima (2004).

Figure 1.1: Brazillian familly on 19th century being served by slaves.

Notes. Jean-Baptiste Debret. 1839.

Therefore, given no other option, the Council of State quickly started efforts to regulate the domestic service. As well documented by Souza (2011), the timing was no coincidence. The City Councilor, viscount of São Luiz do Maranhão, words in 1889 made clear how the need for regulation was now held in high regard: "The service that is intended to be regulated is one of those that demand the greatest attention from public authorities because it is directly or intimately linked to peace, tranquility and the well-being of families, the basis of all social organization".[6] According to the councilor, the regulation, therefore, were necessary "thanks to the extinction of the servile element".

Naturally, due to the huge difference in political power, the regulation proposed by that time was totally in favor of the employers at the expense of the freed workers. Souza (2011) highlights the reaction of the city councilor José do Patrocínio, a member of the abolitionist movement, in a session of the City Council, about the project of regulation of domestic service, classifying the project as "a new law of disguised slavery". The direct association made by the abolitionist councilor about the new regulation project and slavery made clear how the efforts of Brazilian elites to create the regulation was an attempt to reconcile the end of slavery with the maintenance of old habits and exploitation practices. Therefore, gradually, the domestic slaves were replaced by free women, and the relationship of master and servant became one of employer and employee but preserving many similarities with the previous one.

1.3 Data

Our main explanatory variable is the proportion of women domestic slaves (WDS) over total population - as a proxy for domestic slavery prevalence - measured by the Brazilian Census of 1872. Digitalized on an effort of Paiva et al. (2012), the census of 1872 is the first census of the Brazilian population. Thus, despite the existence of other measures of slave population

[6] On a free translation of the excerpt of the councilor report available in Souza (2011).

Figure 1.2: An old institution: Past and Present

(a) Employee walking with his family. Jean-Baptiste Debret. 1839.

(b) White middle class brazilian family going to protest against pres. Dilma Rousseff with their nanny, 2016.

from previous periods, the 1872-census provides the most reliable historical data on slavery prevalence and has the unique feature of cover all Brazilian territory. This historical census data consists of several tables at municipality-level with demographic and socioeconomic information - Figure A.1 on the appendix shows an example of original tables digitalized by Paiva et al. (2012). These tables not only divides the population into slaves and non-slaves but also by gender and type of occupation, making us able to calculate the share of women slaves working on domestic services over the total population in all municipalities as follows:

$$WDS_m = \frac{WDS\ Pop\ 1872_m}{Pop\ 1872_m} \tag{1.1}$$

Where $Pop\ 1872_m$ is the total population in municipality m in 1872, and $WDS\ Pop\ 1872_m$ is the total number of women domestic slaves in municipality m in 1872. Using 1872 census data, it was also possible to measure different socioeconomic and demographic characteristics of municipalities in that period, like the share of literate population, share of foreigners, share of women and share of black population, that we use as control variables in further analysis. We present summary statistics from all these variables on Table A.1 in the Appendix. A more detailed discussion on all control variables is available in the Appendix.

Brazilian municipality boundaries changed significantly over time. From 1872 to 2010 some new municipalities were created, resulting from the union or dissolution of previous ones, and also on the expansion of territory, as the case of the state of Acre, annexed to Brazil in 1903. To match the municipalities of 1872 with contemporary ones, we use the work of IBGE (2011) which traces the origins from all Brazilian municipalities presented in all censuses. We were able to match 615 municipalities that existed in 1872 and 2010. Because state capitals are, in general, outliers in terms of slave prevalence, we drop all of them from our sample, leaving 597 municipalities in the final sample. Further in the Appendix, we show that our results are robust to the inclusion of state capitals in the main sample. Our main source of contemporary data is the Brazilian 2010's Census. We use the definitions of occupations in the census to calculate the

share of female labor force (FLF) working on domestic services by municipality.[7]

Using the 1872 municipalities boundaries shapefiles made available by IBGE (2011), we calculated the area and the distance from the centroid of each municipality to the Brazilian coast. We also have data on rainfall and sunshine from the National Institute of Geology (INGEO), 10 dummy variables for the presence of predominant soil types from the Brazilian Agricultural Research Institute (EMBRAPA), and altitude reported in the "Cadastro de cidades e vilas" published by the Brazilian Census Bureau in 1998.

Figure 1.3 show some descriptive evidence on the relationship of WDS in the 19th century with the share of FLF on domestic occupations in 2010. Using 1872 municipalities boundaries, the map shows the spatial distribution of these two variables. The maps strongly suggest that the cities with a high share of women domestic slaves in 1872 are also the ones with the higher share of the female labor force on domestic occupations. The bivariate relationship depicted above is also illustrated on the binscatterplot in Figure 1.4. The figure shows clearly that the proportion of women domestic slaves in 1872 is positively related to the share of FLF on domestic occupations in 2010. In the Online Appendix, Figure A.4 show that this relationship also holds using different waves of Brazilian census data.

1.4 Baseline WLS Estimates

Having linked historical data with the Brazilian Census from 2010, constructed cross-section data with 597 Brazilian municipalities, and showed the unconditional relationship between women's domestic slavery and the contemporary share of FLF on domestic occupations, we turn our attention to investigate the robustness of this correlation. Our first step is to estimate the following baseline weighted least squares regression (WLS), weighted by within-municipality sample sizes:

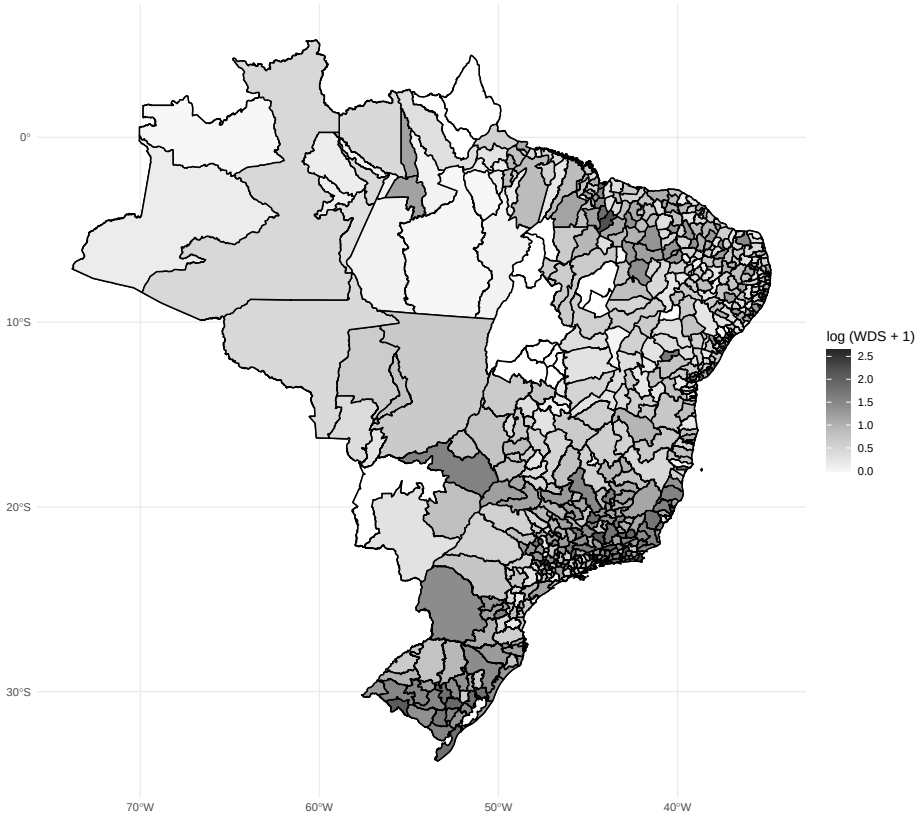
$$Y_m^{2010} = \alpha + \beta\, WDS_m^{1872} + \Gamma X_m^{1872} + \lambda Z_m + \Lambda_s + \varepsilon_m \tag{1.2}$$

Where Y_m^{2010} is the share of the female labor force on municipality m that works on domestic occupations, Λ_s is a set of state fixed effect and ε_m is the error term. Our main explanatory variable WDS_m^{1872} is the share of women domestic slaves over the total population in 1872. Z_m is a vector of geographic variables at municipality-level that includes latitude, longitude, distance to the coast, sunshine incidence, rainfall, altitude, and 10 dummy variables for the presence of different types of predominant soils. X_m^{1872} is a vector of historical controls at the municipality level. X_m^{1872} includes the population density (as a proxy for economic development in 1872), the shares of the literate population, women, foreigners, and also the shares of manufacturing, commerce, agriculture, public administration, and legal professions employment in 1872.

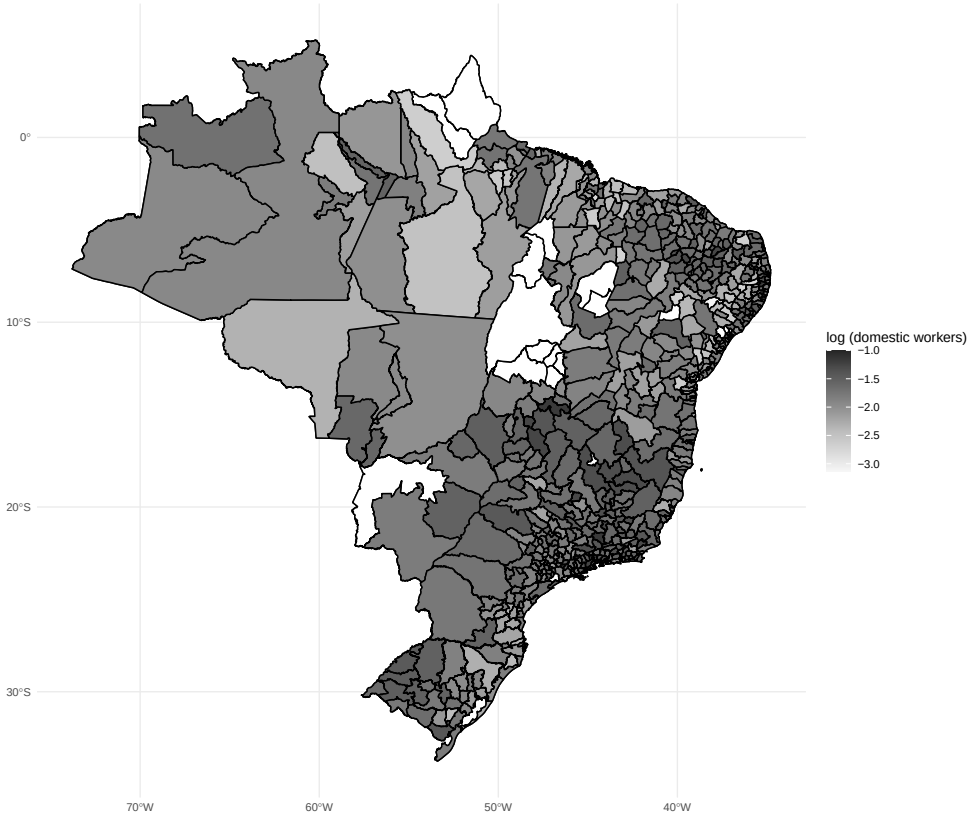
Table 1.1 shows estimates for different specifications of Equation 1.2 controlling for geography, 1872 covariates, state fixed-effects and also different combinations of these controls. The first column of Table 1.1 presents the unconditional relationship between women's domestic slavery and the contemporary share of housemaids over the FLF. In column (2) we include a

[7]We define the FLF as occupied women between 15 and 65 years old.

Figure 1.3: WDS and Domestic Occupations in Brazil - 1872 and 2010



(a) 1872



(b) 2010

Figure 1.4: Binscatterplot: Historical exposure to women domestic slavery and contemporary share of domestic workers in Brazilian municipalities.

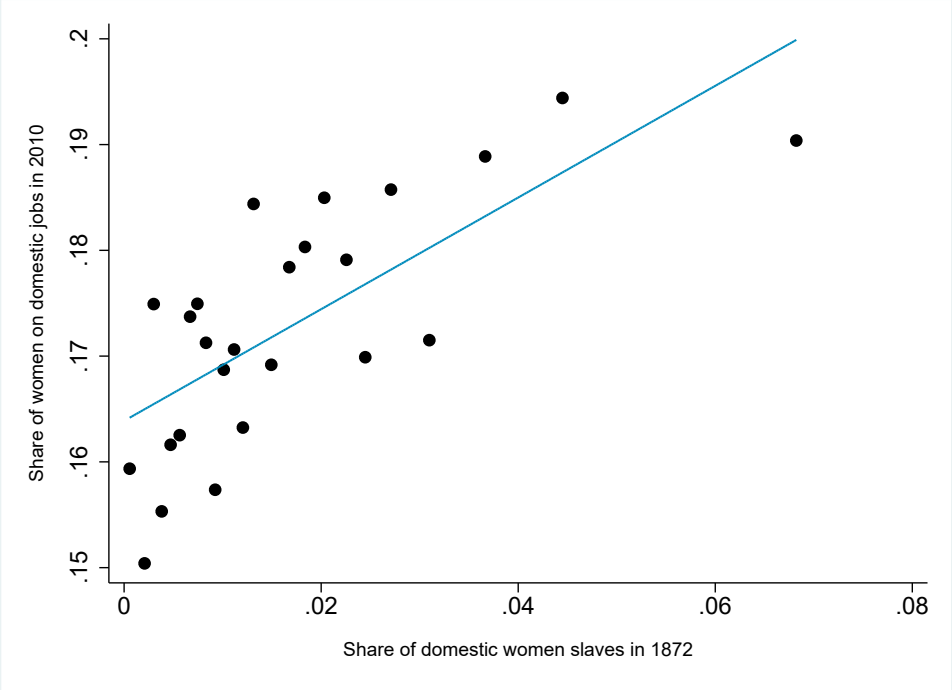


Table 1.1: The Long-run effect of women slavery on the share of women on domestic occupations in 2010: Baseline WLS estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
WDS	0.432***	0.448***	0.225*	0.306***	0.414***	0.354***	0.332***
	(0.136)	(0.137)	(0.127)	(0.110)	(0.118)	(0.105)	(0.103)
Observations	597	597	597	597	597	597	597
R-squared	0.031	0.167	0.239	0.338	0.093	0.218	0.365
Geography		✓		✓		✓	✓
State FE			✓	✓			✓
1872 Covariates					✓	✓	✓

Notes: [a] This table presents results from the estimation of equation 1.2. The sample is composed by contemporary municipalities presented in 2010 Brazilian Census and matched from 1872 Census according to IBGE (2011). Robust standard errors in brackets. [b] *** p<0.01, ** p<0.05, * p<0.1

set of geographic variables as controls. In columns (3) and (5) we separately control for state fixed-effects and 1872 covariates. Finally, our preferred specification, presented in column (7), controls for state fixed-effects, geography, and 1872 covariates. As we move from column (1) to column (7) the coefficient of women's domestic slavery prevalence remains positive and statistically significant. Furthermore, the R-squared of our regression significantly increases when including controls (from 0.03 to 0.36) while having only small changes in the coefficient magnitude. Unweighted estimates presented in Table A.3 in the Appendix found qualitatively identical results.

The estimates in Table 1.1 confirms the unconditional relationship between women's domestic slavery prevalence in 1872 and the share of FLF working on domestic occupations in 2010 presented in the previous section. Even after controlling for state fixed effects, geographic, and historical variables, the coefficient of women's domestic slavery prevalence remains statistically significant. Estimating the standardized beta coefficient of this regression, we can have a better picture of the magnitudes of this effect. On our preferred specification, we find that one standard deviation increase in the share of women domestic slaves is associated with an increase of 10% of standard deviation on the share of FLF working on domestic occupations in 2010, which corresponds to a 2.9% increase in the mean of the dependent variable. This effect is close to other estimates of the impact of historical events on the labor market outcomes as the work of Teso (2019), who found that women in Africa whose ancestors were exposed to slave trade have 4.5%, relative to the mean, higher chance to be on the labor force.

To check if this correlation holds over time we pooled Brazilian census data from different years (1970, 1980, 1991, 2000, and 2010) constructing a panel data set measuring the share of female labor force occupied as housemaids in all 597 municipalities of our main sample by census year. We pooled all censuses with detailed information on female occupations.[8] We then estimate the following regression:

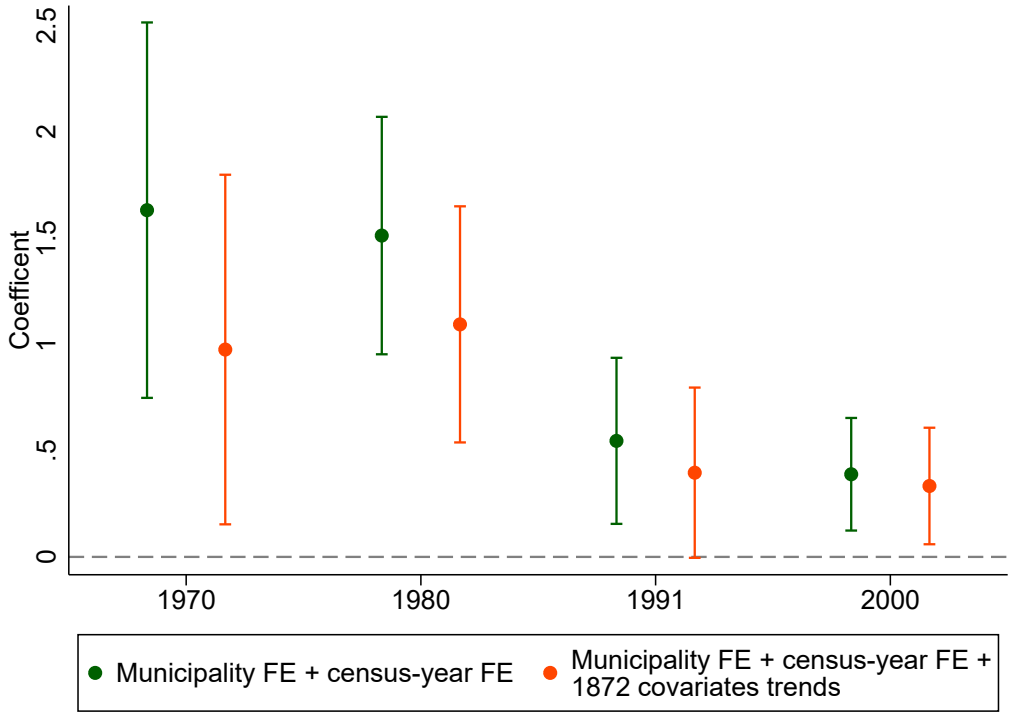
$$\begin{aligned} Y_{mt} = \sum_{t=1970}^{2010} \beta_t \, WDS_m \, 1\left[t = 1970, ..., 2000\right] \\ + \sum_{t=1970}^{2000} \Gamma_t X_m \, 1\left[t = 1970, ..., 2000\right] + \alpha_m + \theta_t + v_{mt} \end{aligned} \tag{1.3}$$

Where Y_{mt} is the share of FLF occupied as housemaids in municipality m in census-year t. The coefficients of interests are β_t which measure the correlation of WDS and the share of FLF working as housemaids compared with this correlation in 2010. We control for trends on 1872 covariates, interacting them with census-year dummies. α_m control for municipality fixed-effects and θ_t for census-year fixed effects. v_{mt} is an error term clustered at the municipality level. Figure 1.5 plot all β_t coefficients from equation 1.3.

The pattern of results in Figure 1.5 shows that the relationship estimated in Table 1.1 holds over time. Results are similar in both specifications controlling and not controlling for 1872 covariates trends. Also, the pattern observed in Figure 1.5 suggests a persistence effect, i.e., the

[8] Despite having available microdata, is impossible to identify domestic occupations in the 1960's census due to the nonexistence of this category in the occupation variable.

Figure 1.5: The effect of slavery on the share of women working as housemaids over time



correlation between WDS and the prevalence of women in domestic occupations is stronger in years more closely to 1872. Putting all the pieces of evidence together, our results show that even controlling for state fixed effects, and an extensive set of geographic, and historical covariates, we found a positive, persistent, robust, and statistically significant correlation between the 1872 women domestic slavery prevalence and the contemporary share of the female labor force working in domestic occupations. In the next section, we perform several falsification exercises and pursue strategies to deal with omitted variable bias.

1.5 Robustness checks

1.5.1 Falsification exercises

An important concern relative to our results is that we could just be capturing the effect of slavery by itself and not only the effect of female domestic slavery, since female domestic slavery may be correlated with total slavery prevalence. In that sense, we perform a falsification exercise using other slave occupations as our main explanatory variables. If our results reflect omitted factors related to total slavery, we should expect that other female slave occupations also correlate with the contemporary share of FLF working as housemaids. We restricted our occupation measures to the other three main female slave occupations observed in the 1872-census: farms, sewing, and fabrics. We also use the prevalence of female slaves in all other occupations except domestic

Table 1.2: Falsification test: Other forms of women slavery and contemporary share of domestic workers

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
WDS	0.225*	0.332***								
	(0.127)	(0.103)								
Farms			-0.0524	0.00244						
			(0.0993)	(0.0879)						
Sewing					-0.128	-0.211				
					(0.478)	(0.424)				
Fabrics							-0.319	-0.234		
							(0.826)	(0.813)		
All other									-0.0428	-0.0135
									(0.0631)	(0.0618)
Observations	597	597	597	597	597	597	597	597	597	597
R-squared	0.239	0.365	0.233	0.353	0.232	0.354	0.232	0.353	0.233	0.353
State FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Geography		✓		✓		✓		✓		✓
1872 Covariates		✓		✓		✓		✓		✓

Notes: [a] This table presents results from the estimation of equation 1.2 using alternative measures of women slavery. The sample is composed by contemporary municipalities presented in 2010 Brazilian Census and matched from 1872 Census according to IBGE (2011). Robust standard errors in brackets. [b] *** p<0.01, ** p<0.05, * p<0.1, + p<0.105

services.

In Table 1.2 we present results from this falsification exercise. Odd columns control only for state fixed-effects, while even columns show our baseline specification, controlling for geography, 1872 covariates, and state fixed-effects. In columns (3) and (4) of Table 1.2 we estimate the effect o female farmer slaves prevalence in 1872 on the contemporary share of FLF in domestic jobs in Brazilian municipalities. Coefficients from these estimates are not statistically different from zero on conventional confidence levels and are very sensitive to the inclusion of controls, even changing signals. This pattern is also observed on the other columns that use the share of seamstress slaves and the share of female slaves working with fabrics as main explanatory variables. Finally, there is no clear relationship between the share of female non-domestic slaves and the share of FLF working as housemaids. Putting all together, the noisy zero results in Table 1.2 reinforce the robustness of our baseline estimates and strongly suggests that we are not just capturing the effect of total slavery or any omitted factors related to it. In Table A.5 in the Appendix, we also show that the coefficient associated with WDS is statistically identical to our baseline estimate if we use these other occupations as controls, instead of using them as the main explanatory variable, as in Table 1.2.

In the same spirit of the falsification exercise in Table 1.2, in Table 1.3 we shown results from another falsification test with a similar approach, using as explanatory variable the share of women slaves and the share of slaves (men and women) over total population, making no distinction regarding slaves occupations. Is important to note here that the share of domestic slaves is contained in all the other two measures used as explanatory variables in Table 1.3.

Table 1.3: Alternative measures of Slavery

	(1)	(2)	(3)	(4)	(5)	(6)
WDS [Std.]	0.140***	0.107***				
	(0.0439)	(0.0333)				
Women Slavery [Std.]			0.133***	0.0533		
			(0.0504)	(0.0457)		
Total Slavery [Std.]					0.110**	0.0405
					(0.0508)	(0.0456)
Observations	597	597	597	597	597	597
R-squared	0.031	0.365	0.026	0.355	0.019	0.354
State FE		✓		✓		✓
Geography		✓		✓		✓
1872 Covariates		✓		✓		✓

Notes: [a] This table presents results from the estimation of standarized regressions of the baseline specification in equation 1.2. The sample is composed by contemporary municipalities presented in 2010 Brazilian Census and matched from 1872 Census according to IBGE (2011). Robust standard errors in brackets. [b] *** p<0.01, ** p<0.05, * p<0.1, + p<0.105

Hence, even if the baseline results were not driven by omitted factors related to other types of slavery, as suggests the results in Table 1.2, is still possible to found significant estimates using these alternative measures of slavery.

To allow direct comparisons between coefficients, all results in Table 1.3 come from standardized regressions. In the odd columns, unconditional regressions show that estimates are statistically identical using the two other broad measures of slavery. On the other hand, results displayed in even columns, where we control for state fixed-effects, geography, and 1872 covariates, are only statistically significant for the specification using women's domestic slavery prevalence as the main explanatory variable. These results, together with estimates in Table 1.2, strongly suggest that our main results are reflecting only the relationship between domestic slavery and contemporary domestic occupations, reducing concerns about omitted factors related to other types of slavery.

1.5.2 Selection on unobservables

Although our results remain robust to the inclusion of a huge set of controls, state fixed effects, and a number of falsification exercises, it might still be the case that there is some unobservable factor correlated with both the share of women domestic slaves and the share of contemporary FLF in domestic occupations that could bias our estimates. Therefore, we use the analysis proposed by Oster (2019) to do both calculate bounds to our estimated effect and assess the likelihood that our estimates were completely explained away by selection on unobservable factors. Table 1.4 show results from this analysis.

In the first panel of Table 1.4 we estimate the necessary value of the linear relationship between bias on observables and bias on unobservables δ for which the effect of the share

Table 1.4: Oster (2019): Assessing unobservables selection

	Values of R^{max}			
	$R^{max} = 2\tilde{R}$	$R^{max} = 1.5\tilde{R}$	$R^{max} = 1.25\tilde{R}$	$R^{max} = 1.1\tilde{R}$
	(1)	(2)	(3)	(4)
Estimated δ when $\beta = 0$	1.486	2.901	5.539	12.194
	Values of R^{max}			
	$R^{max} = 2\tilde{R}$	$R^{max} = 1.5\tilde{R}$	$R^{max} = 1.25\tilde{R}$	$R^{max} = 1.1\tilde{R}$
	(5)	(6)	(7)	(8)
Unbiased coefficient when $\delta = 1$	0.149	0.254	0.296	0.318
Baseline estimate	0.332	0.332	0.332	0.332

Notes: This table present results from Oster (2019) analysis of unobservable selection bias. Here, δ measures the degree of proportionality between selection in observables and unobservables variables. In columns (1) to (4) I present results of the estimated necessary value of δ for which the effect of the share of domestic women slaves in 1872 on the share of contemporary domestic workers (β) would be equal to zero. In columns (5) to (8), I present the estimated unbiased coefficient (β), assuming different values for R^{max}. All results where estimated using Stata *psacalc* command.

of WDS in 1872 on the share of contemporary domestic workers (β) would be equal to zero. For instance, if $\delta = 2$, the bias on unobservables should be twice stronger than the bias on observables to explain away baseline results. Each column assumes a different value of R_{max}, where R_{max} is the R-squared of a regression that would include all unobservable variables. Results for estimates of δ are all higher than the cutoff suggested by Altonji, Elder e Taber (2005) and Oster (2019) of $\delta = 1$ even assuming the conservative value of $R_{max} = 2\tilde{R}$, where $\tilde{R}$ equals the R-squared of our baseline specification. We found that to explain away our baseline results, the bias on unobservables should be 1.5 to 12 times stronger than the bias on observables which is arguably unlikely.

Finally, on the second panel of Table 1.4, following Oster (2019) we calculate bounds to our estimates under different assumptions about the R_{max}, the R^2 of the true model. The bias-adjusted coefficient β estimated under these different assumptions are all positive and greater than zero. In our more conservative estimate, assuming that the true model explains twice the variation on our outcome relative to our baseline model, and that $\delta = 1$, the true effect estimated is 0.149 which is 45% of our baseline estimate. In the more optimistic scenario, where the $R^{max} = 1.1\tilde{R}$, our true effect should be equal to 0.318, 95% of the baseline estimate. All these results reinforce that is pretty much unlikely that our results are driven by omitted variable bias.

1.6 Mechanisms

Having established a robust statistical association between the intensity of women's domestic slavery in 1872 and the contemporary share of the female labor force in domestic occupations,

we turn our attention to discuss some mechanisms that could explain this result. Our main discussion emphasizes two important channels of causality: demand and supply. From the demand side, the mechanism is the culture, represented by a strong prejudice against manual work that emerged in the slave society and marked the foundation of the country persisting until modern days and generating a high demand for domestic services.

The supply-side channel is mostly related to underdevelopment. As argued by Acemoglu, García-Jimeno e Robinson (2012) and Bertocchi e Dimico (2014), slavery is strongly related to poverty and inequality. Therefore, the lack of opportunities on the labor market for recently freed women, generating a persistence of poverty, inequality, and underdevelopment through generations, could have resulted in a higher pool of women in general low-skill occupations today. The rest of this section tries to disentangle between these mechanisms.

1.6.1 Other low-skill occupations

To assess if our results are driven by the supply side, in Table 1.5, using the 2010's Census definitions of occupations, we look to the effect of women's domestic slavery on the share of FLF in other low-skill jobs. If our results are explained by the persistence of a higher pool of less-educated women in cities where domestic slavery was more prevalent, we should expect a significant and positive statistical association between our historical measure of domestic slavery and the share of FLF working in other low-skilled occupations in 2010. On the other hand, if the main mechanism behind our results is the persistence of prejudice against manual and domestic work, i.e., the demand side, we should expect a zero or negative effect of domestic slavery on some other low-skill occupations meaning that the higher share of domestic workers reflects just the reallocation of less-educated women to domestic service.

Results in Table 1.5 are consistent with a demand-side explanation. Among all low-skilled occupations used as dependent variables in this exercise, none are statistically significant. The non-significant results indicate that our main results are not driven by a persistent higher pool of less-skilled women in the labor market, ruling out the supply side mechanism. Another important concern that may arise is if, for some reason, women's domestic slavery led to more female labor force participation in general. In this case, our estimates could only reflect the fact that there are more women in the labor market rather than the persistence of the domestic service. To check for this, in column (10) of Table 1.5 we report results using the share of women aged between 15 and 65 years old in the municipality that are on the labor market (formal or informal sector) by the time of the census interview as the dependent variable. Results show that there is no clear statistical association between the share of WDS in 1872 and the contemporary female labor force participation in Brazilian municipalities. Overall, the estimate in column (10) of Table 1.5 suggests that the prevalence of women's domestic slavery is not related to the participation or not of women in the labor market, but rather on the quality of this participation.

1.6.2 Domestic Slavery and Development

To test if our results are driven by differences in contemporary development indicators between cities with high and low women domestic slavery in the past, in Table 1.6 we present results for our main specification controlling for contemporary measures of inequality, the log of GDP per

Table 1.5: The long run effect of women domestic slavery on other female occupations

	(1) **parcel delivery**	(2) **garbage collector**	(3) **informal sales women**	(4) **saleslady**	(5) **street food seller**
WDS	-0.0152	-0.00871	-0.0151	0.0685	0.00847
	(0.0129)	(0.00735)	(0.0174)	(0.0452)	(0.00558)
Observations	597	597	597	597	597
R-squared	0.200	0.163	0.397	0.309	0.344
	(6) **cashier**	(7) **hairdresser**	(8) **cooker**	(9) **telephonist**	(10) **FLFP**
WDS	0.0323	0.0387	0.0286	-0.0206	-0.00858
	(0.0200)	(0.0295)	(0.0268)	(0.0370)	(0.186)
Observations	597	597	597	597	597
R-squared	0.353	0.443	0.303	0.332	0.687
Effect on domestic occupations			0.332***		
			(0.103)		
State FE	✓	✓	✓	✓	✓
Geography	✓	✓	✓	✓	✓
1872 Covariates	✓	✓	✓	✓	✓

Notes: [a] This table presents results from the estimation of equation 1.2 using different occupations as dependent variables. [b] *** p<0.01, ** p<0.05, * p<0.1

Table 1.6: Slavery and domestic occupations: Controlling for possible mediators

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
WDS	0.364***	0.385***	0.354***	0.330***	0.297***	0.353***	0.338***	0.229**
	(0.104)	(0.0948)	(0.104)	(0.109)	(0.0982)	(0.104)	(0.109)	(0.0988)
Gini Index	0.0656							0.194***
	(0.0516)							(0.0511)
Per capita GDP		-0.0124***						-0.0161***
		(0.00371)						(0.00403)
HDI			-0.0120					0.351***
			(0.0468)					(0.133)
Literacy				0.0787**				0.0826
				(0.0376)				(0.0748)
College					-0.258***			-0.639***
					(0.0795)			(0.113)
High School						-0.0132		-0.233**
						(0.0463)		(0.0952)
Urbanization							0.0370***	0.0679***
							(0.0136)	(0.0200)
Observations	597	597	597	597	597	597	597	597
R-squared	0.222	0.241	0.218	0.225	0.245	0.218	0.232	0.356
Geography	✓	✓	✓	✓	✓	✓	✓	✓
State FE	✓	✓	✓	✓	✓	✓	✓	✓
1872 Covariates	✓	✓	✓	✓	✓	✓	✓	✓

Notes: [a] Effects of women domestic slavery on the contemporary share of women domestic workers controlling for possible contemporary channels. [b] *** p<0.01, ** p<0.05, * p<0.1

capita, the Human Development Index, different measures of human capital, and urbanization. Each column of Table 1.6 controls for one of that indexes and column (8) controls for all of them together. The coefficient of WDS is quite stable and significant in all columns. Also, the results are statistically identical to our baseline specification. Therefore, the results suggest that the influence of these development dimensions in our baseline estimates is, if anything, limited.

In Table 1.6, we show that our results are robust to the inclusion of contemporary controls that could be potential mediators of our main estimates. However, Acharya, Blackwell e Sen (2016a) points out that the inclusion of potential mediators as control variables could lead to bias due to bad controlling and propose a method to check if potential mediators could explain away regression results. We follow this procedure and implement sequential g-estimation testing for potential mediators. Table 1.7 shows the results of this test.

The test in Table 1.7 consists in subtract from our dependent variable the estimated effect of each potential mediator plus the level of this variable and regress this result on our variable of interest and pre-treatment controls. The estimated coefficient resultant of this procedure is the treatment effect net the effect of possible mediators. In each column of Table 1.7 we estimate the effect of women's domestic slavery on the share of the female labor force net the effect of a different potential mediator. Through all columns of Table 1.7 the coefficients are statistically significant and almost have the same magnitudes of the baseline specification on Table 1.1. Putting all together, results in Table 1.7 suggest that inequality, GDP, HDI, human capital, and

Table 1.7: Mediation Analysis

	Gini Index	Per capita GDP	HDI	Literacy	College	High school	Urbanization
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
WDS	0.343***	0.367***	0.332***	0.322***	0.260**	0.333***	0.319***
	(0.1171)	(0.1134)	(0.1166)	(0.1189)	(0.110)	(0.118)	(0.116)
Observations	597	597	597	597	597	597	597
R-squared	0 0.321	0.416	0.379	0.355	0.430	0.367	0.352
State FE	✓	✓	✓	✓	✓	✓	✓
Geography	✓	✓	✓	✓	✓	✓	✓
1872 covariates	✓	✓	✓	✓	✓	✓	✓

Notes: Effects of women domestic slavery on contemporary share of women domestic workers net the effect of possible contemporary channels. This analysys is based on Acharya, Blackwell e Sen (2016a). The final estimation only controls for geography and 1872 covariates and state fixed effects. The sample is composed by contemporary municipalities presented in 2010 Brazilian Census and matched from 1872 Census according to IBGE (2011). Bootstrap standard errors in brackets. [b] *** p<0.01, ** p<0.05, * p<0.1, + p<0.105

urbanization cannot solo explain our main results.

1.6.3 WDS and prejudice against manual work

Until now we show evidence that the supply-side mechanism cannot fully explain our results, but have little evidence on the demand-side mechanism. As argued in section 2, Brazilian society was, since its foundation, deeply marked by a strong prejudice against manual work and this might be one of the explanations for the high share of the female labor force on domestic occupations in the country. To go further on this investigation we use a different data set from Ações Discriminatórias no Âmbito Escolar survey (Discriminatory Actions in the School, hereinafter called ADAE) realized in 2009, that aims to measure discrimination behaviors in school communities in 76 municipalities (92 if including the state capitals).

The ADAE survey interviewed students, teachers, employees, and parents from different schools in different municipalities asking questions about discriminatory behaviors. Interviewed individuals were questioned if they strongly agree, agree, disagree, or strongly disagree with several discriminatory statements. We focus our analysis on two statements that are directly related to prejudice against manual work and domestic service. The first statement is that "black women are more skilled than white women to be housemaids". The other statement is that "black people are more skilled in manual work". Both of these statements represent precisely the kind of discrimination of manual and domestic work that could be related to slavery, i.e., the direct association of manual and domestic work to black people. Our interest here is to investigate how the variation in WDS in the 19th century is related to the prevalence of these discriminatory beliefs today, to check if, as pointed out by other scholars, women's domestic slavery is related to this kind of prejudice. An important limitation of this analysis is that the distribution of beliefs among the school community may not be equal to the distribution of beliefs in all the population. Therefore, these correlations should be interpreted with caution. However, despite its limitations, this analysis can still be insightful.

In each panel of Figure 1.6 we plot simple correlations between the share of respondents on the municipality that agree or strongly agree with each statement and the prevalence of women

Table 1.8: Historical Exposure to women domestic slavery and discriminatory beliefs in school community

3*	**"Black women are more skilled than white women to be housemaids"**				**"Black people are more skilled in manual work"**			
	Index		**Agree or strongly agree**		Index		**Agree or strongly agree**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
WDS	6.231***	5.982***	2.090***	2.006***	3.334*	3.267*	1.110*	1.096*
	(1.531)	(1.519)	(0.501)	(0.487)	(1.934)	(1.951)	(0.651)	(0.657)
Observations	3,241	3,222	3,241	3,222	3,245	3,226	3,245	3,226
Municipalities	76	76	76	76	76	76	76	76
R-squared	0.057	0.090	0.044	0.064	0.043	0.091	0.028	0.064
Geography	✓	✓	✓	✓	✓	✓	✓	✓
State FE	✓	✓	✓	✓	✓	✓	✓	✓
1872 Covariates	✓	✓	✓	✓	✓	✓	✓	✓
Individual Controls		✓		✓		✓		✓

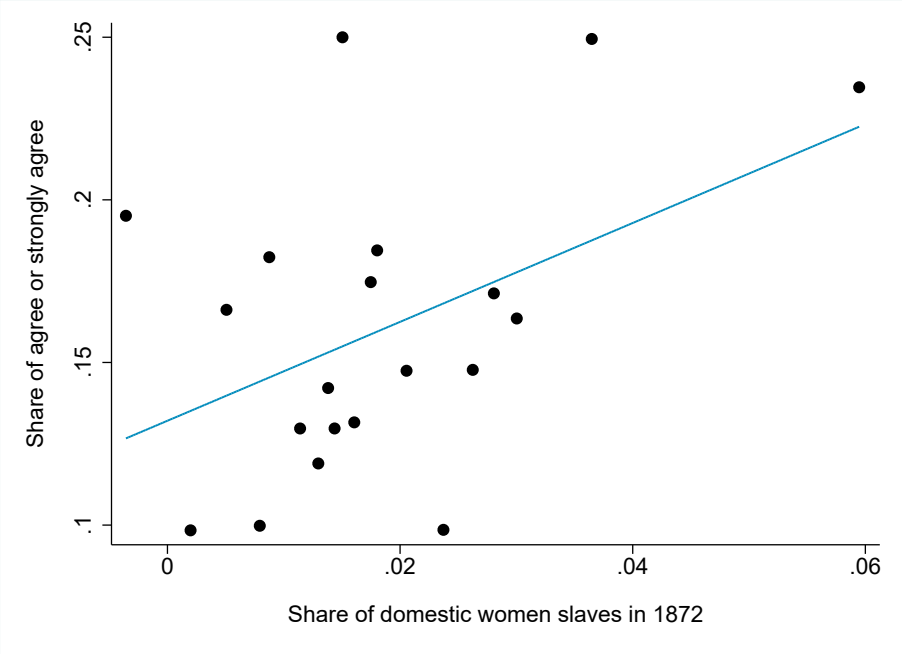
Notes: *** p<0.01, ** p<0.05, * p<0.1

domestic slavery in 1872. As can be seen in Figure 1.6, higher agreement with discriminatory beliefs relating to manual labor and housework to black people is positively correlated with exposure to WDS in 1872. In Table 1.8 we regress the share of agreements with both the statements and an index ranging from 1 to 4 (1 being "strongly disagree" and 4 "strongly agree") on the share of WDS in 1872 in each municipality controlling for state fixed effects, geography, 1872 covariates, individuals controls, and weighting for within municipality sample size. All standard errors are clustered at the municipality level.

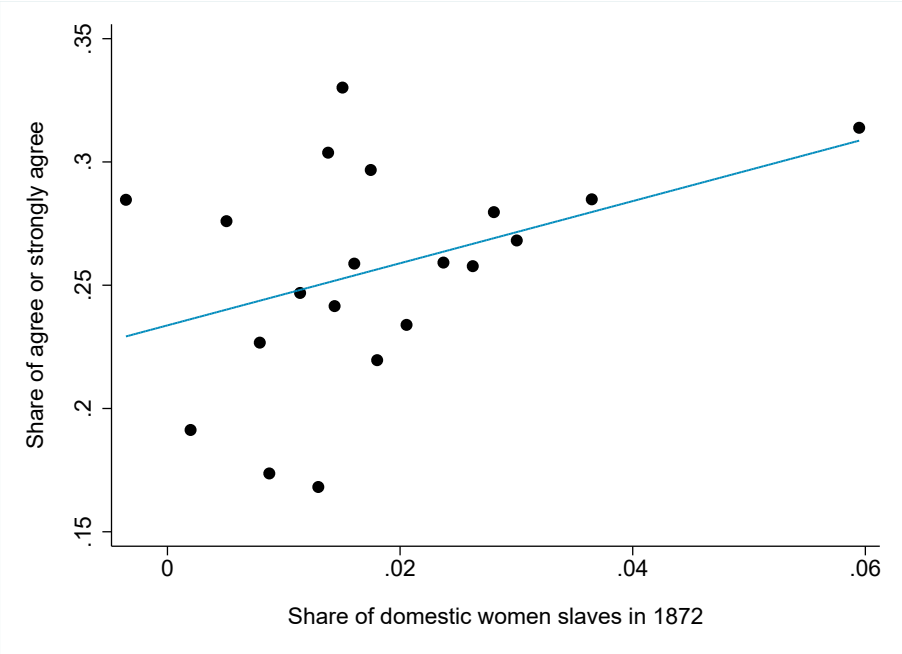
Results in Table 1.8 confirms the ones presented in Figure 1.6 showing a positive correlation between discriminatory beliefs relating domestic and manual work to black people, and the intensity of WDS back in 1872. Results are statistically significant in all columns, either using the index or the probability of agreement with the statement as dependent variables. Putting all together, these correlations may signal that the culture of dislike manual and domestic work, typical of slave societies, have, someway, persisted through time and might be an important determinant of the high share of FLF on domestic occupations in municipalities where women domestic slavery was more prevalent in the past.

1.7 Conclusion

In this paper we test the hypothesis of that the high demand for domestic services in Brazil was shaped by slavery, an institution abolished more than 120 years ago. Leveraging on historical data from the 1872 census, we document a strong and robust statistical association between the share of women slaves in 1872 and the contemporary share of the female labor force (FLF) working in domestic occupations in Brazilian municipalities. Rather than influence the participation or not of women in the labor market, we showed that slavery affected the quality



(a) "Black women are more skilled than white women to be housemaids"



(b) "Black people are more skilled in manual work"

Figure 1.6: Women slavery and prejudice against manual work

Notes: Notes: This figure presents binscatter plots on the relationship of the % of interviewed individuals - students, parents, professors, employees and principals from a random sample of Brazilian schools - by municipality that agreed or strongly agreed with two prejudiced statements and the share of women domestic slaves on the municipality in 1872. The sample is composed by 76 municipalities and all correlations are conditional on state fixed effects. Data is from Ações Discriminatórias no Âmbito Escolar survey (Discriminatory Actions in the School, here in after called ADAE).

of this participation. We also showed that our results cannot be fully explained by current development, inequality, or human capital accumulation levels, and found suggestive evidence that cultural persistence, through the prejudice against manual labor, may be an important mediator of our results.

CHAPTER 2

The long-run effects of a permanent agricultural shock on education and earnings

2.1 Introduction

Developing countries' rural populations face many risks because of expected and unexpected events, such as conflicts, climate shocks, and crop diseases. Households' ability to smooth transitory shocks – credit access, savings, or good coverage by social protection policies – may determine the severity of the shock and whether it will translate into short or long-run impacts on people's lives. The effects of transitory shocks on education, earnings, and child labor are well documented in the economic literature. Short-run adverse shocks may decrease (MACCINI; YANG, 2009; CARRILLO, 2020b; COGNEAU; JEDWAB, 2012), or increase (BAKER; BLANCHETTE; ERIKSSON, 2019) educational achievement and earnings.

Agricultural shocks' impacts on child labor also are mixed (MANACORDA; ROSATI, 2011; KRUGER, 2007; DURYEA; LAM; LEVISON, 2007; BEEGLE; DEHEJIA; GATTI, 2006). The conflicting results align with the theory (BASU; VAN, 1998), and their interpretation depends on how they impact the substitution effect (changes in the opportunity cost of children time) and income effects – changes in the full household income (SOARES; KRUGER; BERTHELON, 2012). Moreover, the impacts on education, earnings, and child labor may also depend on how farmers are able to substitute crops. In the case of the boll weevil infestation in the U.S., farmers substituted cotton for corn, peanuts, and sweet potatoes, which were less suitable for children (BAKER; BLANCHETTE; ERIKSSON, 2019). Nevertheless, little is known when the exogenous shock is not transitory and happens in municipalities where the affected production represents an important share of the total agricultural outputs. In a long-lasting adverse event, households could adapt, and the shock would be mitigated with time. Surprisingly, this is different from what our results suggest.

This paper studies the long-run effects of a significant exogenous and long-lasting event in cocoa production in Brazil on education and the labor market. We explore the witches' broom outbreak in cocoa farms in the world's second most important cocoa production region until 1988, the southeast of Bahia's state in northeast Brazil. The peak of infected fruits happened almost 12 years after the outbreak, and by 2023 the region had yet to recover its full potential. In 1985, this region produced 80% of Brazilian and 62% of Latin American cocoa (IOCC, 1993). Data and historical documents report that cocoa production decreased by 80% in the first ten years after the disease, pushing almost 250 thousand workers to unemployment.

For several reasons, the context of the witches' broom in Bahia is particularly appealing to

study the long-run impacts of exogenous permanent agricultural shocks.[1] First, the municipalities affected by the witches' broom disease highly depended on cocoa production. At the outbreak, cocoa was the second most exported product from the Bahia state. One year before the outbreak, the share of cocoa in the total agriculture production was, on average, 84% in the affected municipalities. The median share was 93%. This high dependency made the region very vulnerable since a negative shock to cocoa production automatically converted into a strong shock on the total income of the municipality. Notably, nothing happened in the region despite the evidence that similar adverse shocks may lead to a permanent crop substitution in the local agricultural sector (LANGE, 2009; BAKER; BLANCHETTE; ERIKSSON, 2019). No other crop substituted the cocoa, and the local agricultural industry never recovered. In 2010, cocoa represented 72% of the total agricultural output in the affected municipalities. However, the total agricultural output was only 7.3% of the 1988 output.

Our empirical strategy exploits variations in the location and time of the outbreak at the municipal level in Brazil. To assess the impact of the whiches' broom disease, we leverage information about people born in municipalities affected and not affected by the disease and explore the difference in educational attainments between cohorts older and younger than eighteen years old at the time of the witches' broom outbreak, which varies between 1990 and 1992 depending on the city. We then estimate difference-in-differences and event studies regressions.

The underlying hypothesis is that cohorts older than 18 had taken most of their educational decisions, while younger cohorts still needed to make many choices. It is a reasonable assumption because Brazil's expected age to graduate high school is seventeen. In addition, the region's offer of college, university, or vocational education was minimal at the time of the outbreak. Then, we should not expect any difference in educational results between individuals older than 18 in affected and not affected regions. We use the 2000 and 2010's Brazilian demographic Censuses and historical information about the timing and severity of the crisis in each city. Our sample contains 5 million individuals who live in one of the nine states of the Brazilian northeast. Our sample is restricted to those born after the witches' broom outbreak and less than 65 years old at each demographic census.

The main results show that the witches' broom outbreak negatively affected the education and income of individuals living in affected municipalities. People below eighteen years old living in municipalities affected by the witches' broom disease have 2.8 percentage points (p.p.) less likely to have a high school degree and 3.2 p.p. less likely to have an elementary school. Compared to the control group average, these numbers represent a 10.5% lower probability of having a high school degree and an 8% lower probability of having an elementary school degree. The individuals affected by the witches' broom outbreak also have wages 4.8% lower. Those effects are stronger for individuals between zero and 12 years old during the witches' broom outbreak.

We also show that the impacts are higher in municipalities with a higher dependency on cocoa production before the witches' broom outbreak. We do that by splitting the sample

[1] Bahia state has about 15 million inhabitants, comprising an area almost the size of France. A high share of its working population has no jobs or works without any formal contract, and it has the highest percentage of the population receiving the cash transfer program *Bolsa Família*, targeted at the poorest families in Brazil.

between municipalities above and below the median of the cocoa dependency range, measured as the share of cocoa in the total agricultural production in 1988. The effects on high school achievement and wages increase to 3.2 p.p. and 8.5 p.p., respectively. Following the empirical strategy proposed by Clay, Schmick e Juster (2021), we also provide evidence that the effects are stronger for girls than boys and do not differ by race.

The results listed above are the first main contribution of this study. As far as our knowledge goes, this is the first paper that explores an exogenous shock that was not temporary. Moreover, our setting is particular because the peak of the disease only happened a few years after the outbreak, the disease was never eliminated, and farmers could not substitute the production for other crops. The witches' broom destroyed the foundations of the cocoa region, one of the wealthiest micro-regions of the Brazilian Northeast[2]. Our results are in line with the studies that explore transitory exogenous shocks such as the boll weevil disease in the US Cotton belt (BAKER; BLANCHETTE; ERIKSSON, 2019; AGER; HERZ; BRUECKNER, 2020), recessions (STUART, 2022), coffee shock prices in Latin America (PADRÓN; BURGER, 2015; CARRILLO, 2020b; KRUGER, 2007), desert locust in African countries (LE; NGUYEN, 2022) or on the impact of climate events, as droughts (ROCHA; SOARES, 2015a) and floods (MACCINI; YANG, 2009). Additionally, neither the above studies nor other research focuses on a highly-dependent region in a specific monoculture, such as the cocoa region in Bahia.

Whether the impacts of a transitory shock persist depends on the household's ability to cope with it. For example, positive in-utero exposure to an income shock may affect calories and nutrient intakes, having long-run effects on education and wages. In the case of a non-transitory shock, people's lives are directly affected for a long period, and young people may be the most impacted. In this sense, our paper is more closely related to two other studies that explore the impact of the green revolution on GDP (GOLLIN; HANSEN; WINGENDER, 2021) and the inflows of immigrants on consumption (MAYSTADT; VERWIMP, 2014). Two events that created permanent positive changes in the local economy that are different from the permanent negative shock we are exploring.

We further provide many robustness checks. Since the outbreak occurred in a staggered fashion between 1990 and 1992, we also used the estimator proposed by (SUN; ABRAHAM, 2021a), showing that the differences in treatment timing do not bias our results. The robustness section shows that other idiosyncratic shocks at the municipality level or concurrent shocks at the same time as the outbreak are unlikely to explain our results.

To investigate the mechanisms that may explain our main results, we estimate an event-study regression of the interaction of year dummies with a treatment indicator, where the treatment is being affected by the witches' broom outbreak, and the outcome is the share of children working compared to the total population of children in the municipality.[3] The result suggests an increase in child labor by 2.5 percentage points in 2000 and 2010 in affected regions compared to non-affected regions.

This is the second main contribution of our study. The results on child labor are consistent

[2]The northeast of Brazil has 23 micro-regions.

[3]According to the Brazilian statute of children and teenagers, any kind of work in Brazil is strictly prohibited for people younger than fourteen years old. See Estatuto Brasileiro da Crianca e do Adolescente - ECA. Law 8.069/1990. <http://www.planalto.gov.br/ccivil_03/leis/L8069.htm>

with the luxury axiom in the multi-equilibrium model developed by Basu e Van (1998), where parents choose not to send their children to work when incomes are sufficiently high. The opposite occurs when the incomes are low. They also assume that adult and child labor is (not perfect) substitutes, which is in line with Walker (2007). More specifically, we provide a better test of what happens when there is a change in the full household income. Short-term fluctuations in wages and income should be mostly associated with increases in the opportunity cost of children's time (substitution effect). A permanent shock is related to changes in households' total income, representing pure income effects (luxury axiom) (SOARES; KRUGER; BERTHELON, 2012).

Therefore, temporary shocks that affect household income may change the opportunity cost of schooling. Children are forced to work to help the family's income while the shock last (BAKER; BLANCHETTE; ERIKSSON, 2019). However, permanent shocks change not only the cost of opportunity of children's time but the total household's total income, and children may be sent for long periods to work to support their families. The empirical evidence using Brazilian data and exploring temporary shocks is mixed. Soares, Kruger e Berthelon (2012) provides an empirical test of the Basu model to the Brazilian context, showing that higher household wealth is associated with lower child labor and higher schooling. Filho (2012) showed that families that became eligible to receive rural pensions in Brazil have a lower probability of sending their children to work. Duryea, Lam e Levison (2007) found that when a head of the Brazilian household lost their job, the probability of having children working increases. However, there is also empirical evidence from coffee shocks showing that child labor increases during economic booms (KRUGER, 2007; CARRILLO, 2020b). This points out that the relation between shocks and child labor may depend on the specificity of the labor demand and offer (MANACORDA; ROSATI, 2011) and the characteristics of the shock (SOARES; KRUGER; BERTHELON, 2012).

We also provide one additional minor contribution. We add to the literature that explores the effects of economic shocks on populations without access to savings, credit markets, and social protection systems (BEEGLE; DEHEJIA; GATTI, 2006; BANDARA; DEHEJIA; LAVIE-ROUSE, 2015). In addition to the witches' broom outbreak in an impoverished area, from 1987 to 1994, Brazil faced the worst inflationary period in its history.[4] Therefore, during the witches' broom outbreak, most of the credit markets in the country were nonexistent, and most households had no savings. Furthermore, cocoa production intensively uses low-skilled workers, reducing their mobility to other activities in a crisis. Households cannot borrow and save pre and during crises in an environment of incomplete (or lack of) capital markets and insurance (JENSEN, 2000). Because of their parents' volatile income, reducing children's educational investment is a survival strategy.

[4]With the total annual inflation rate achieving 107,492.07% between February 1986 and November 1989. The inflation rate was controlled only with a pool of macroeconomic policies in 1994, which introduced the current currency, the Real.

2.2 Background

Between 1961 and 1988, Brazil was the second biggest global cocoa producer. In 1985 for example, Brazilian production was about 448,577 tons of cocoa, representing 70.5% of Ivory Cost production, the biggest producer in the world. Bahia was the state with the higher share of the national production, approximately 86%.[5] The southeast of Bahia's state concentrated the cocoa production. Figure 2.1 shows the map of Bahia state and highlights the municipalities with cocoa production, most known as the Ilhéus-Itabuna microregion. Many studies, technical reports, and books described the importance of cocoa production for the region, associating cocoa with the development of agribusiness to investments in infrastructure and development of local human capital (UESC., 2015; Ceplac, 2009). Cocoa was also present in the region's popular fairy tales and culture, being the main background of many of Jorge Amado's books (Santos, 2017).[6]

The cocoa production in the region was characterized by large farms owned by a few elite families, which led to very high inequality in the region. Besides, it became a mono-culture because of the high prices of cocoa and the inequality in land ownership. Therefore, the region was highly dependent on it, with very low diversification in income sources. Indeed, during that period, cocoa ranked as the second most exported commodity from the Bahia state. The average municipality affected by the witch broom in the state attributed 44% of their total agricultural output to cocoa production, while some municipalities exceeded 80%. Even the development of city services depended on the cocoa economy, with the elite members being the main clients.

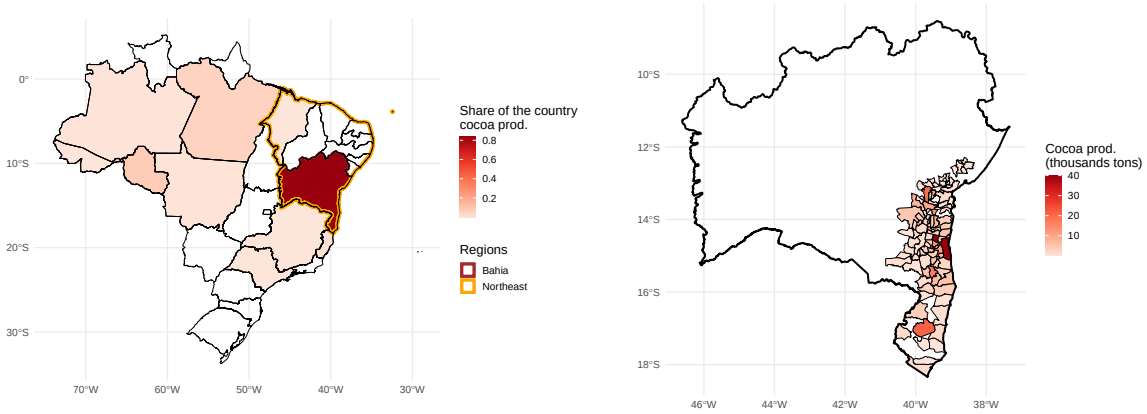
The Witches' broom disease is a fungal disease that affects cocoa trees, caused by the pathogen Moniliophthora perniciosa. The disease is characterized by the appearance of abnormal growth on the branches of the cocoa tree that resembles a broom, hence the name "witches' broom." The fungus infects the young shoots and causes them to grow into dense clusters, which are unsuitable for cocoa production. The affected branches can produce small and malformed pods, leading to a significant reduction in yield. The disease is prevalent in many cocoa-growing regions, particularly in South America, and can have a devastating impact on cocoa production.

In May 1989, the Ilhéus-Itabuna microregion's fate started to change with the first discovery of the Witches' broom in Uruçuca municipality. In October 1989, Camacan municipality also reported the presence of the disease. Figure 2.2 shows each municipality with official reports of witches' broom disease in Bahia's State. The disease was known to be endemic in the Amazon region for many years but had never arrived in the south of Bahia until the sudden outbreak in 1989. At that time, the principal explanations for the disease were bioterrorism conducted by cocoa producers' competitors in the Amazon Forest and Ivory Coast. Despite nothing having been proved about the responsible and the real motivations, the consensus is that the fungus spread was criminal and intentional (ROCHA, 2006). Based on the spatial

[5]Bahia is a large-sized state with about 15 million inhabitants and whose territory is about the size of France. It is one of the poorest states in Brazil. Bahia's labor market has a large share of informal jobs, low-educated workers, and high unemployment rates. According to the 2010 Population Census, informal jobs represented half of the total employment, and half of the workers had at most eight years of educational attainment. In 2010, the share of informal workers– those not contributing to social security– was 35.4% in Brazil and 49.4% in Bahia. In 2019, Bahia had the second-highest unemployment rate in Brazil—17% against the national rate of 11%.

[6]Jorge Amado is one of the greatest Brazilian novel writers.

Figure 2.1: Spatial distribution of cocoa production in Brazil and Bahia - 1988



(a) All states (b) Bahia

Notes. Panel (a) displays the distribution of cocoa production by state in Brazil during 1988. The yellow border line delineates the Northeast region. Panel (b) illustrates the spatial distribution of cocoa production in municipalities of the state of Bahia with production levels greater than zero in 1988.

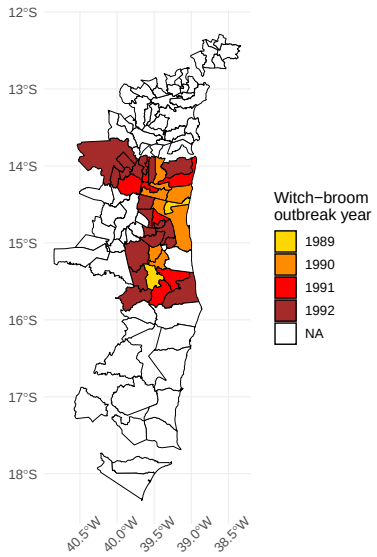
pattern of the infections and the coincidental timing of the first two infections (two different and 100km apart focus sites located in the cocoa region's center) Pereira, Almeida e Santos (1996) concluded that the disease was criminally introduced. The spread, however, was random and explained mainly by the wind and animals carrying the witches' broom mushroom.

Because witches' broom is one of the most dangerous diseases for cocoa production, many studies tried to develop technical procedures to deal with it (IOCC, 1993; MEDEIROS et al., 2010; LISBOA et al., 2020; SCARPARI et al., 2005; FIORAVANTI; VELHO, 2011). There are two remarkable differences between the witches' broom fungus and other agricultural shocks. Firstly, the outbreak was sudden and unexpected, making it impossible for the producers to take preventive measures whereas price and weather shocks are somewhat anticipated. Secondly, while price and weather shocks are temporary, witches' broom is permanent and becomes endemic to the region once it arrives. In an interview we conducted with technicians from the Ministry of Agriculture, they explained that witches' broom is common in the Amazon forest as well. However, the southeast of Bahia has a very particular climate that makes the disease spread extremely fast, while it doesn't happen in the Amazon Forest cocoa farms.[7]

Appendix figure B.4 shows the number of infected cocoa fruits per year. At the outbreak moment in Bahia, there was very little knowledge about how to fight the disease, with the main recommendation being to cut and burn sick trees. It leads to the destruction of farms and families' sources of income. This recommendation was proven wrong, but no specific cure or management exists for the witches' broom. The treatment is evaluated case by case based on the local climate and cocoa genetics. In addition, it is essential to point out that no program was created by the Municipalities, the State, or the Federal level governments to support the affected

[7]The meeting happened on August 28, 2022. The technicians work at CEPLAC, an agency from the Ministry of Agriculture that works only with cocoa. Two of the three personnel who participated in the meeting worked at CEPLAC during the witch broom outbreak.

Figure 2.2: Witch broom outbreak by municipalities and year



Notes. This figure depicts the spatial distribution of outbreak dates of Witch Broom disease in affected municipalities. The data originates from (LISBOA et al., 2020). The municipalities depicted with border lines but lacking any color indicate cocoa production in 1989 but were not impacted by the disease.

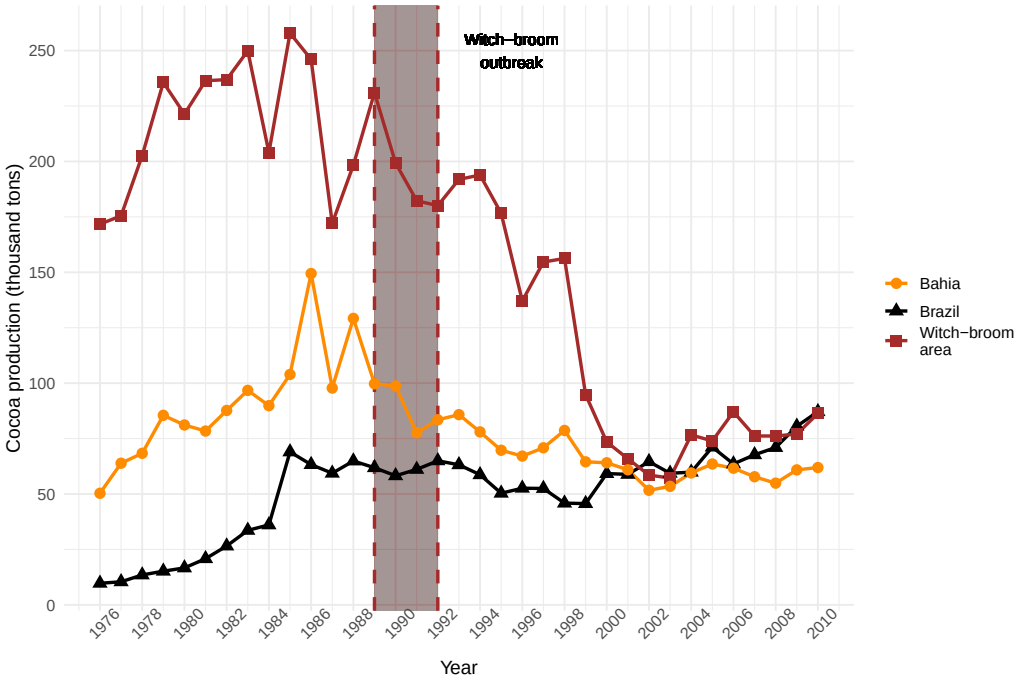
families.

Because of the witches' broom, cocoa production reduced from 448,577 tons in 1985 to only 96,000 tons in 1999. The Ilhéus-Itabuna microregion had the highest level of unemployment in its history, with 250 thousand rural workers losing their jobs and the average cocoa revenue reducing from US$ 600 million/year to US$ 200 million/year (Ceplac, 2009). Figure 2.3 shows the production of cocoa through time. Cocoa production has had a negative trend since 1985, when cocoa prices started to fall. However, it became steeper after the witches' broom outbreak, achieving lower production levels in 2000, the peak year of cocoa-infected products (Ceplac, 2009).

Figure 2.4 shows that the average yearly agriculture income decreased over time, suggesting that there was no transformation in the sector and no other crop development was sufficient to recover the agricultural industry. It is important to highlight some characteristics of the cocoa tree and the region to understand why crop substitution was difficult. First, most of the region is covered by tropical forest and are protected by environmental laws. So, farmers can not destroy the area to open plantation fields, even though they own a large share of the territory. Second, cocoa trees are huge compared to other traditional crops studied in the literature, like coffee, cotton, and beans. Cocoa trees grow in the tropical forest environment. Removing it is costly and difficult because of the trees' size and roots.

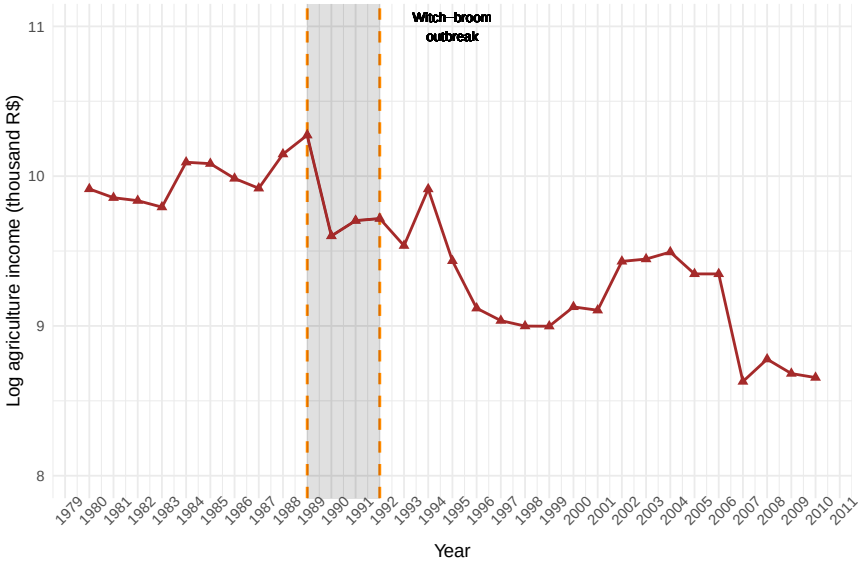
Finally, The witches' broom disease has two essential features for our study. The first is an incubation period between the disease inoculation and the signals that make it possible to identify sick trees. Only after the incubation period can the sick trees be identified because of the appearance of very specific mushrooms. The second is that there is no particular cure or preventive manipulation to prevent the disease development and dissemination (ALVES et al.,

Figure 2.3: Trends in Cocoa production 1976 to 2010



Notes. This figure displays the trends of cocoa production over time, measured in thousand tons, for different regions. The red line indicates the production in municipalities affected by the Witch Broom disease. The orange line represents the net production of the Bahia state, excluding the production in municipalities impacted by the disease. Finally, the yellow line represents the net production of Brazil, excluding the production in Bahia.

Figure 2.4: Average yearly agriculture income in the Witch Broom area from 1980 to 2010



Notes. This figure presents a plot of the logarithm of the average yearly agricultural income (value of production) in municipalities impacted by the Witch Broom disease, utilizing data obtained from the Brazilian Municipal Agriculture Survey.

2006; SCARPARI et al., 2005). The sick trees with the disease in the initial stage are difficult to spot, and if the mushrooms are not correctly destroyed, they can disseminate the disease to other trees after small pieces of it are taken by the wind and land in another tree. Appendix figures B.1, B.2 and B.3 illustrate a healthy cocoa fruit, a fruit contaminated with the witches' broom and the witches' broom mushroom that indicates that the tree is contaminated with the disease.

2.3 Data and Empirical Strategy

2.3.1 Data

To assess the long-run effects of the witches' broom outbreak, we use the 2000 and 2010 waves of the Brazilian census. The census has detailed information on education and labor market outcomes, like occupation and wages. Since the 2000s and 2010s censuses do not ask individuals the municipality of birth, we keep on the sample only individuals that declared to be born in the municipality of residence and use this information as a proxy to the municipality of residence at the time of the shock. We only consider municipalities in the northeast region and excluded from the sample individuals older than 65. To improve the comparability of age cohorts, we restricted the sample to individuals from 0 to 35 years old at the time of the witches' broom outbreak. For municipalities not affected by the witches' broom, we consider individuals with 0 to 35 years by 1989, the first year of the disease. Finally, each municipality's witches' broom outbreak dates were collected using data from (PEREIRA; ALMEIDA; SANTOS, 1996).

2.3.2 Empirical Strategy

We are interested in the effect of the witches' broom disease outbreak on the probability of completing elementary and high school education and wages in the long run. Our empirical strategy exploits variations in the location and time of the outbreak at the municipal level in Brazil[8]. First, we estimate the equation 2.1 that generalizes the difference-in-differences framework exploiting the differential timing of the year of the witches' broom outbreak across municipalities. The unit of analysis is the individual.

We are comparing individuals above and below eighteen years old living in affected and not affected municipalities at the time of the outbreak. The estimated parameters must be interpreted as an intention to treat the effect because not everyone in the treated municipalities was directly affected by the shock.

$$Y_{im} = \beta_{im} WB_{im} * A_{age \leq 18} + \tau A_{age \leq 18} + \gamma X_i + \rho_m + a_{2010} + \varepsilon_{im} \tag{2.1}$$

X_i is a vector of socioeconomic characteristics, such as gender and race, and ρ_m is a municipality fixed effect that controls for unobserved determinants of long-run outcomes across municipalities. Y_{im} is the outcome that will assume a value equal to 1 if the individual completed elementary education or high school. Y_{im} will also represent the logarithm of the individual earnings. The

[8] See Araújo, Carrillo e Sampaio (2021) and Baker, Blanchette e Eriksson (2019) for a similar empirical strategy.

key parameter is β_{im}, which summarizes the magnitude of the witches' broom (WB) impact. A negative and significant estimate would suggest that exposure to witches' broom disease reduces education or earnings in the long run. In addition, equation 2.2 is an event-study version of the previous equation to examine the witches' broom disease impacts on education and wages by comparing adjacent birth cohorts. In this case, individuals are grouped in eight cohorts WB_c, and we add a cohort fixed effect θ_c.

$$Y_{icm} = \sum_{k=0}^{8} \beta_k * 1\{19 \leq WB_c - K \leq 18\} + \gamma X_i + \theta_c + \rho_m + a_{2010} + \varepsilon_{icm} \tag{2.2}$$

The cohorts below 18 years old living in municipalities affected by the witches' broom outbreak are the treated group because they did not finish their schooling decisions, while the cohorts above 18 years old at the time of the outbreak are the control group because they had already taken most of their educational decisions. The interpretation of these estimates assumes that individuals between 18 and 35 years when the witches' broom happened in their municipality of residence do not alter their educational decisions.

Under this identifying assumption, our empirical framework yields estimates of the causal effects of the witches' broom on long-run outcomes. There are two reasons to expect that. The first is that the offer of technical and college education was very scarce in this region before 2000 (OECD, 2021). Therefore, young adults had minimal options to choose between work and study after eighteen. The second is that the typical age for finishing elementary education in Brazil is 14, while the typical age to finish high school is 17. Therefore, only a very strong belief would refuse these two assumptions together.

We believe that three potential mechanisms explain the results. The first one is the increase in child labor, which is consistent with the luxury axiom Basu1998,Soares2012HouseholdBrazil. In section 2.4.3 we estimate an event study regression that confirms that child labor may explain the findings. The second is the potential impacts of the income drop on health outcomes, which is also well established in the literature Rocha2015, and the third is that which broom shock may have led to a reduction in education inputs in the affected municipalities, such as school closure due to the drop in municipality revenues. Unfortunately, there are no available data in Brazil at the municipality level before the shock to test the educational and health hypothesis. Even though we cannot rule out those potential mechanisms, we provide some descriptive evidence that individuals in the affected regions have lower education indicators ten years after the outbreak. We also estimate a triple-difference model proposed by (CLAY; SCHMICK; JUSTER, 2021) to verify if there are heterogenous impacts by gender or race.

We further provide many robustness checks. First, because of the differential timing of the outbreak across municipalities, section 2.4.4 presents the (SUN; ABRAHAM, 2021a) estimator for a DiD with staggered adoption. The main results do not change, eliminating potential bias arising from the OLS estimation. Second, another potential concern is that migration could bias our results. Affected families may have chosen to migrate to other municipalities to find better employment opportunities. To overcome that, we also estimate a model in a restricted sample composed of individuals that reported that they were born and always lived in the city c. Section 2.4.4 shows that migration does not seem to drive our results. Besides, section 2.4.4 also explains that there is some sparse evidence of internal migration within municipalities in the

Ilhéus-Itabuna region, but not about people leaving the micro-region. Third, in section 2.4.4 we provide evidence that the effects are not driven by some municipality idiosyncratic characteristic by assuming that there was some shock in the same municipalities in 1970 or 1980, or by any concurrent event in 1990.

2.4 Results

This section presents the results of the empirical strategy described in 2.3.2. We split the section into three parts. First, we present the main results for all cohorts. Second, we present the heterogeneity analysis by cocoa dependency before the shock, sex, and race. Finally, we present a bunch of robustness checks and placebo analyses.

2.4.1 Baseline results

Columns (1) and (2) of table 2.1 show the impact of the witches' broom disease on the probability of having completed at least a high school degree using equation 2.1. Cohorts younger than eighteen years old at the time of the witches' broom disease exposure are 2.8 percentage points (p.p.) less likely to have a high school degree, representing a 10.5% lower probability when compared to the control group average. Columns (3) and (4) show a slightly stronger estimate, but compared to the control group average, it represents an 8% lower probability of completing elementary school. Columns (5) and (6) show that cohorts exposed to the witches' broom have wages -5.1% lower than cohorts not exposed to the witches' broom.

Figures 2.6 and 2.5 add by showing the long-term witches' broom effects for different cohorts estimated using the equation 2.2. These figures present two main messages. First, the results are stronger for cohorts younger than 12 years old, both for education and wages. Second, the results are not statistically significant for cohorts between 16 and 18 years old at the time of the shock.

2.4.2 Heterogeneous effects

As explained before, cocoa production in Bahia was a monoculture with low diversification. Many municipalities' economic systems were dependent on it. Appendix figure B.8 shows the share of cocoa production in relation to the total agriculture production in each city affected by the witches' broom in 1988, before the outbreak. The average share of cocoa in total agricultural production was 84%, and the median was 93%.

We use this information to create two groups, municipalities above and below the median of cocoa production in 1988. The visual representation is presented in appendix figure B.9. The control group is the same, individuals living in municipalities not affected by the disease.

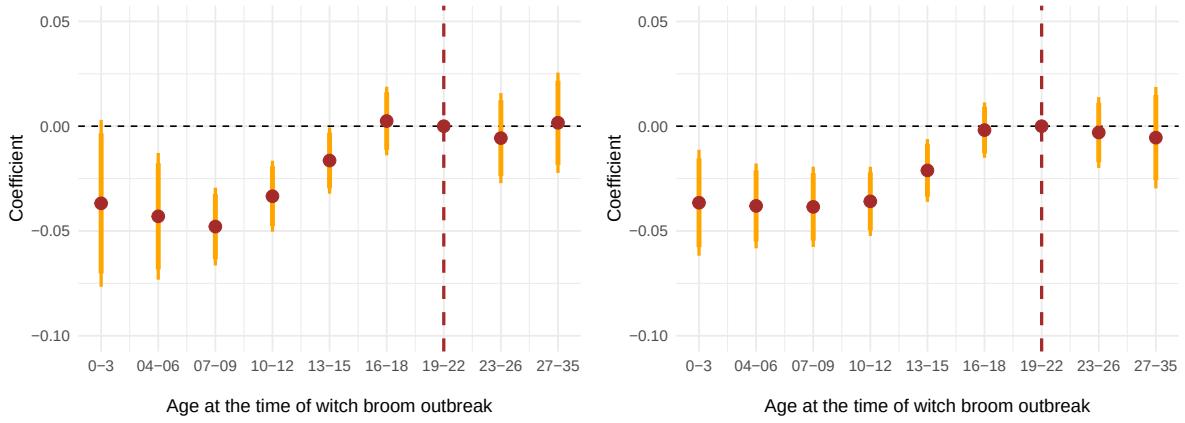
Columns 1 to 3 of table 2.2 show the results for the municipalities above the median, and columns 4 to 6 the results for the municipalities below the median. The results suggest a very similar impact for municipalities below the median. Municipalities above the median experienced a small increase in the impact of the witches' broom on earnings and elementary schools. In addition, there was an 18% increase in the estimated impact on the likelihood of

Table 2.1: Long Run effect of witches' broom on Childhood exposure cohorts

	High School		Elementary School		log(wages)	
	(1)	(2)	(3)	(4)	(5)	(6)
Childhood exposure	-0.028***	-0.028***	-0.032***	-0.032***	-0.058***	-0.051**
	(0.008)	(0.008)	(0.010)	(0.010)	(0.022)	(0.022)
R^2	0.081	0.084	0.111	0.117	0.208	0.227
Observations	5,056,631	5,031,826	5,056,631	5,031,826	1,934,196	1,927,801
Municipality FE	✓	✓	✓	✓	✓	✓
Birth-year FE	✓	✓	✓	✓	✓	✓
Census wave FE	✓	✓	✓	✓	✓	✓
Ind. Controls		✓		✓		✓

Notes. The Table displays the regression results of the estimation of equation 2.1 and also alternative specifications. The dependent variable in columns (1) and (2) is a dummy that equals one if the individual completed high school. In columns (3) and (4) the dependent variable is an indicator variable that equals one if the individual completed elementary school. Finally, in columns (5) and (6), the dependent variable is the log of wages. The estimate corresponds to an ITT effect—to the estimated coefficient of Equation (2.1)—. Standard errors are clustered at the municipality level.

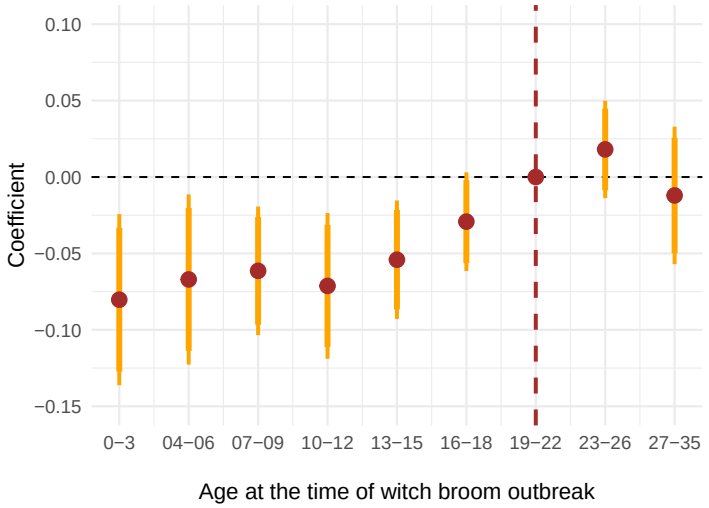
Figure 2.5: Long-run consequences of witches' broom outbreak on education



(a) Elementary School (b) High School

Notes. The figure displays the baseline results for the probability of having completed elementary and high school up to 20 years after the witches' broom outbreak. The horizontal axis shows the age at the moment of the witches' broom outbreak. The estimate corresponds to an ITT effect—to the estimated coefficient of Equation (2.2)—. Standard errors are clustered at the municipality level. Confidence intervals: 95% and 90%.

Figure 2.6: Long run consequences of witches' broom outbreak on wages



Notes. The figure displays the baseline results for wages up to 20 years after the witches' broom outbreak. The horizontal axis shows the age at the moment of the witches' broom outbreak. The estimate corresponds to an ITT effect—to the estimated coefficient of Equation (2.2)—. Standard errors are clustered at the municipality level. Confidence intervals: 95%.

completing elementary school.

Although child labor is a remarkable characteristic in Brazilian agriculture, Manacorda e Rosati (2011) suggested using the Brazilian census that it is more intense in girls' labor than boys'. Cogneau e Jedwab (2012) provide descriptive evidence that boys in the agricultural sector in the Ivory Coast present higher enrollment and lower probability of working than girls. Besides, they also show that this difference is higher in cocoa production areas than in non-cocoa production areas. In a historical study, Walker (2007) showed that cocoa production in the 19th century in Brazil made highly intense use of women and children enslaved people. He also explains that there was a formal state recommendation for using both groups because of the low-skilled and lower-strong labor demand for cocoa production.

Table 2.3 shows the estimation of a triple-difference model as in Clay, Schmick e Juster (2021). The results provide suggestive evidence of the higher impacts on girls than boys, which can be translated into a more intense use of girls in cocoa production when a price shock happens (COGNEAU; JEDWAB, 2012). Girls have a lower likelihood of completing elementary and high school than boys. Appendix Tables B.1 show that there is no evidence of differential effects of the witch broom outbreak by race.

We further explore the heterogeneous effects of the witches' broom outbreak by sex and race using the event study design. Appendix figure B.7 shows that the witches' broom outbreak affected both groups equally when considering the impacts in each cohort. Figure B.7 also shows no difference in which broom impacts by race. The result by race differs from other studies that use a similar identification strategy, like in the case of long-term impacts of the boll weevil, which found larger impacts on black children (BAKER; BLANCHETTE; ERIKSSON, 2019).

Table 2.2: Long-Run effect of witches' broom on exposed cohorts by cocoa dependence

	Panel A: Above median			**Panel B: Below median**		
	High School	Elementary School	log(wages)	High School	Elementary School	log(wages)
	(1)	(2)	(3)	(4)	(5)	(6)
Childhood exposure	-0.033***	-0.035***	-0.052**	-0.025**	-0.030**	-0.062**
	(0.009)	(0.010)	(0.026)	(0.010)	(0.013)	(0.026)
R^2	0.081	0.111	0.208	0.081	0.111	0.208
Observations	4,993,100	4,993,100	1,907,572	5,011,237	5,011,237	1,915,683
Municipality FE	✓	✓	✓	✓	✓	✓
Birth-year FE	✓	✓	✓	✓	✓	✓
Census wave FE	✓	✓	✓	✓	✓	✓

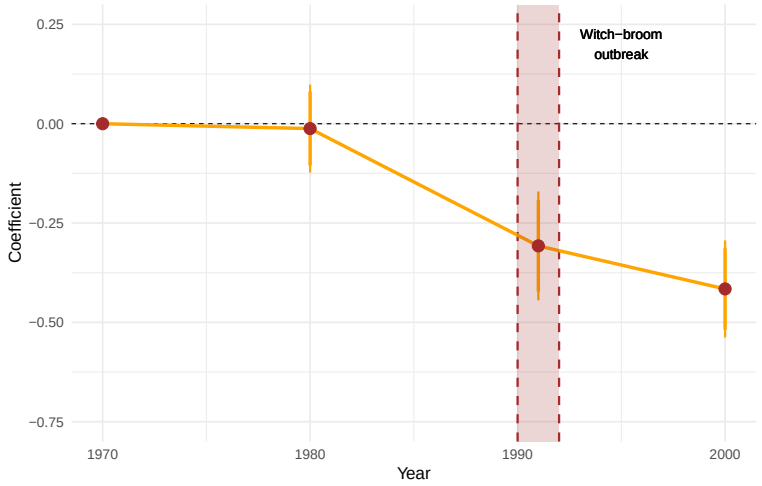
Notes. Each panel of the Table displays the regression results of the estimation of equation 2.1 dropping treated municipalities from the sample according to a measure of cocoa dependence. The measure consists of the share of cocoa production in each municipality over the total agriculture production, before the witches' broom outbreak. Panel A considers only treated municipalities above the average of cocoa dependence, dropping from the sample treated municipalities below the median. Panel B considers only treated municipalities below the average of cocoa dependence, dropping the treated municipalities above the median from the sample. Both panels use the same municipalities in the control group as our baseline specifications. The estimate corresponds to an ITT effect—to the estimated coefficient of Equation (2.1)—. Standard errors are clustered at the municipality level.

Table 2.3: witches' broom effect by gender

	High School	Elementary School	log(wage)
	(1)	(2)	(3)
Childhood exposure	-0.021***	-0.026***	-0.045
	(0.007)	(0.009)	(0.029)
Childhood exposure * Women	-0.016**	-0.012*	-0.025
	(0.006)	(0.007)	(0.030)
R^2	0.085	0.116	0.220
Observations	5,056,631	5,056,631	1,934,196
Municipality FE	✓	✓	✓
Birth-year FE	✓	✓	✓
Census wave FE	✓	✓	✓
Women × Municipality FE	✓	✓	✓
Women × Birth-year FE	✓	✓	✓
Women × Census wave FE	✓	✓	✓

Notes.The Table displays the baseline regression results of the estimation of equation 2.1 and also results for the interaction of the childhood exposure dummy with a dummy equal to one if the individual is female as in (CLAY; SCHMICK; JUSTER, 2021). The dependent variable in columns (1) and (2) is a dummy that equals one if the individual completed high school. Finally, in columns (3) and (4), the dependent variable is the log of wages. The estimate corresponds to a ITT effect—to the estimated coefficient of Equation (2.1)—. Standard errors are clustered at the municipality level.

Figure 2.7: The short-term effect of witches' broom outbreak on average earnings



Notes. The figure displays estimated coefficients of an event-study regression of the interaction of year dummies with a treatment indicator, where the treatment is being affected by the witches' broom outbreak, on the income of municipalities in the Northeast of Brazil. Data is from the 1970, 1980, 1991, and 2000 censuses.

2.4.3 Mechanism

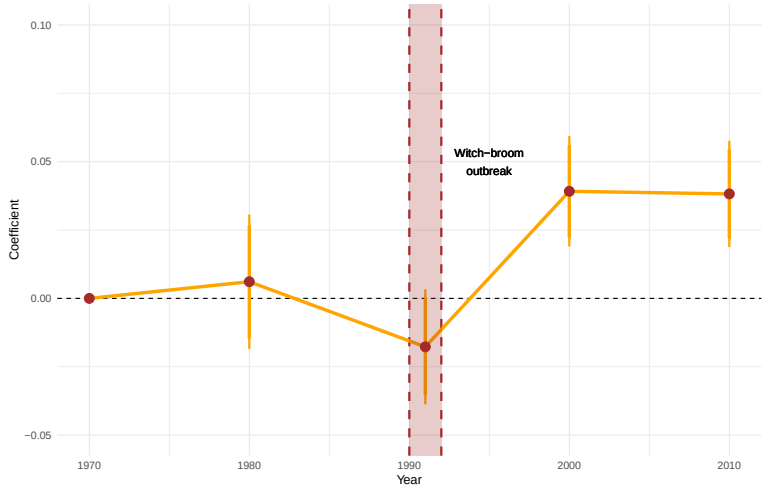
The previous sessions showed that the witches' broom had long-term effects on human capital accumulation (education) and wages. Our central assumption is that due to the drop in earnings and the lack of savings, families decided to send their children to work to compensate for the income loss, which is in line with the main models of child labor (BASU; VAN, 1998; EDMONDS, 2007). Figure 2.7 show the impacts of the disease on the municipality's average earnings. The results suggest that the municipalities' income fell between 25 to 38 percent between 1991 and 2000 because of the witches' broom.

The fall in family income can lead to the growth in child labor (BASU; VAN, 1998). According to the Brazilian statute of children and teenagers,[9] any work is strictly prohibited for people younger than fourteen years old in Brazil. Therefore, we aggregate the share of children between ten and thirteen years old working in each city of the Northeast region and estimate an event-study regression of the interaction of year dummies with a treatment indicator, where the treatment is being affected by the witches' broom outbreak, such as the one presented in figure 2.7, but as the share of children working as the dependent variable.

Figure 2.8 suggests a strong positive effect of the witches' broom outbreak on the probability of child work at the municipality level. The witches' broom increased the child labor in affected municipalities by 2.5 percentage points, an increase of 30% compared to the control group average. The effects appeared in 2000 and stood until 2010, even though the introduction of the National program against child labor (PETI) in 1996 and its expansion in 2002 when the program was coupled with the Brazilian cash transfer program Bolsa Família. Brazilian law also

[9]Estatuto Brasileiro da Crianca e do Adolescente - ECA. Law 8.069/1990. <http://www.planalto.gov.br/ccivil_03/leis/L8069.htm>

Figure 2.8: The short-term effect of witches' broom outbreak on the share of working children



Notes. The figure displays estimated coefficients of an event-study regression of the interaction of year dummies with a treatment indicator, where the treatment is being affected by the witches' broom outbreak, on the share of children working in municipalities in the Northeast of Brazil. Data is from the 1970, 1980, 1991, 2000, and 2010 censuses.

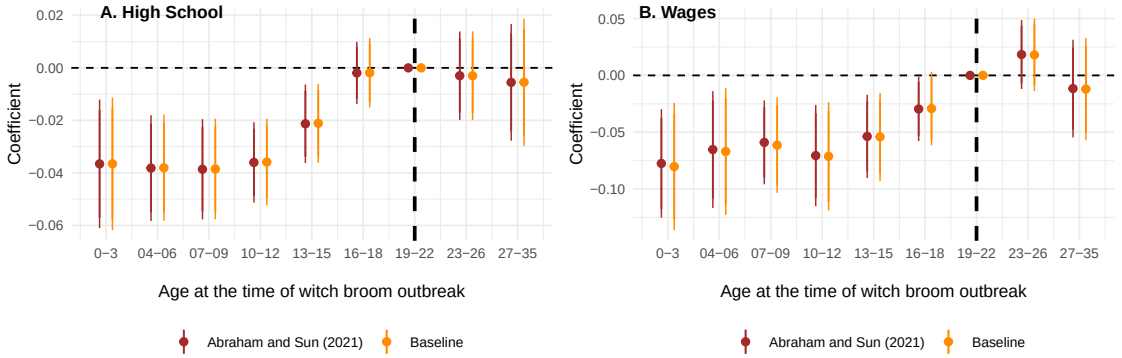
specifies stringent rules under which people between fourteen and seventeen can work. The main rule is that they can work short-term as an apprentice and restrict the activities they can do. However, because we cannot disentangle what would be child labor and what is apprentice work, we restrict our sample to people below fourteen years old, only.

To provide more evidence that the probable mechanism that led to the long-term impacts on education and health is child labor, we used a yearly national microdata survey called PNAD[10]. We used PNAD 1995 to create the appendix table B.2, because, in 1996, PETI was launched. This table shows in column 2 the share of children that works in cocoa in Bahia State, compared to the total number of children working in agriculture. Although the interviewed population of Bahia could indicate that they worked in 19 different broad agricultural productions at PNAD 1995, which can be disaggregated in almost 375 specific activities, cocoa production responded to 4.3% of all child labor in the agricultural sector of Bahia State in 1995.

Column 3 of appendix table B.2 shows the share of young individuals below eighteen years that works in cocoa and reported that they started working at the age i, in column 1. The denominator is the share of children that works in any other agricultural production and reported that they started working at the age i. Thus, in 1995, 18.2% of the individuals below eighteen that reported starting working at seven years old worked in cocoa production. Finally, column 4 shows the average age at which individuals started working per age group in 1995. It shows that individuals between ten and seventeen started working right after the first years of the witches' broom outbreak (1990). Unfortunately, the PNAD only provides information at the state level, and we cannot reproduce this table after 2000 due to changes in the methodology to define the

[10]Pesquisa Nacional por Amostra de Domicílios. It is usually indicated as a "micro census", nationwide representative, and also conducted by the Brazilian Bureau of Statistics - IBGE.

Figure 2.9: Long run consequences of witches' broom outbreak: Baseline vs Abraham and Sun (2021) estimator



Notes. The figure displays the baseline results for the probability of having completed high school and the log of earnings up to 20 years after the witches' broom outbreak and results for the estimator proposed by Abraham and Sun (2021) (). The horizontal axis shows the age at the moment of the witches' broom outbreak. The estimate corresponds to an ITT effect—to the estimated coefficient of Equation (2.1)—. Standard errors are clustered at the municipality level. Confidence intervals: 95% and 90%.

sectors.

Finally, appendix table B.3 adds by showing, using the Census data, that in 2000 the percentage of individuals that used to go to school or that never went is much higher in witches' broom-affected areas than in not affected areas. Besides, the difference is higher for individuals between eleven and twelve years old. Unfortunately, we cannot recover this information from the 1991 census.

2.4.4 Robustness

2.4.4.1 Staggered Difference-in-Differences

Section 2.2 and Figure 2.2 explain that the witches' broom outbreak had differential timing across municipalities. Therefore, the two-way fixed effect estimation can be biased (ROTH et al., 2022b). To overcome that, we estimate equation 2.2 using Sun e Abraham (2021a) estimator. Figure 2.9 suggests that the estimation presented in previous sections is not biased by the staggering outbreak of the disease since results from the baseline are qualitatively identical and quantitatively similar to the estimator proposed by Sun e Abraham (2021a). It is somewhat expected, given that we used a large number of never treated municipalities in the control group, the fact that treatments occurred in a short interval of time (1989 to 1992), and because the incubation period of the witches broom, indicating no clear reasons for the treatment effect to vary by treatment groups.

2.4.4.2 Migration

A potential concern is that migration could bias our results. Affected families may have migrated to other municipalities to find better employment opportunities. Since in our primary sample, we are only considering individuals born in the same municipality where they were interviewed

Figure 2.10: Long run consequences of witches' broom outbreak: Baseline vs non-movers

Notes. This Figure displays the baseline results and results considering the municipality of residence as a proxy for the municipality of birth. The probability of having high school and wages up to 20 years after the witches' broom outbreak are the dependent variables. The horizontal axis shows the age at the moment of the witches' broom outbreak. The estimate corresponds to an ITT effect—to the estimated coefficient of Equation (2.1)—. Standard errors are clustered at the municipality level. Confidence intervals: 95%.

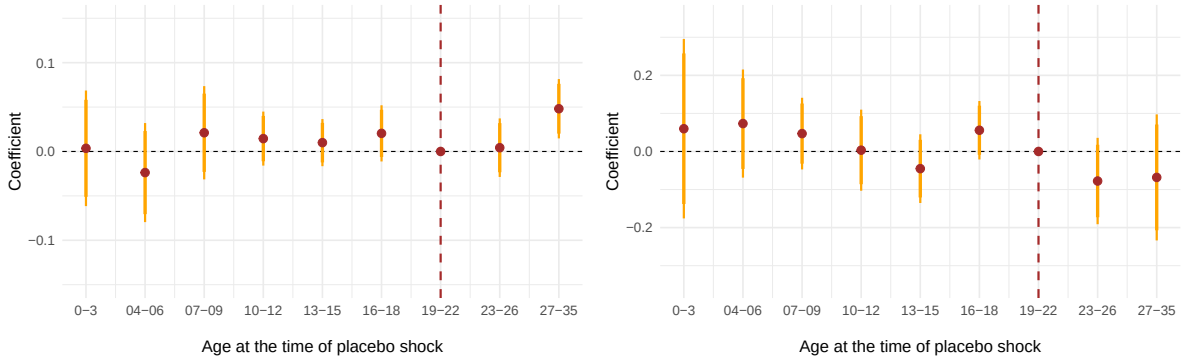
in the censuses, migration could lead to biased estimates. To check how much of an impact migration could have on our baseline estimates, Figure 2.4.4.2 compares our baseline results with the ones when considering the municipality of residence, whenever the birth municipality is. As can be seen in Figure 2.4.4.2, results don't change much across both specifications, indicating that if there is some bias due to migration, it is limited. Some historical documents report some migration within Ilhéus-Itabuna micro-region, in which migrants moved to the region's biggest municipalities, such as Porto Seguro, Ilhéus, and Itabuna, but not to other parts of the state or other states (UESC., 2015; PEREIRA; ALMEIDA; SANTOS, 1996; Ceplac, 2009; SERGIPE; ROCHA, 2006).

2.4.4.3 Placebo 1: idiosyncratic characteristics of affected municipalities

So far, we have shown how individuals' exposure in childhood to the witches' broom outbreak today have worse labor market and education outcomes than cohorts in municipalities not exposed to the shock. However, it might be the case that younger cohorts in treated municipalities were always worse off than the ones in non-treated municipalities because of the idiosyncratic characteristics of affected municipalities. To test if that is the case, we estimated equation 2.2 arbitrarily assigning a placebo shock in 1960 to the same municipalities that, in the future, will be affected by the witches' broom outbreak and look for differences in the same outcomes of individuals on the census of 1970 and 1980.

Due to limitations of the 1970s census, we do not have information on individual wages and use. Instead, family income is the dependent variable. We measure education using the number of years of schooling, a variable compatible between the 1970s and 1980s censuses. The sample is composed only of individuals in the Brazilian Northeast that have 0 to 35 years old in 1960. Figure B.6 presents the results of the falsification exercise. Since the 1970s and 1980s

Figure 2.11: The long-run consequences of a Placebo Treatment



(a) Income (b) Years of schooling

Notes. The figure displays the results of a placebo exercise using 1970s and 1980s census data and a fictional shock in 1960 on the municipalities that will be affected by the witches' broom in the future. The horizontal axis shows the age at the moment of the placebo shock. The estimate corresponds to an ITT effect—to the estimated coefficient of Equation (2.2)—. Standard errors are clustered at the municipality level. Confidence intervals: 95% and 90%.

censuses and interviews occurred before the witches' broom outbreak, we should not expect any difference in the labor market and education outcomes of cohorts' exposure in childhood to the placebo shock in the 60s. Indeed, as shown in Figure B.6, there is no difference in wages or years of schooling between younger and older cohorts' exposure and no exposure to the placebo shock, reinforcing the robustness of our baseline estimates.

2.4.4.4 Placebo 2: concurrent effects

In the previous sections, we assume that no other effects are affecting the cocoa producer region at the time of the outbreak. Those effects may arise due to price changes, global demand changes, or any other idiosyncratic shock affecting the region that we cannot observe. To rule out those potential effects, we run the following exercise. First, we drop all witches' broom-affected municipalities from the sample. Second, we assume that the municipalities with cocoa production that were not affected by the witches' broom are treated, and some idiosyncratic shock happened to them in 1990. Recall from figure 2.1 that there are some municipalities that were not affected. Third, we run equation 2.1 comparing the cocoa producer region net of witches' broom affected municipality against non-cocoa producer municipalities. The results are displayed in table 2.4. The results suggest that no other shock happened in the cocoa market simultaneously to the witches' broom disease.

2.5 Conclusion

This paper studies the long-run effects of a significant long-lasting shock in cocoa production in Brazil on education and the labor market. We explore the witches' broom outbreak in cocoa farms in the world's second most important cocoa production region until 1988, the southeast of

Table 2.4: Placebo analysis: concurrent effects

	High School (1)	Elementary School (2)	log(wages) (3)
Childhood exposure	-0.003	0.006	0.005
	(0.009)	(0.010)	(0.020)
R^2	0.075	0.100	0.208
Observations	4,538,411	4,538,411	1,838,953
Municipality FE	✓	✓	✓
Birt-year FE	✓	✓	✓
Census wave FE	✓	✓	✓

Notes. The Table displays the regression results of the estimation of equation 2.1 dropping municipalities affected by the witches' broom from the sample and considering cocoa producer municipalities not affected by the witches' broom as treated units, assigning 1990 as the treatment date. The estimate corresponds to an ITT effect—to the estimated coefficient of Equation (2.1)—. Standard errors are clustered at the municipality level.

Bahia's state in the northeast of Brazil.

Our results show that the witches' broom outbreak negatively affected the education and income of individuals living in affected municipalities. People below eighteen years old living in municipalities affected by the witches' broom disease have a 10.5% lower probability of having a high school degree, an 8% lower probability of having elementary school, and wages 4.8% lower.

Those effects are greater for individuals between zero and twelve years old during the witches' broom outbreak. We provide suggestive evidence that these long-run adverse effects on human capital and wages are explained by the aggregated impacts on cocoa production that led to a fall in the GDP per capita and household incomes since the witches' broom disease pushed the southeast region of Bahia to a recession period and pushed children in affected municipalities to start to work early.

CHAPTER 3

Let the Water Do the Work: Climate Adaptation Policies and Labor Market Outcomes

3.1 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 if 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

[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).

labor market outcomes of their household members. This allowed us to estimate the 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 e 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; OLKEN, 2014; ROCHA; SOARES, 2015b; DINKELMAN, 2017; CARRILLO, 2020a; BLAKESLEE; FISHMAN; 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 infrastructure. Many papers have primarily focused on the health benefits of improving access to water, such as Galiani, Gertler e Schargrodsky (2005), Kremer et al. (2011), Zhang (2012), Bhalotra et al. (2021), Marcus (2021). Furthermore, a study conducted by 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 e 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 e Zhou (2021), which use village-level data and estimate panel regressions showing that a water program in China increased off-farm employment.

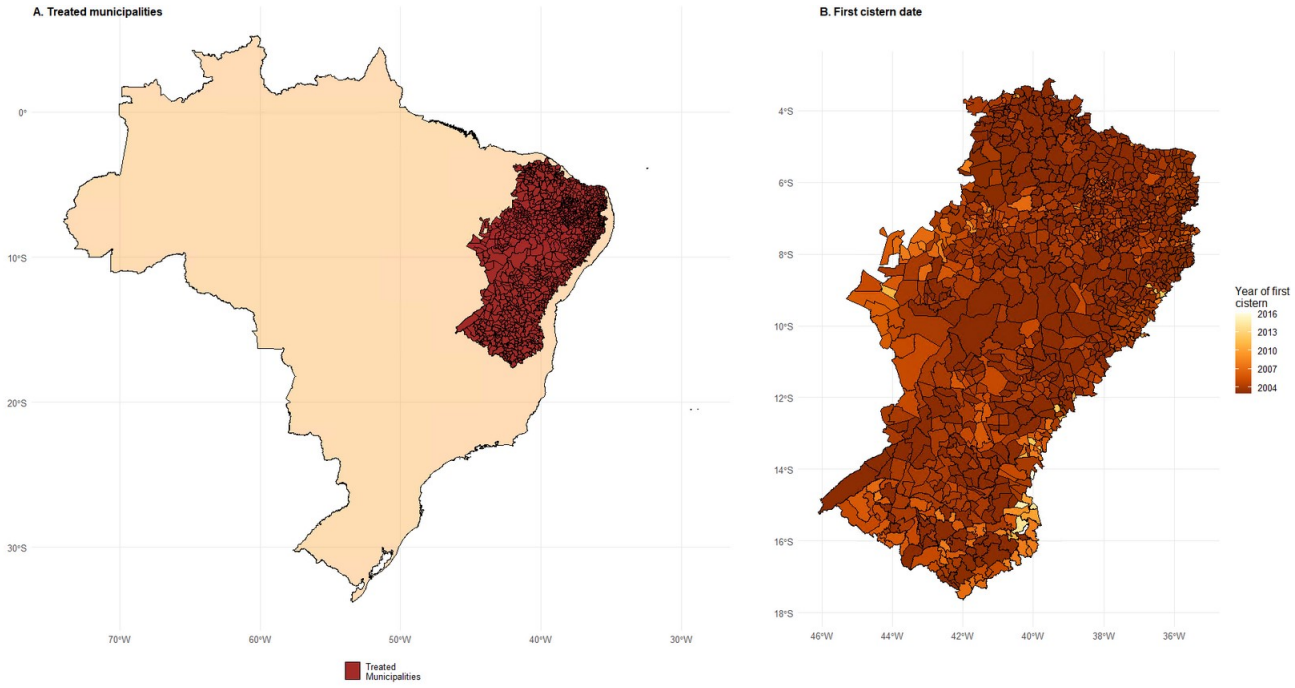
Finally, our paper is also connected to the existing literature exploring the effects of improved infrastructure on development outcomes. For instance, Dinkelman (2011) and Vidart (2023) discovered that providing households with electricity increased labor force participation. Additionally, Asher e Novosad (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.

3.2 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 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.

[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".

Figure 3.1: 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.

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 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).

3.3 Data and Reserach Design

3.3.1 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*

[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.

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.

3.3.2 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 e 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., 2022a). 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 3.1. Also, for inference, we follow (CALLAWAY; SANT'ANNA, 2021) bootstrapping procedure, adjusting for household clusters and, alternatively, for municipality clusters.[6]

$$ATT_l^w = \sum_g ATT(g, g+l) \tag{3.1}$$

It is important to note that the Doubly-Robust estimator is robust to treatment effect heterogeneity over time, reducing concerns raised by Sun e Abraham (2021b) 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 e 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 3.1, is that the researcher could look at each $ATT_{l<0}$ and empirically test if the parallel trends assumption holds.

3.4 Results

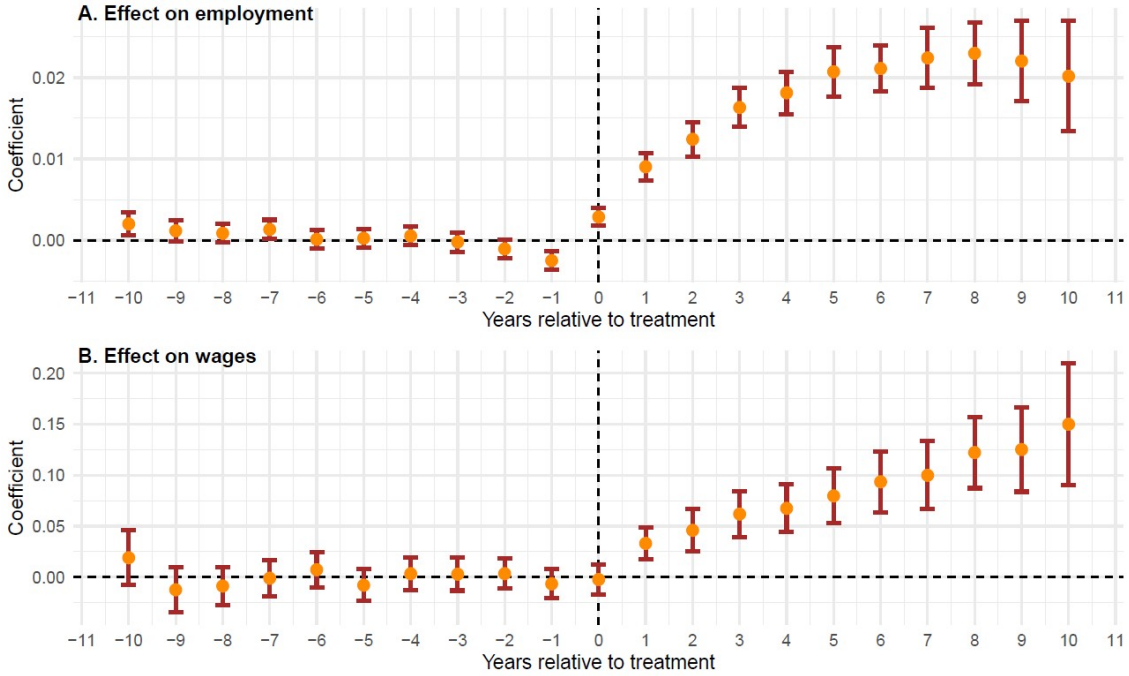
3.4.1 Employment and wages

Figure 3.2 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

[5] For a comprehensive discussion, one may refer to Callaway e Sant'Anna (2021) and Roth et al. (2022a).

[6] All estimates were obtained using the open-source R package *did*.

Figure 3.2: The effect of receiving a Cistern on labor market outcomes



Notes.This figure presents the event-study estimates using the Callaway e 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.

using the Callaway e 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, 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 3.1.

Table 3.1: 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 e 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.

Moreover, results in both panels A and B of Figure 3.2 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.

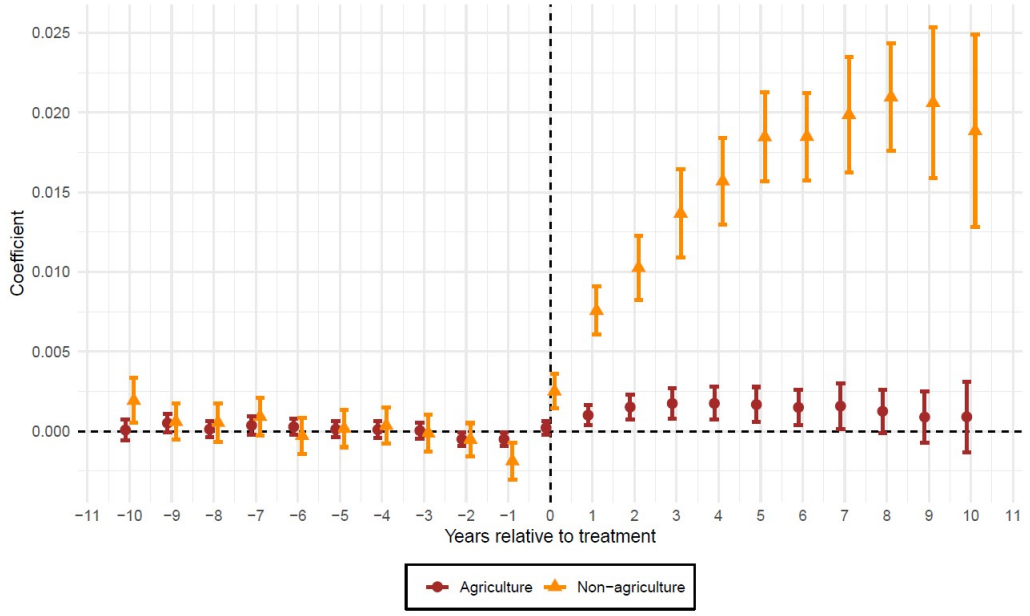
3.4.2 Off-farm work

Figure 3.3 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 C.4 presents the same results as Figure 3.3, but with a breakdown of off-farm jobs in three additional sectors. Industry and Construction are the two sectors where employment increased the most.

3.5 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 3.2 shows that most beneficiaries on the survey

Figure 3.3: The effect of receiving a Cistern on formal employment by sector



Notes. This figure presents the event-study estimates using the Callaway e 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.

Table 3.2: 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.

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.

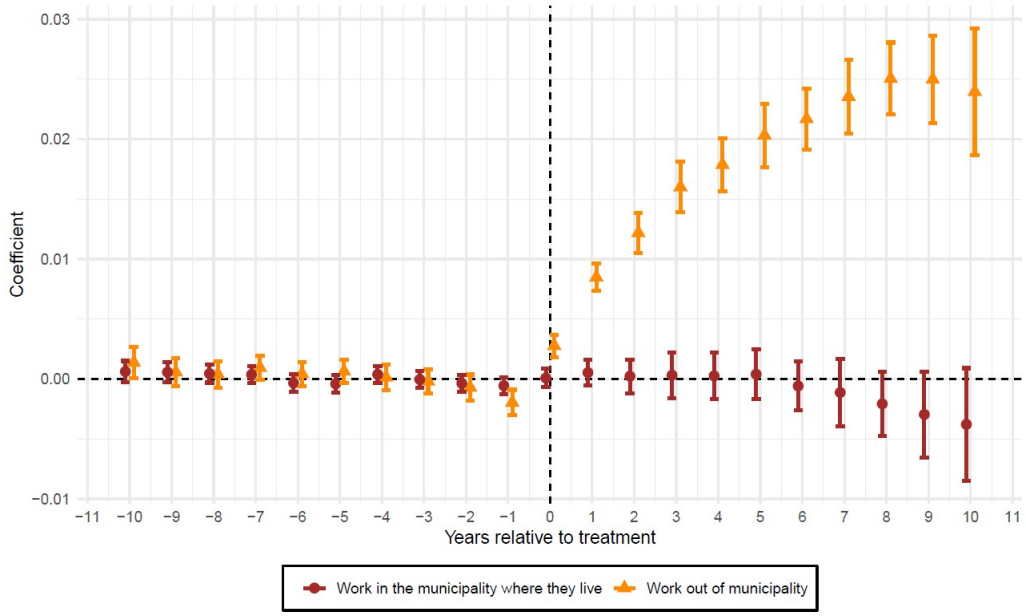
3.5.1 Heterogenous effects

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 3.3.2, 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 3.4.

The results displayed in Figure 3.4 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.

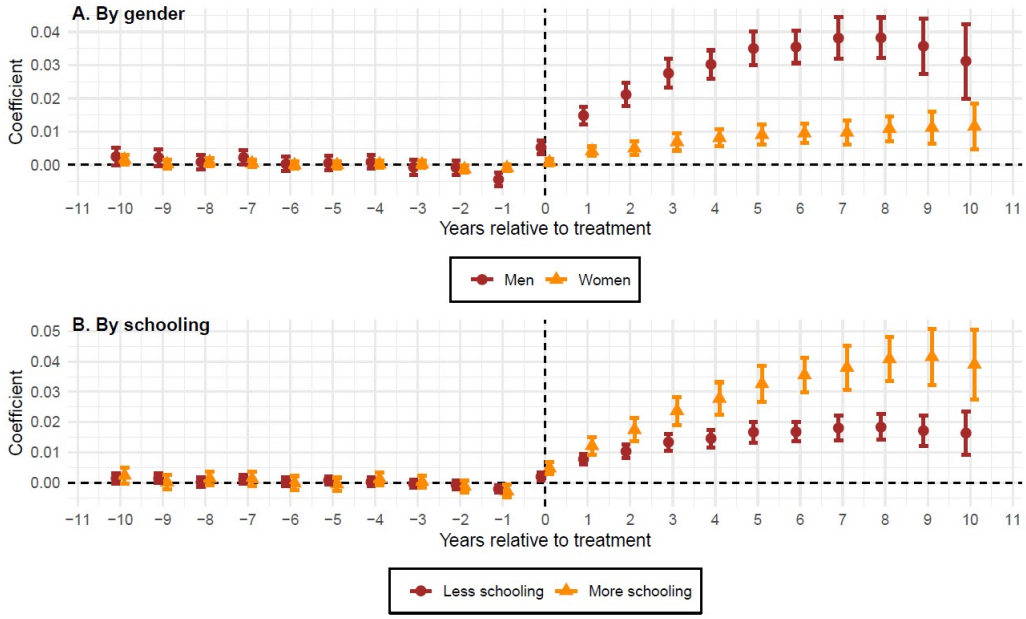
Our second step is to check which demographic groups are more affected by the policy. The idea behind this exercise is to test if the groups more prone to higher commuting times are the ones more affected, which would be a pattern consistent with the time-saving mechanism. We display the results in Figures 3.5 and 3.6. Our estimates show that the effect of receiving a cistern is stronger for young and more educated men, which strongly suggests that time

Figure 3.4: The effect of receiving a Cistern on formal employment location



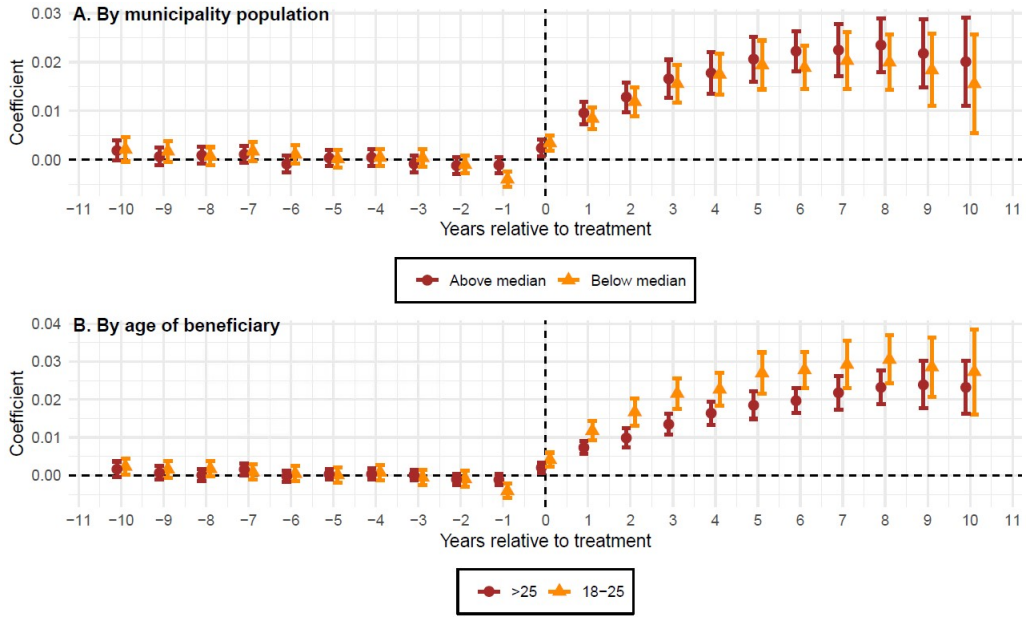
Notes. This figure presents the event-study estimates using the Callaway e Sant'Anna (2021) estimator with individual-level panel data spanning from 2002 to 2016. The control group consists of individuals who have not yet been treated, as well as those who received the cistern in 2017. In the yellow 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 3.5: The effect of receiving a Cistern on formal employment by gender and education



Notes. This figure presents the event-study estimates using the Callaway e 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 3.6: The effect of receiving a Cistern on formal employment by population and age



Notes.This figure presents the event-study estimates using the Callaway e 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.

allocation has a major role in explaining our results. These results are also consistent with the ones found by 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.

3.5.2 Alternative sample and outcomes

As discussed in Section 3.3.2, 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 3.3 presents the results obtained using the new restricted sample. To assess their

Table 3.3: 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 e 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.

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 3.1, 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 3.3. 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 3.3 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 3.3 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.

3.6 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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APPENDIX A

Women slavery and the roots of domestic labor

A.0.1 Data Sources and Variable Definitions

A.0.1.1 Variable definitions

A.0.1.2 18721's variables

Women's domestic Slavery (WDS) The number of female slaves working in "domestic services" in each municipality over the total population, according to the 1872 census.

Population density The total population of the municipality according to the 1872 census over the area (in km^2) of each municipality using borders of 1872. The area was computed based on the coordinates of each polygon representing the municipality.

Share literate Share of the literate population over total population in 1872.

Share of women Share of women (slaves and free) over the total population in each municipality, according to 1872 census.

Share manufacturing Municipality labor share in manufacturing over total population, according to the 1872 census.

Share agriculture Municipality labor share in agriculture over total population, according to the 1872 census.

Share public administration Municipality labor share in public administration over total population, according to the 1872 census.

Share foreingners Share of foreingners over total population in the municipality, according to the 1872 census.

A.0.1.3 Geographic variables

Latitude Computed latitude of the centroid of each municipality using the borders of 1872.

Longitude Computed longitude of the centroid of each municipality using the borders of 1872.

Distance to the coast Computed nearest distance (in km^2) from the centroid of each 1872 municipality from the coast of Brazil.

Altitude The average altitude of each municipality, reported in the "Cadastro de cidades e vilas" published by the Brazilian Census Bureau in 1998. Data gently made available by Naritomi, Soares e Assunção (2012).

Sunshine The average amount of sunshine during the day for the period of 1931 to 1990, expressed in 100 hours per year, obtained from the National Institute of Geology (INGEO). Data gently made available by Naritomi, Soares e Assunção (2012).

Rainfall The average quantity of water precipitation in each municipality for the period of 1931 to 1990, expressed in 100 millimeters per year, obtained from the National Institute of Geology (INGEO). Data gently made available by Naritomi, Soares e Assunção (2012).

Soils (10 predominant types) A set of 12 binary variables indicating the types of soil present in a 0.1 degree ray from the municipality's center, obtained from the Brazilian Agricultural Research Institute (EMBRAPA). Data gently made available by Naritomi, Soares e Assunção (2012).

A.0.1.4 2010's variables

Share of housemaids The share of female labor force (women aged bewteen 15 and 65 years old) working in "domestic service" in the municipality, according to 2010's census. We use the occupation codes equals to 9111 and 9112, defined as "workers in general domestic services".

Log GDP per capita The log of the Gross Domestic Product of municipalities in 2010 over total population. Data from IPEADATA.

HDI Human Development Index of Brazilian municipalities in 2010. Data from Atlas of Human Development in Brazil.

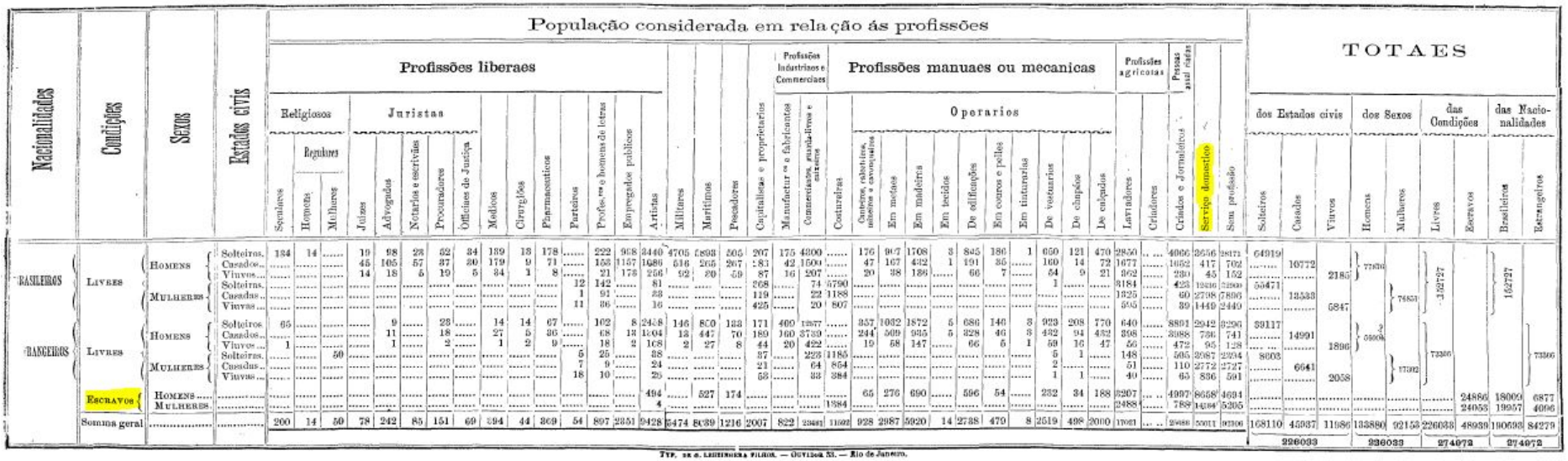
Share literate Share of the literate population over total population according to the 2010' census.

Share college Share of population with college degrees according to the 2010' census.

Share high school Share of population with completed high school according to the 2010' census.

Share urban Share of urban population according to the 2010' census.

Figure A.1: Example of original 1872-census tables from the Municipality of Rio de Janeiro.



População considerada em relação ás profissões

Nacionalidades	Condições	Sexos	Estados civis	Profissões liberaes: Religiosos — Seculares	Religiosos — Regulares — Homens	Religiosos — Regulares — Mulheres	Juristas — Juizes	Juristas — Advogados	Juristas — Notarios e escrivães	Juristas — Procuradores	Juristas — Officiaes de Justiça	Medicos	Cirurgiões	Pharmaceuticos	Parteiras	Profess.res e homens de lettras	Empregados publicos	Artistas	Militares	Maritimos	Pescadores	Capitalistas e proprietarios	Profissões industriaes e commerciaes — Manufactur.res e fabricantes	Profissões industriaes e commerciaes — Commerciantes, guarda-livros e caixeiros	Costureiras	Operarios — Caixeiros, cobradores, ajudantes e carroceiros	Operarios — Em metaes	Operarios — Em madeira	Operarios — Em tecidos	Operarios — De calçados	Operarios — Em couros e pelles	Operarios — Em tinturarias	Operarios — De vestuarios	Operarios — De chapéos	Operarios — De calçados	Profissões agricolas — Lavradores	Profissões agricolas — Criadores	Pessoas sem profissão — Criados e Jornaleiros	Pessoas sem profissão — Serviço domestico	Pessoas sem profissão — Sem profissão
BRASILEIROS	LIVRES	HOMENS	Solteiros.	134	14	.....	19	98	28	52	34	139	13	178	.....	222	968	3440	4705	5893	205	207	175	4200	.....	176	907	1708	3	845	186	1	950	121	470	2850	.....	4066	3656	2872
			Casados.	.....	.....	.....	45	105	57	37	20	179	9	71	.....	153	1157	1686	516	265	267	183	42	1500	.....	47	167	432	1	191	35	.....	160	14	72	1677	.....	1052	417	702
			Viuvos.	.....	.....	.....	14	18	6	19	5	34	1	8	.....	21	173	256	92	20	59	87	16	207	.....	20	38	186	.....	66	7	.....	54	9	21	962	.....	230	45	152
		MULHERES	Solteiras.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	142	.....	81	.....	.....	.....	268	.....	74	5790	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	8184	.....	423	13216	52930
			Casadas.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	93	.....	23	.....	.....	.....	119	.....	22	1188	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1825	.....	60	2708	7896
			Viuvas.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11	86	.....	16	.....	.....	.....	425	.....	20	807	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	595	.....	39	1449	2449
ESTRANGEIROS	LIVRES	HOMENS	Solteiros.	66	.....	.....	.....	9	.....	28	.....	14	14	67	.....	102	8	2428	146	860	133	171	469	1957	.....	357	1032	1872	5	686	146	3	923	208	770	640	.....	8801	2942	6296
			Casados.	.....	.....	.....	.....	11	.....	18	.....	27	5	35	.....	68	13	1204	13	447	70	189	160	3739	.....	244	509	935	5	328	46	3	432	94	452	398	.....	3988	756	741
			Viuvos.	1	.....	.....	.....	1	.....	2	.....	1	2	9	.....	18	2	168	2	27	8	44	20	422	.....	19	68	147	.....	66	5	1	59	16	47	55	.....	472	95	128
		MULHERES	Solteiras.	.....	.....	50	.....	.....	.....	.....	.....	.....	.....	.....	6	25	.....	38	.....	.....	.....	37	.....	223	1185	.....	.....	.....	.....	.....	.....	.....	6	1	.....	148	.....	505	2087	2294
			Casadas.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	9	.....	24	.....	.....	.....	21	.....	64	864	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	51	.....	110	2772	2727
			Viuvas.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18	10	.....	25	.....	.....	.....	58	.....	31	384	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	40	.....	65	836	591
	ESCRAVOS	HOMENS		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	494	.....	527	174	.....	.....	.....	.....	65	276	690	.....	596	54	.....	232	34	188	6207	.....	4997	8658	4694
		MULHERES		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	1584	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2488	.....	789	1484	5205
Somma geral				200	14	50	78	242	85	151	69	394	44	369	54	897	2351	9428	5474	8039	1216	2007	822	23401	11092	928	2987	5920	14	2738	479	8	2519	498	2000	17961	.....	29688	50011	9300

TOTAES

dos Estados civis — Solteiros	Casados	Viuvos	dos Sexos — Homens	Mulheres	das Condições — Livres	Escravos	das Nacionalidades — Brasileiros	Estrangeiros
64919	16772	2185	77870	76853	152727		152727	
55471	13533	6847						
53117	14991	1896	2 05909	17392	73306			73306
8603	6641	2058						
						24886	18009	6877
						24053	19957	4096
168110	45037	11086	133880	92153	226033	48939	190693	84279
226033			226033		274972		274972	

Typ. de o. Leuzinger e Filhos. — Ouvidor 53. — Rio de Janeiro.

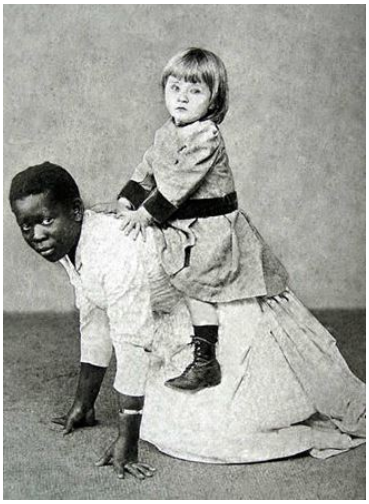
Table A.1: Summary Statistics

	Mean	Std. Dev.	N
Panel A.Vars in 1872			
Share slaves	0.141	0.104	597
Share Women Domestic Slaves (WDS)	0.017	0.016	597
Share women slaves	0.066	0.046	597
Population density	8.507	11.241	597
Share literate	0.148	0.086	597
Share women	0.489	0.025	597
Share employment manufacturing	0.002	0.004	597
Share employment agriculture	0.309	0.129	597
Share employment public administration	0.001	0.001	597
Share of foreingners	0.024	0.045	597
Panel B. Geography			
Latitude	-14.000	8.322	597
Longitude	-44.000	5.526	597
Distance to the coast (km)	220.000	270.000	597
Altitude	3.474	3.338	597
Sunshine (100 hours/year)	21.487	3.826	597
Rainfall (100 milimeters per year)	12.492	4.444	597
Argisol	0.317	0.466	597
Cambisol	0.117	0.322	597
Spondosols	0.012	0.108	597
Gleysols	0.017	0.128	597
Oxisol	0.312	0.464	597
Luvisols	0.059	0.235	597
Neosols	0.106	0.307	597
Nitosols	0.003	0.058	597
Planosols	0.050	0.219	597
Plinthosols	0.052	0.222	597
Panel C. Variables in 2010			
Share women in domestic ocupations	0.173	0.049	597
ln (Per capita GDP)	1.445	0.773	597
HDI	0.664	0.077	597
Share literate	0.838	0.094	597
Share college	0.042	0.030	597
Share high school	0.156	0.057	597
Share urban	0.708	0.206	597

Note: Variables in panels A correspond to socioeconomic characteristics for each municipality and year originally available from the 1872 census. Data for geographic variables are originally mainly from IBGE and other different sources detailed in the Appendix.

Figure A.2: Housemaids on the second half of 19th century.

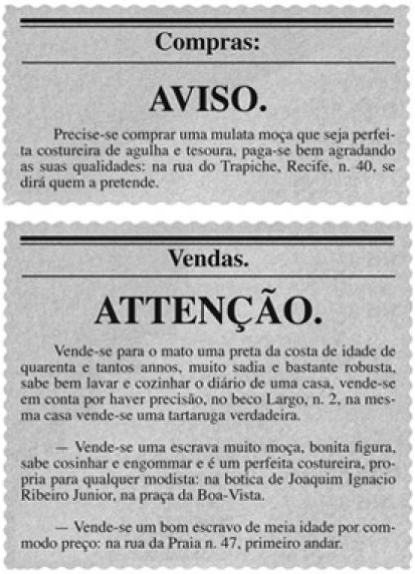
(a) Children posing with their nanny, 1890.



(b) Housemaid playing with a child in 1899, Rio de Janeiro.

Source: Koutsoukos (2007).

Figure A.3: Advertisements for the purchase and sale of slaves in newspaper. Recife, 19th century



Compras:

AVISO.

Precise-se comprar uma mulata moça que seja perfeita costureira de agulha e tesoura, paga-se bem agradando as suas qualidades: na rua do Trapiche, Recife, n. 40, se dirá quem a pretende.

Vendas.

ATTENÇÃO.

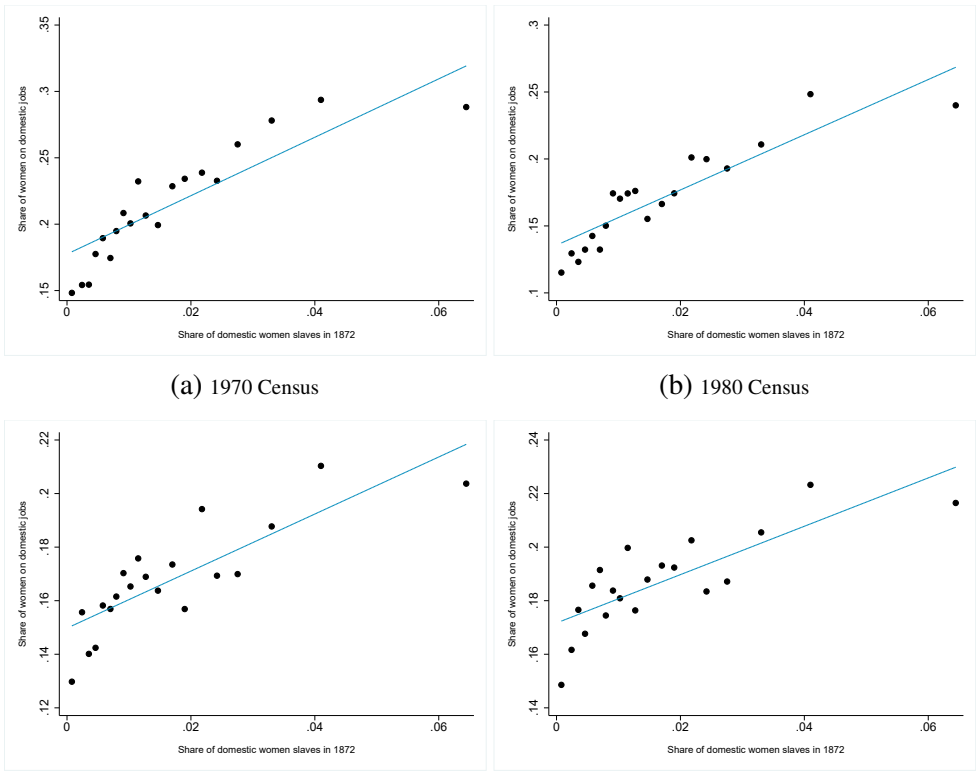
Vende-se para o mato uma preta da costa de idade de quarenta e tantos annos, muito sadia e bastante robusta, sabe bem lavar e cozinhar o diário de uma casa, vende-se em conta por haver precisão, no beco Largo, n. 2, na mesma casa vende-se uma tartaruga verdadeira.

— Vende-se uma escrava muito moça, bonita figura, sabe cosinhar e engommar e é um perfeita costureira, propria para qualquer modista: na botica de Joaquim Ignacio Ribeiro Junior, na praça da Boa-Vista.

— Vende-se um bom escravo de meia idade por commodo preço: na rua da Praia n. 47, primeiro andar.

Source: Freyre (2015)

Figure A.4: Binscatterplot: Historical exposure to women slavery and contemporary share of domestic workers in Brazilian municipalities - Different Census data.

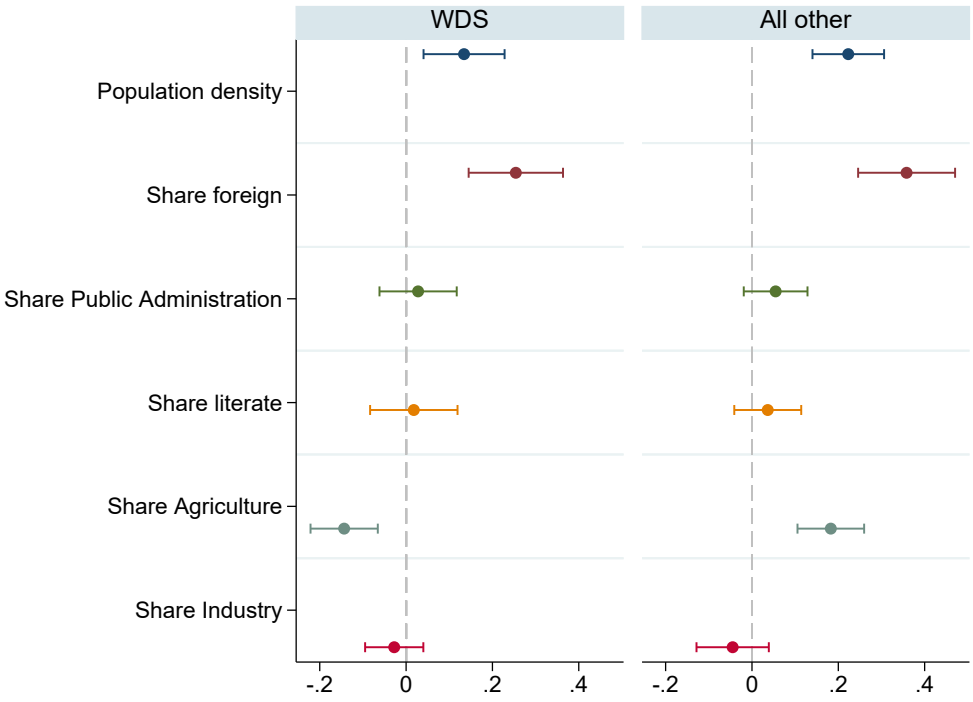


(a) 1970 Census (b) 1980 Census

(c) 1991 Census (d) 2000 Census

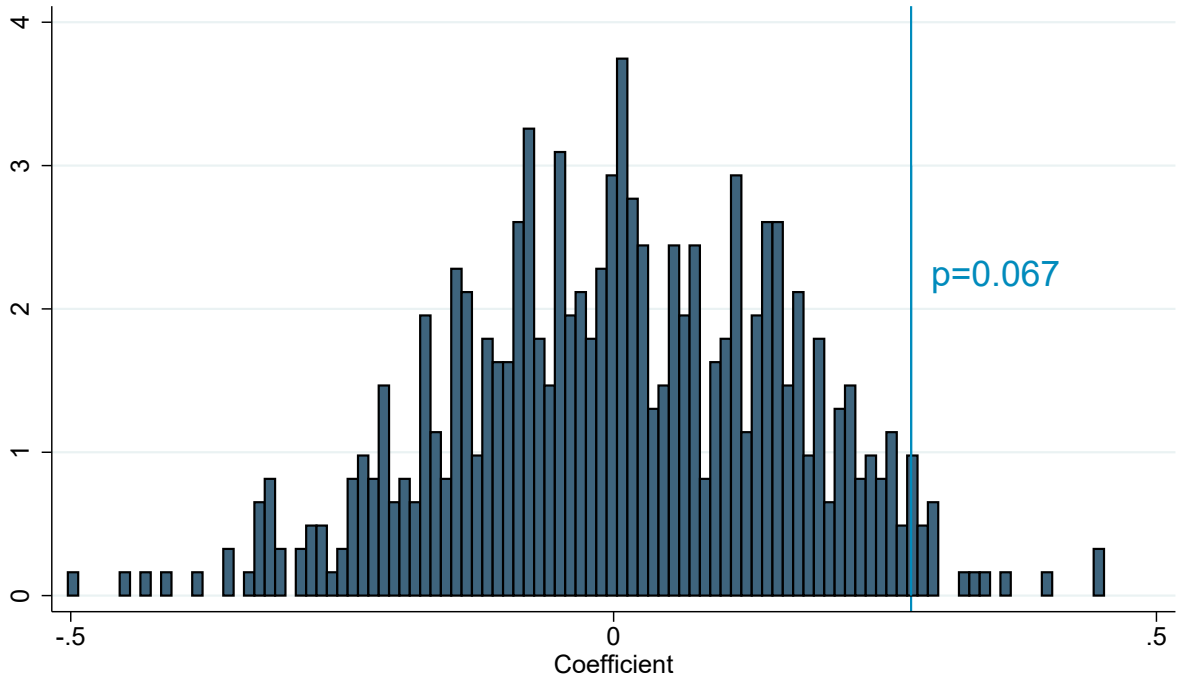
Notes: This figure present binscatterplots of the share of women domestic slaves and the share of female labor force in domestic jobs using data from four differents waves of Brazilian Census.

Figure A.5: WDS and municipality characteristics in 1872



Notes: This figure plot the standardized coefficients and 95% confidence intervals of simple regressions estimates of the relationship between the share of women domestics slavery and municipality characteristics in 1872.

Figure A.6: Permutation Test: Placebo women domestic slaves shares



Notes: This figure plot the distribution of placebo coefficients. We randomly assign each municipality a placebo domestic women slaves share, and re-estimate our main specification using the implied placebo treatment measure. This procedure is repeated 1000 times. The share of the 1000 absolute placebo coefficients that are larger than the absolute actual coefficient (0.293) is the p-value for the hypothesis that $\beta = 0$. The blue vertical line represent the true estimate.

Table A.2: The Long-run effect of women slavery on the share of women on domestic occupations in 2010: Baseline WLS estimates: Unweighted regressions

	(1)	(2)	(3)	(4)
WDS	0.553***	0.379***	0.210**	0.212**
	(0.122)	(0.114)	(0.106)	(0.107)
Observations	597	597	597	597
R-squared	0.031	0.185	0.329	0.340
Geography		✓	✓	✓
State FE			✓	✓
1872 Covariates				✓

Notes: [a] This table presents results from unweighted estimates of our baseline regression. The sample is composed by contemporary municipalities presented in 2010 Brazilian Census and matched from 1872 Census according to IBGE (2011). Robust standard errors in brackets. [b] *** p<0.01, ** p<0.05, * p<0.1

Table A.3: Conley (1999) Standard errors

	(1)	(2)	(3)	(4)
WDS	0.432***	0.448***	0.306***	0.332***
	(0.136)	(0.137)	(0.110)	(0.103)
Conley (1999) standard errors with distance cutoff:				
50 km	(0.102)***	(0.110)***	(0.106)***	(0.105)***
100 km	(0.131)***	(0.130)***	(0.0844)***	(0.0933)***
150 km	(0.152)***	(0.140)***	(0.0792)***	(0.0871)***
200 km	(0.155)***	(0.137)***	(0.0854)***	(0.0812)***
250km	(0.162)***	(0.145)***	(0.0774)***	(0.0736)***
Observations	597	597	597	597
R-squared	0.031	0.167	0.338	0.365
Geography		✓	✓	✓
State FE			✓	✓
1872 Covariates				✓

Notes: [a] This table presents (CONLEY, 1999) standard errors using difference distance cuttofs. [b] *** p<0.01, ** p<0.05, * p<0.1

Table A.4: Slavery and the share of men working as housemaids

2*	Men		Women	
	(1)	(2)	(3)	(4)
WDS	0.0550	0.0308	0.432***	0.332***
	(0.0355)	(0.0362)	(0.136)	(0.103)
Observations	597	597	597	597
R-squared	0.005	0.330	0.031	0.365
Geography		✓		✓
State FE		✓		✓
1872 Covariates		✓		✓

Notes:[a] This table presents regression results of different specifications of equation 1.2. Specifications on columns (1) and (2) use the share of men working in domestic occupations as dependent variable. In columns (3) and (4) the dependent variable is our baseline measure of women in working in domestic occupations. [b] *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A.5: The Long-run effect of slavery on the share of women on domestic occupations in 2010: Controlling for other slaves occupations

	(1)	(2)	(3)	(4)	(5)
WDS	0.332***	0.336***	0.338***	0.338***	0.336***
	(0.103)	(0.106)	(0.104)	(0.103)	(0.105)
Farms		-0.0268			
		(0.0883)			
Sewing			-0.283		
			(0.425)		
Fabrics				-0.464	
				(0.800)	
All other					-0.0270
					(0.0611)
Observations	597	597	597	597	597
R-squared	0.365	0.365	0.366	0.365	0.365
State FE	✓	✓	✓	✓	✓
Geography	✓	✓	✓	✓	✓
1872 Covariates	✓	✓	✓	✓	✓

Notes: [a] This table presents results from the estimation of equation 1.2. The sample is composed by contemporary municipalities presented in 2010 Brazilian Census and matched from 1872 Census according to IBGE (2011). We control for the share of female slaves in different occupations over total population in 1872. Robust standard errors in parenthesis . [b] *** p<0.01, ** p<0.05, * p<0.1, + p<0.105

Table A.6: The Long-run effect of slavery on the share of women on domestic occupations in 2010: Controlling for colonial institutions naritomi2012institutional

	(1)	(2)	(3)	(4)	(5)
WDS	0.341***	0.326***	0.324***	0.329***	0.324***
	(0.104)	(0.102)	(0.105)	(0.105)	(0.106)
Sugar boom	-0.00762				-0.00829
	(0.00899)				(0.0112)
Gold boom		0.0263***			0.0232**
		(0.00993)			(0.0111)
Coffee boom			-0.0139		-0.0102
			(0.0134)		(0.0152)
Distance to Portugal (km)				1.78e-05	3.60e-05
				(6.45e-05)	(6.17e-05)
Observations	597	597	597	597	597
R-squared	0.366	0.374	0.367	0.365	0.375
State FE	✓	✓	✓	✓	✓
Geography	✓	✓	✓	✓	✓
1872 Covariates	✓	✓	✓	✓	✓

Notes: [a] This table presents results from the estimation of equation 1.2. The sample is composed by contemporary municipalities presented in 2010 Brazilian Census and matched from 1872 Census according to IBGE (2011). We control for colonial institutions variables as defined by (NARITOMI; SOARES; ASSUNÇÃO, 2012). Robust standard errors in parenthesis . [b] *** p<0.01, ** p<0.05, * p<0.1, + p<0.105

Table A.7: The Long-run effect of slavery on the share of women on domestic occupations in 2010: Controlling for the share of free blacks

	(1)	(2)	(3)
WDS	0.332***	0.336***	0.336***
	(0.103)	(0.104)	(0.103)
Share free blacks		0.0339	
		(0.0401)	
Share of free black women			0.0449
			(0.0748)
Observations	597	597	597
R-squared	0.365	0.366	0.365
State FE	✓	✓	✓
Geography	✓	✓	✓
1872 Covariates	✓	✓	✓

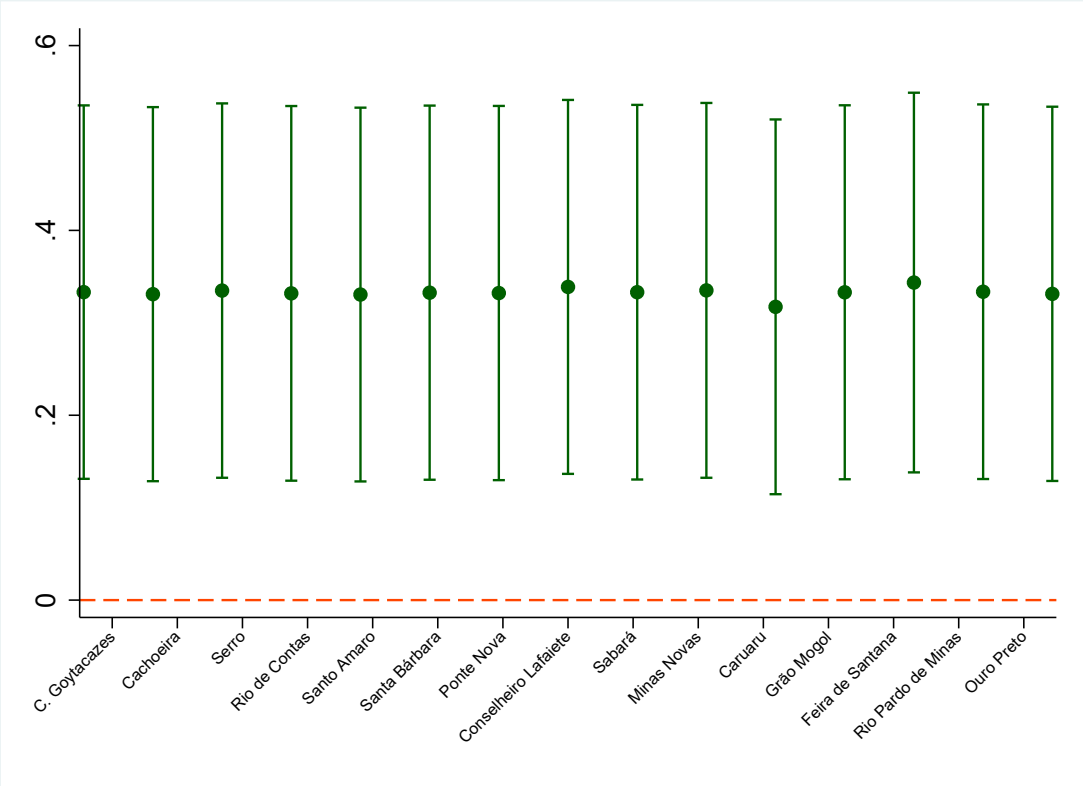
Notes: [a] This table presents results from the estimation of equation 1.2. The sample is composed by contemporary municipalities presented in 2010 Brazilian Census and matched from 1872 Census according to IBGE (2011). We control for the share of free blacks and the share of free black women over total population in 1872. Robust standard errors in parenthesis . [b] *** p<0.01, ** p<0.05, * p<0.1, + p<0.105

Table A.8: The Long-run effect of domestic women slavery on the share of FLF in domestic occupations in 2010 - Including state capitals in the sample

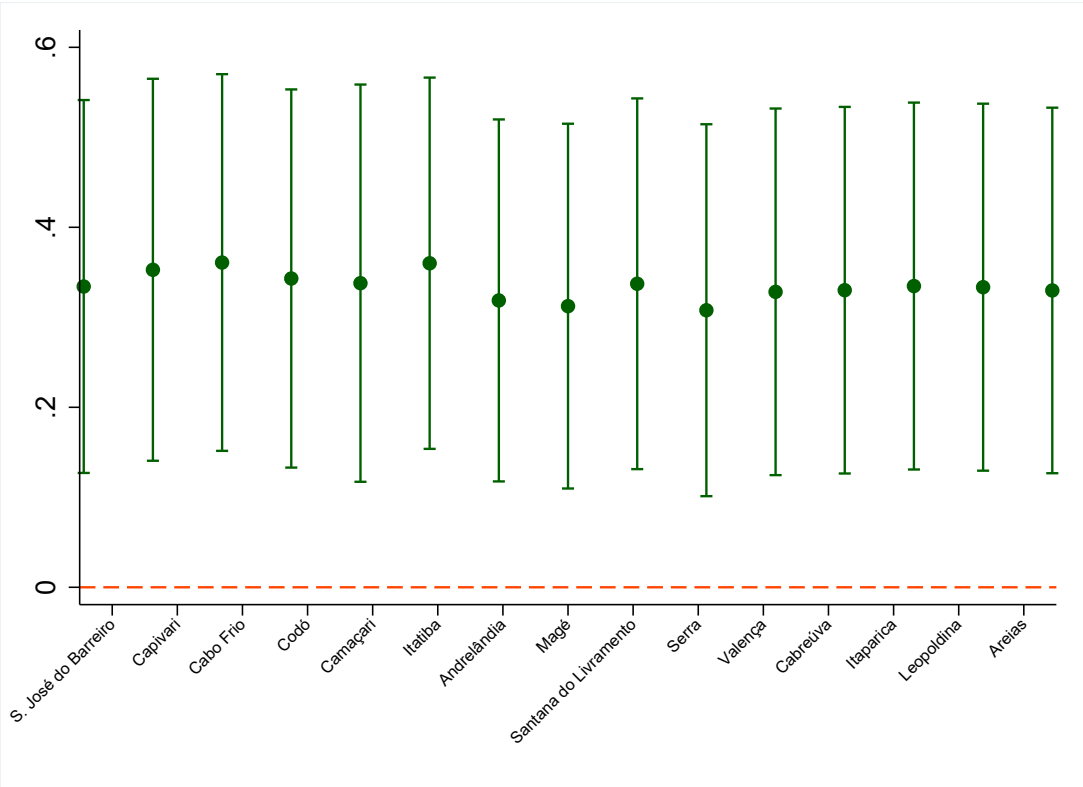
	(1)	(2)	(3)	(4)
WDS	0.352**	0.307*	0.423***	0.273**
	(0.158)	(0.161)	(0.123)	(0.126)
Observations	615	615	615	615
R-squared	0.160	0.096	0.231	0.393
Geography	✓		✓	✓
1872 Covariates		✓	✓	✓
State FE				✓

Notes:[a] This table presents regression results of different specifications of equation 1.2 including all 2010' state capitals in the sample. [b] Standard errors clustered at municipality-level in parenthesis . *** p<0.01, ** p<0.05, * p<0.1, + p<0.105

Figure A.7: Leaving-one-out: Dropping cities from the sample



(a) Dropping the 15 largest cities in 1872



(b) Dropping the 15 cities with higher share of domestic slaves in 1872

A.1 Instrumental Variables Analysis

Although unlikely, given the set of evidence showed before, is still possible that our results could be explained away by omitted variable bias. To alleviate such concerns we present results of alternative specifications using two measures of sugar cane agriculture suitability as instruments for women domestic slavery. As well documented in Brazilian historiography, sugar cane was one of the first major economic activities of the colony and was responsible for the first wave of African slaves dragged to the territory (ALGRANTI, 1997). By the time of Portuguese colonization in the 16th century, the absence of large amounts of gold mines, as in the Spanish America, made the colonizers install settlements for sugar cane production, due to previous experiences in other colonies. Therefore, regions presenting higher geographic suitability for sugar cane production historically imported more slaves than regions with lower suitability.

We use data from Brazilian Agricultural Research Corporation (EMBRAPA) and from the Food and Agriculture Organization of the United Nations. Using EMBRAPA data, we constructed an index that ranges from 0 to 3 that is based on the sugar cane agro-ecological zoning of Manzatto et al. (2009), which identified the presence of very suitable, suitable, with low suitability and unsuitable lands in Brazilian municipalities using agroclimatic measures.[1] The FAO's Global Agro-Ecological Zones (GAEZ) provides an alternative measure of sugar cane suitability. The data consists of agroclimatic measures of the maximum attainable yields (in tons per hectare per year) by grid-cells. We use attainable yields for rain-fed conditions and intermediate levels of inputs/technology. Using this data, we compute the average value of attainable yields for grid cells inside each municipality boundaries. In this analysis, due to the weak first-stage in other regions, we restricted our sample only to municipalities historically affected by the sugar cane economic boom of the 17th century, as defined by Naritomi, Soares e Assunção (2012). Figure A.8 highlights the 176 cities used in this sample while Figure A.9 displays the spatial distribution of our two sugar cane suitability measures.

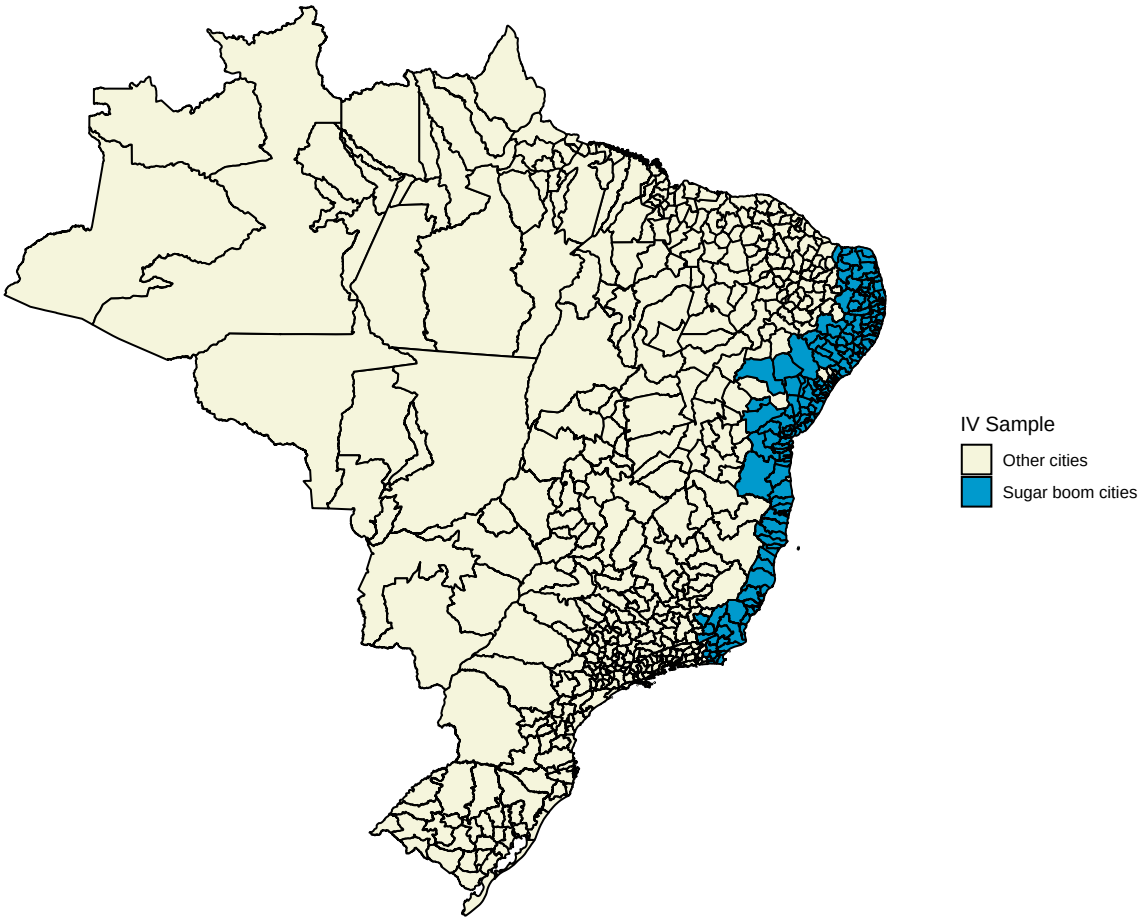
Second-stage (2SLS) regression results are displayed in Panel A of Table A.9. In both specifications, our results are qualitatively similar to our baseline WLS regressions reported in Table 1.1, but have larger magnitudes. Overall, standardized regression coefficients show that one standard deviation increase in the share of domestic women slaves in 1872 is associated with an increase in the 2010's FLF occupied in domestic services of about 0.67 to 1.15 of a standard deviation.

In Panel B of Table A.9 we present our first stage results, using our both measures of sugar cane suitability. To avoid measurement errors issues, we present estimates using the share of domestic women slavery, instrumented by sugar cane agriculture suitability. As can be seen in Table A.9 our first-stage results are robust and statistically significant in both specifications, with and without state fixed effects for our two instruments.

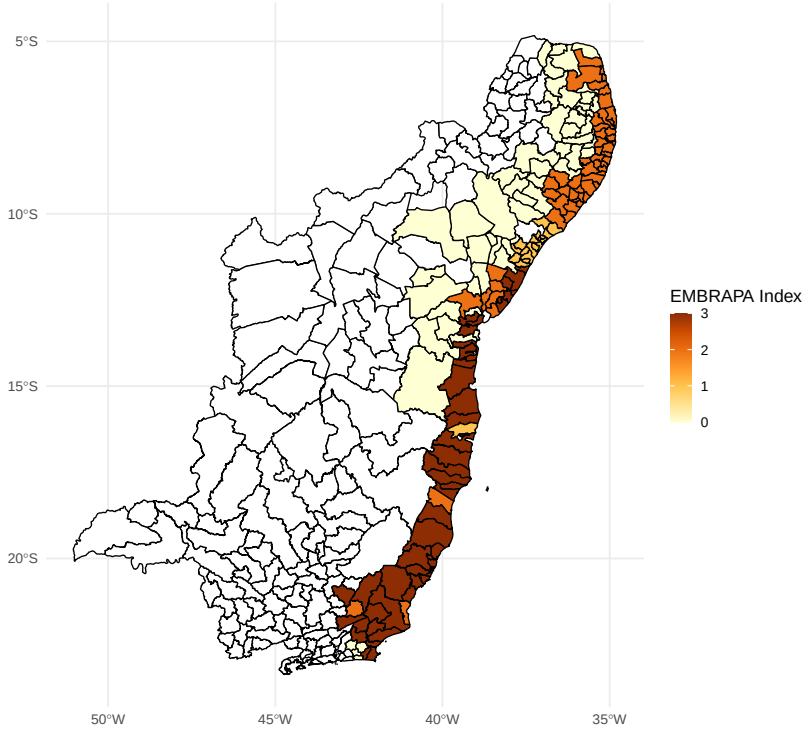
Finally, despite our instrument be arguably exogenous and the fact that agriculture suitability measures have been widely used as instruments for slavery on economic history literature

[1]The value of 3 is assigned if there is the presence of very suitable land in the municipality. If there are suitable portions of land and no very suitable land the index is assigned to 2. If there are only portions of land with low suitability and none with higher suitability, the index from this municipality is assigned to 1. Finally, if there are only unsuitable lands in the municipality, the index is equal to zero. The higher the index, the higher are the suitability of a given municipality to sugar cane production.

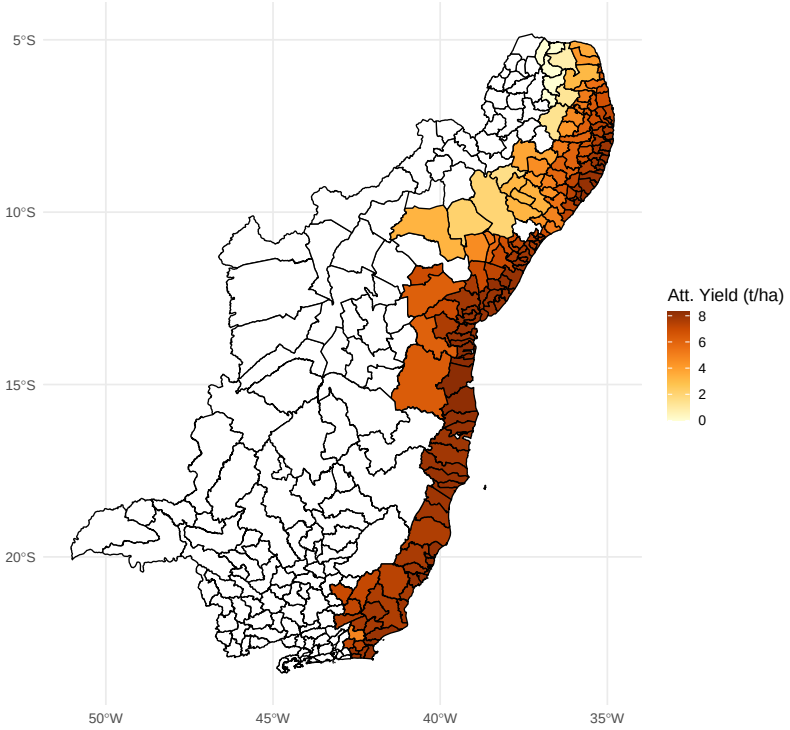
Figure A.8: Sugar Cane boom cities



Note: This figure highlights the municipalities affected by the sugar cane boom, as defined by (NARITOMI; SOARES; ASSUNÇÃO, 2012). These municipalities compose the sample used in the instrumental variables analysis. The map shows municipality boundaries of Brazil in 1872.



(a) EMBRAPA Index



(b) FAO Attainable Yields (t/ha)

Figure A.9: Sugar cane suitability measures

Notes: These figures shows the spatial distribution of the EMBRAPA sugar cane suitability index (Panel (a)) and FAO agro-climatic attainable yield for sugar cane (Panel (b)) in the sugar cane boom area of influence.

Table A.9: Slavery and domestic occupations: IV Estimates

3*	Panel A: IV second stage				2*OLS	
	EMBRAPA Index		FAO Att. Yield			
	(1)	(2)	(3)	(4)	(5)	(6)
WDS [Std.]	0.324*	0.670*	0.590***	1.150***	0.178***	0.180**
	(0.177)	(0.363)	(0.217)	(0.355)	(0.0602)	(0.0700)
Observations	175	175	176	176	176	176
State FE		✓		✓		✓
	Panel B: First stage					
	(1)	(2)	(3)	(4)		
EMBRAPA Index [Std.]	0.461***	0.281**				
	(0.120)	(0.121)				
FAO Att. Yield [Std.]			0.510***	0.386***		
			(0.147)	(0.127)		
Observations	175	175	176	176		
R-squared	0.199	0.302	0.080	0.285		
State FE		✓		✓		
F-stat	14.85	5.845	12	9.926		

Notes: [a] Instrumental variables estimate of the effect of slavery on the contemporary share of women working in domestic occupations, using suitability for growing sugar cane and distance to the coast as instruments. Robust standard errors in brackets. [b] *** p<0.01, ** p<0.05, * p<0.1, + p<0.105

(ACHARYA; BLACKWELL; SEN, 2016b; RUBIO, 2019) our results still depend on the exclusion restriction assumption to hold, that is results in Table A.9 are trustful as long as sugar-cane suitability affects the contemporary share of the female labor force on domestic occupations only through its effect on slavery. If, for example, cities with higher suitability for sugar-cane crops have developed other institutions that affected the existence of domestic service today, we would not be able to claim that our identification strategy is plausible. Although this assumption cannot be definitively tested, we assessed its plausibility by running an empirical exercise in the same spirit as Nunn e Wantchekon (2011) and Acharya, Blackwell e Sen (2016b).

Our empirical exercise consists in estimate reduced-form regressions of our dependent variable on sugar-cane agriculture suitability for cities located in different regions where there are no historical records of slave plantations of sugar, so there is no relationship between sugar-cane suitability and slavery. Using Naritomi, Soares e Assunção (2012) measures of exposition to economic booms that made use of forced labor in Brazil, we split our main sample in cities exposed to the sugar cane boom (our IV sample), gold boom, and coffee boom and estimated this reduced form specification. If our suitability measure affected the contemporary share of FLF on domestic occupations only through slavery, we should only find statistically significant results on our IV sample. Results from this falsification exercise are displayed in Table A.10 and strongly suggest that the exclusion restriction holds. That is, our sugar-cane suitability measure only affects our dependent variable in cities where it is related to slavery. In the gold boom cities and coffee boom cities, point estimates are very close to zero and also are not statistically significant at conventional levels.

Table A.10: Reduced form relationships between sugar cane suitability and share of women on domestic occupations

2*	Sugar boom		Gold boom		Coffee boom	
	(1)	(2)	(3)	(4)	(5)	(6)
EMBRAPA Index	0.00918**		0.000546		0.00291	
	(0.00384)		(0.00319)		(0.00303)	
FAO Att. Yield		0.00971***		-0.000393		-0.00158
2*		(0.00286)		(0.00156)		(0.00497)
Observations	175	176	140	143	153	157
R-squared	0.208	0.260	0.399	0.399	0.123	0.110
State FE	✓	✓	✓	✓	✓	✓

Notes: [a] *** p<0.01, ** p<0.05, * p<0.1, + p<0.105

APPENDIX B

The long-run effects of a permanent agricultural shock on education and earnings

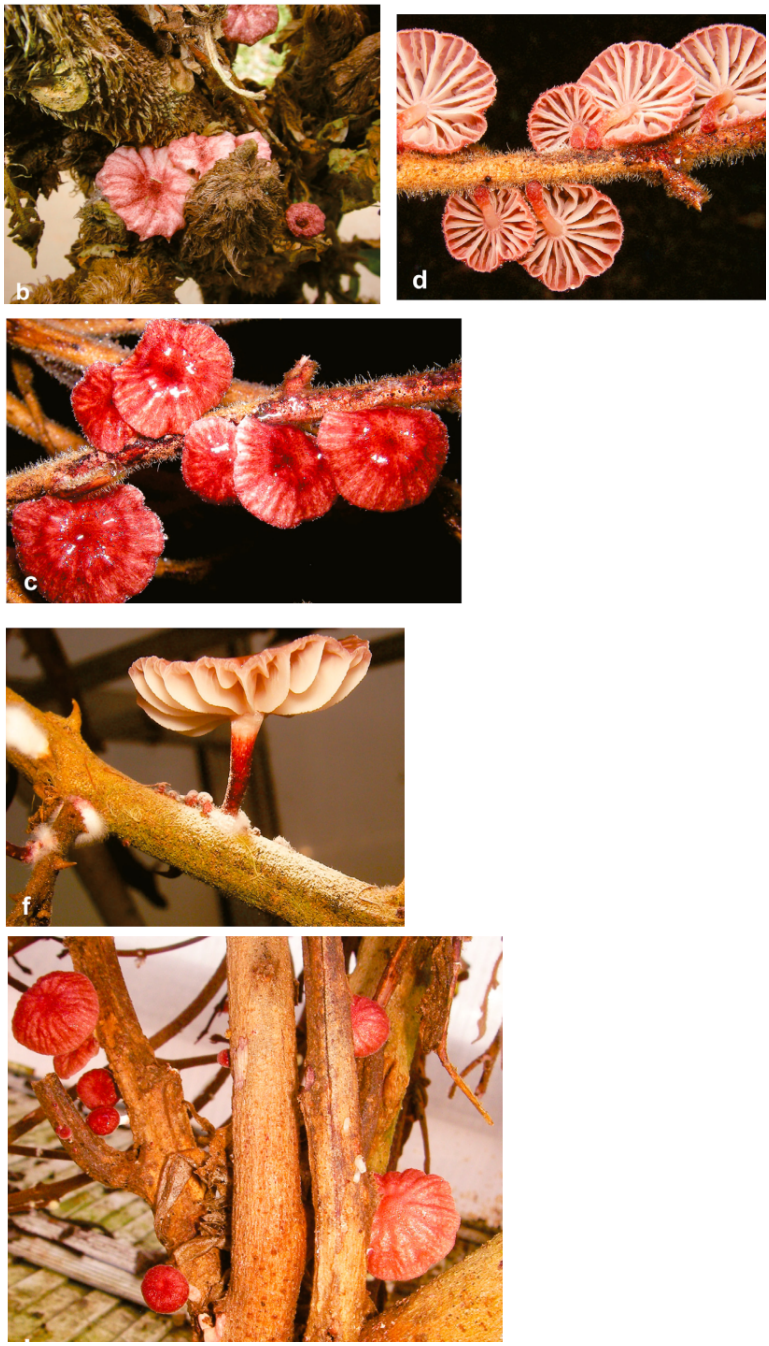
Figure B.1: Healthy cocoa

source: <https://agresearchmag.ars.usda.gov/2005/oct/cocoa/>

Figure B.2: Cocoa with witches' broom

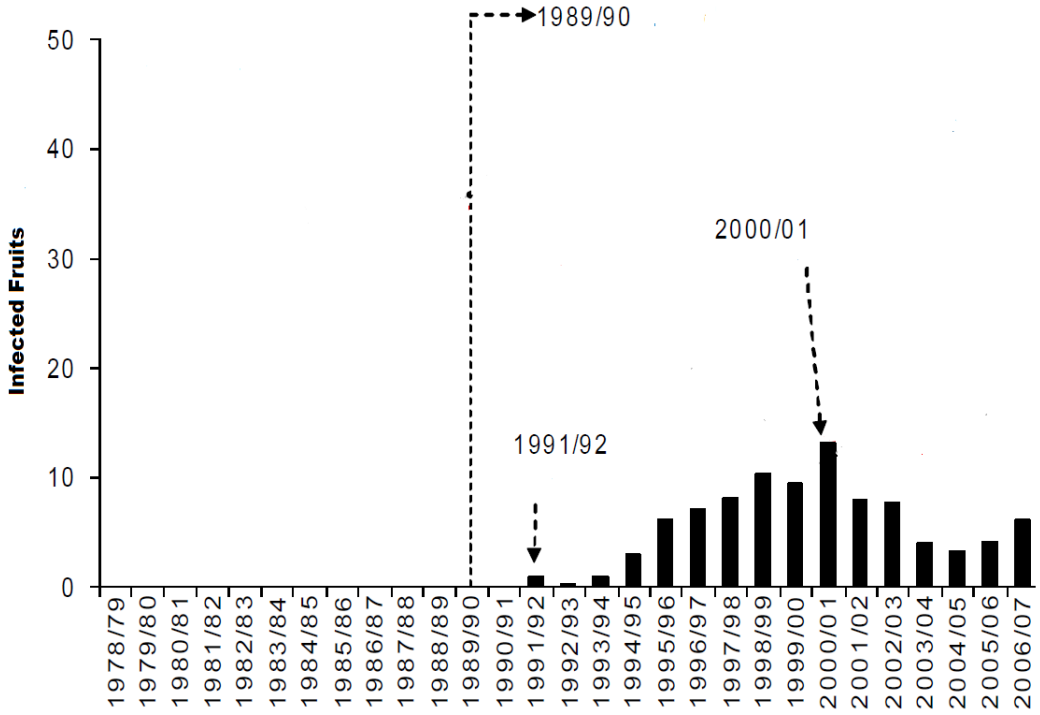
source: <https://agresearchmag.ars.usda.gov/2005/oct/cocoa/>

Figure B.3: Different types of witches' broom mushroom



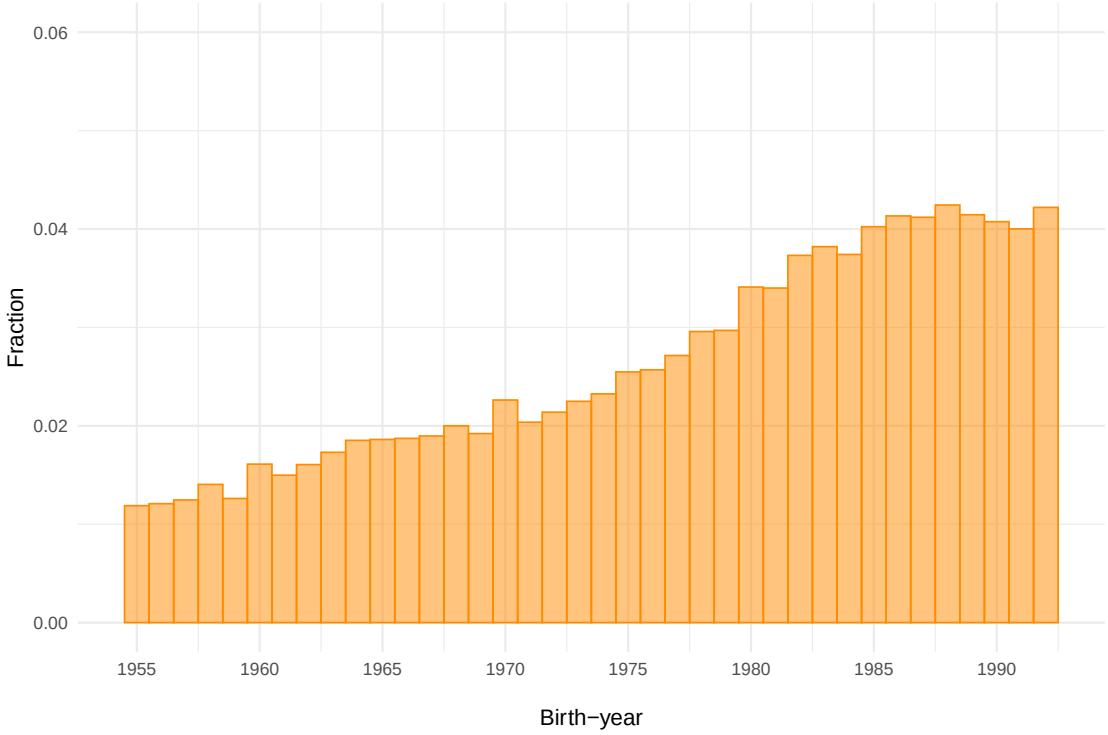
source: (LISBOA et al., 2020)

Figure B.4: Tons of cocoa fruits infected with the witches' broom by year



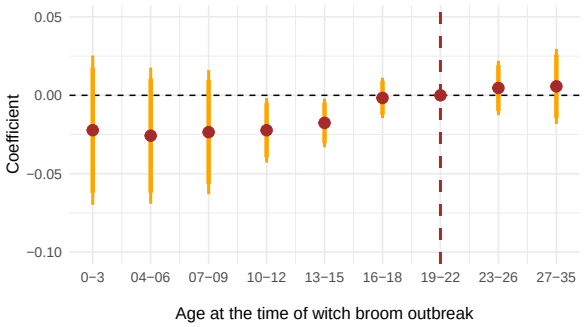
Source: adapted from (Ceplac, 2009). Note: this graph is based on a representative sample of 139 farms in the cocoa produced region. The CEPLAC and the Ministry of Agriculture do not have information about the number contaminated fruits per municipality and year throughout the time.

Figure B.5: Birth cohorts in estimation sample



Notes: This figure presents the birth cohorts in our estimation sample. Source: Brazilian census (2000-2010).

Figure B.6: The long-run consequences of Witch-broom - alternative control group including only Bahia state

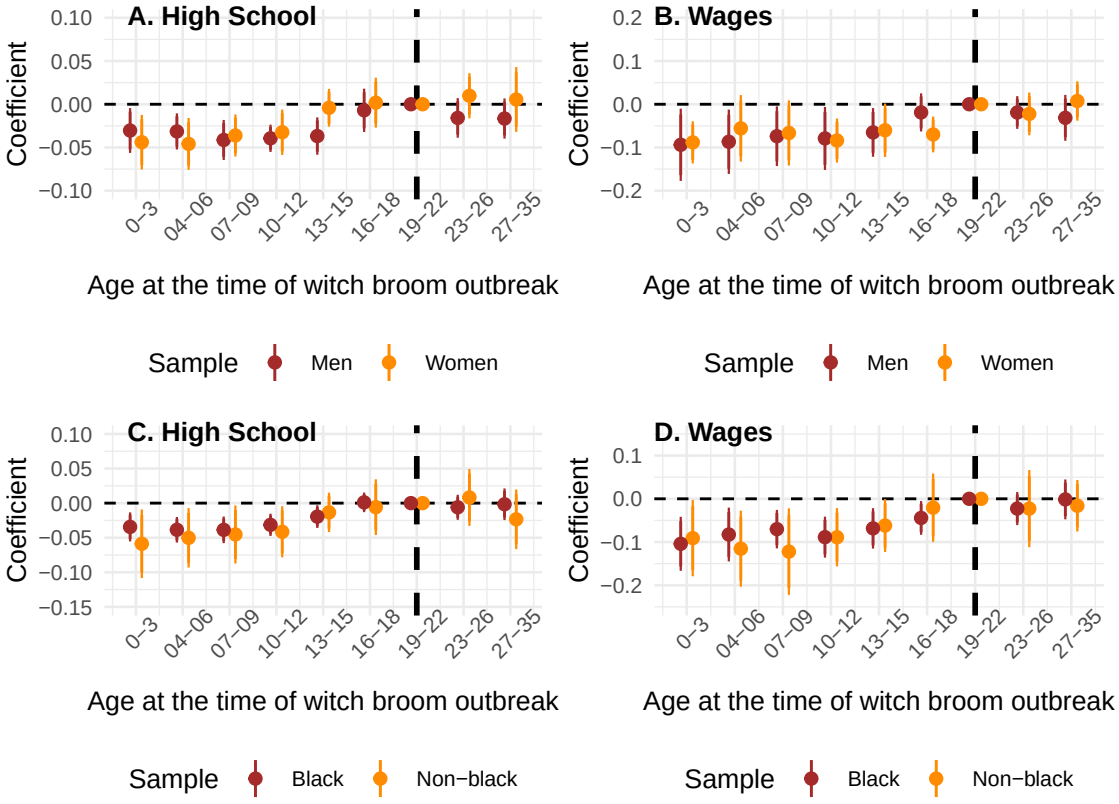


(a) High School

(b) Wages

Notes. The figure displays the results for the probability of having high school and wages up to 20 years after the witches' broom outbreak. The control group includes only municipalities in the state of Bahia. The horizontal axis shows the age at the moment of the witches' broom outbreak. The estimate corresponds to a ITT effect—to the estimated coefficient of Equation (2.2)—. Standard errors are clustered at the municipality level. Confidence intervals: 95%.

Figure B.7: Long run consequences of witches' broom outbreak by gender and race



Notes. The figure displays results for heterogenous effects by race and gender. The probability of having high school and wages up to 20 years after the witches' broom outbreak are the dependent variables. The horizontal axis shows the age at the moment of the witches' broom outbreak. The estimate corresponds to an ITT effect—to the estimated coefficient of Equation (2.1)—. Standard errors are clustered at the municipality level. Confidence intervals: 95%.

Table B.1: witches' broom effect by race

	High School (1)	Elementary School (2)	log(wage) (3)
Childhood exposure	-0.031***	-0.031***	-0.066**
	(0.011)	(0.012)	(0.031)
Childhood exposure * Black	0.004	-0.002	-0.003
	(0.011)	(0.012)	(0.021)
R^2	0.086	0.117	0.224
Observations	5,031,826	5,031,826	1,927,801
Municipality FE	✓	✓	✓
Birth-year FE	✓	✓	✓
Census wave FE	✓	✓	✓
Black × Municipality FE	✓	✓	✓
Black × Birth-year FE	✓	✓	✓
Black × Census wave FE	✓	✓	✓

Notes. The Table displays the baseline regression results of the estimation of equation 2.1 and also results for the interaction of the childhood exposure dummy with a dummy equal to one if the individual is black as in (CLAY; SCHMICK; JUSTER, 2021). The dependent variable in columns (1) and (2) is a dummy that equals one if the individual completed high school. Finally, in columns (3) and (4), the dependent variable is the log of wages. The estimate corresponds to a ITT effect—to the estimated coefficient of Equation (2.1)—. Standard errors are clustered at the municipality level.

Table B.2: Percentage of individuals younger than 18 years old working in the cocoa, compared to other agricultural productions in Bahia state in 1995

max width=1max totalheight=1keepaspectratio,center

Age i	# child working - cocoa / # child working in any agr. /	# age child working in cocoa started # age child working in any agr. started	Average starting / working age
5		9.5%	
6		17.6%	
7		18.2%	
9		3.3%	
10	9.4%	3.1%	8.33
11	5.1%	5.9%	8.50
12	2.2%	6.1%	8
13	2.3%	6.4%	10
05-13		5.9%	
10-13	4.3%	4.2%	
14	4%	11.5%	7.99
15	6%	27.3%	10.85
16	6%	50.0%	9.8
17	11%	10.76	

Notes. The table displays in column 1 the age indicator. Column 2 displays the share of children working in cocoa in Bahia state (on the total of children working in any agriculture production in the state). This should be interpreted as: 5.1% of all children with eleven years, in 1995, working in Bahia is working at cocoa production. Column 3 should be interpreted as 6.4% of all people below eighteen years old that is working in Bahia in 1995, works in cocoa production, and started working at eleven years old. Finally, the last column shows the average starting working age of children that was working in cocoa production in 1995.

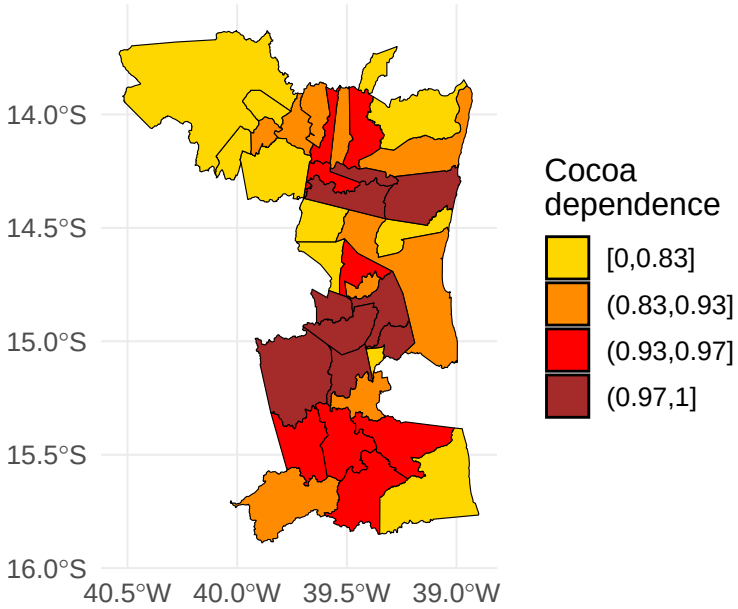
Table B.3: Percentage of individuals younger than 18 years old that are enrolled in school or kindergarten in 2000

max width=1max totalheight=1keepaspectratio,center

	witches' broom municipalities				Others			
	Yes, priv.	Yes, Pub.	No, but used to	Never	Yes, priv.	Yes, Pub.	No, but used to	Never
10	0.0	92.9	7.1	0.0	0.6	92.4	4.7	2.2
11	0.0	81.6	13.2	5.3	0.6	92.8	4.0	2.5
12	0.0	75.9	17.2	6.9	0.5	91.0	5.9	2.6
13	1.5	75.0	14.7	8.8	0.7	87.6	8.8	2.9
14	1.6	68.8	26.4	3.2	0.7	82.8	13.5	3.0
15	0.5	67.4	29.5	2.6	0.7	73.8	21.7	3.9
16	0.0	52.6	39.9	7.5	0.6	63.6	31.3	4.5
17	0.4	44.5	46.3	8.9	0.6	52.2	41.7	5.6

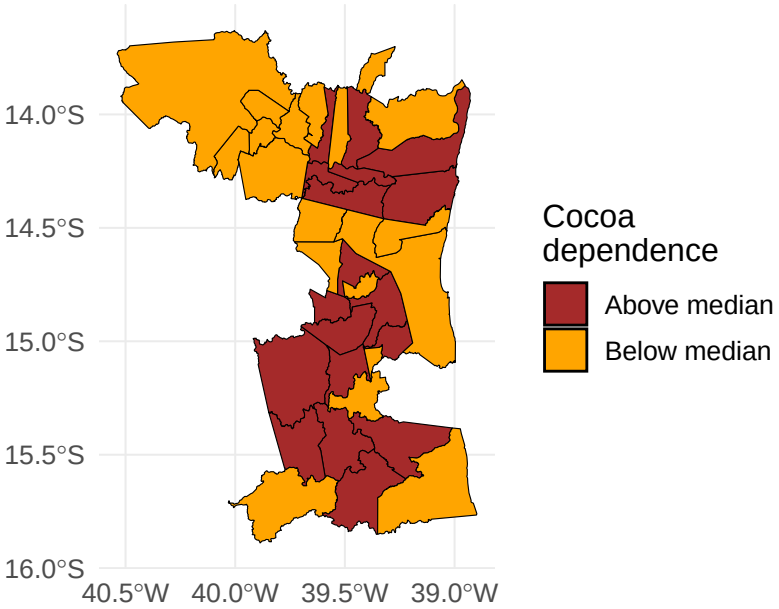
Notes. The table display, using the 2000 census, the percentage of individuals younger than 18 years old that are enrolled in school or kindergarten in 2000. They are split into two groups, regions affected and not affected by the witches' broom. Yes, priv = yes, she is studying in a private school. Yes, Pub = yes, she is studying in a public school. No, but used to = no, she is not studying, but she used to study. Never = she never ever studied.

Figure B.8: Cocoa dependence in municipalities affected by the witches' broom disease



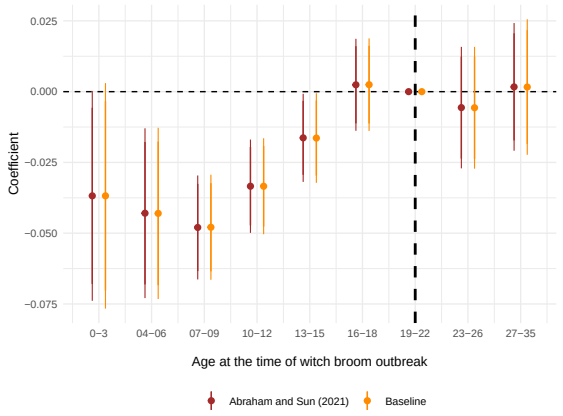
Notes. The figure plots the spatial distribution of an index of cocoa dependence in municipalities affected by the witches' broom. The index is the share of cocoa production over total agriculture production on the municipality in 1988, a year before the first witches' broom outbreak.

Figure B.9: Cocoa dependence in municipalities affected by the witches' broom disease



Notes. The figure plots the spatial distribution of an index of cocoa dependence in municipalities affected by the witches' broom. The index is the share of cocoa production over total agriculture production on the municipality in 1988, a year before the first witches' broom outbreak.

Figure B.10: Baseline estimates vs Abraham and Sun (2021) estimator - Elementary school

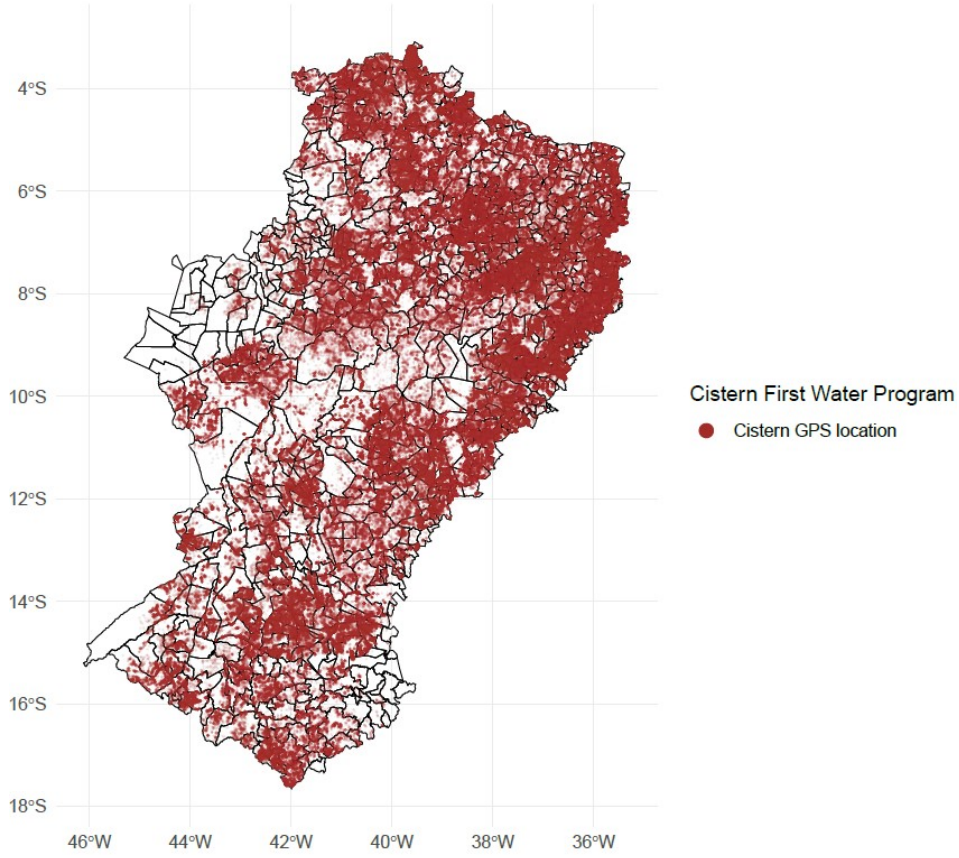


Notes. The figure displays the baseline results for the probability of having completed elementary school and the log of earnings up to 20 years after the witches' broom outbreak and results for the estimator proposed by Abraham and Sun (2021) (). The horizontal axis shows the age at the moment of the witches' broom outbreak. The estimate corresponds to a ITT effect—to the estimated coefficient of Equation (2.1)—. Standard errors are clustered at the municipality level. Confidence intervals: 95%.

APPENDIX C

Let the Water Do the Work: Climate Adaptation Policies and Labor Market Outcomes

Figure C.1: Cisterns geographical distribution

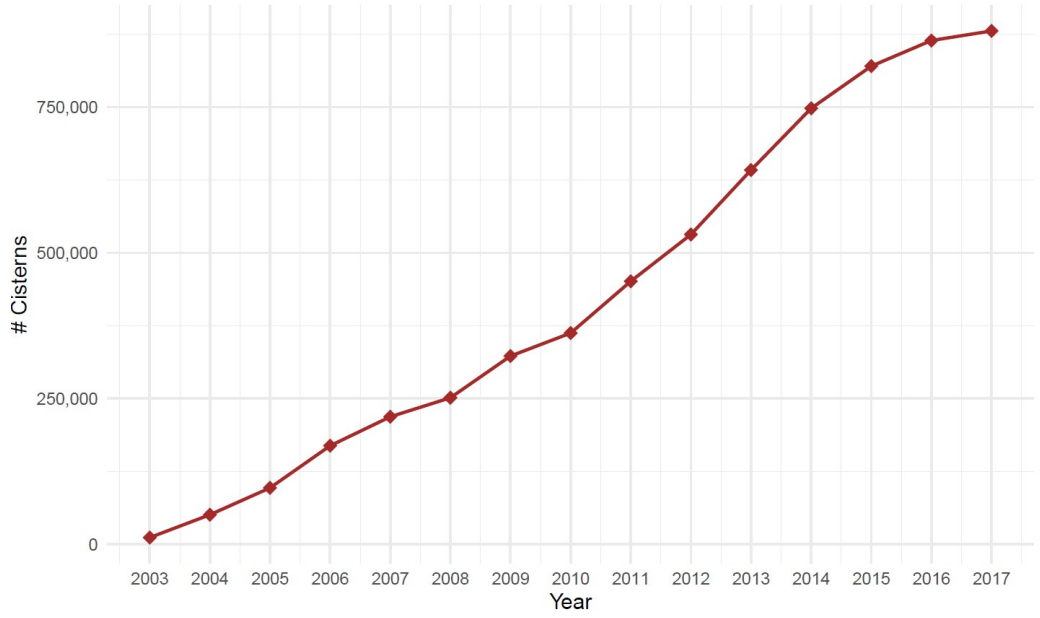


Notes. The map shows the spatial distribution of the cisterns in the Brazilian semiarid. The plot uses data on the exact GPS location of the cisterns.

Figure C.2: Cistern in the Brazilian semiarid

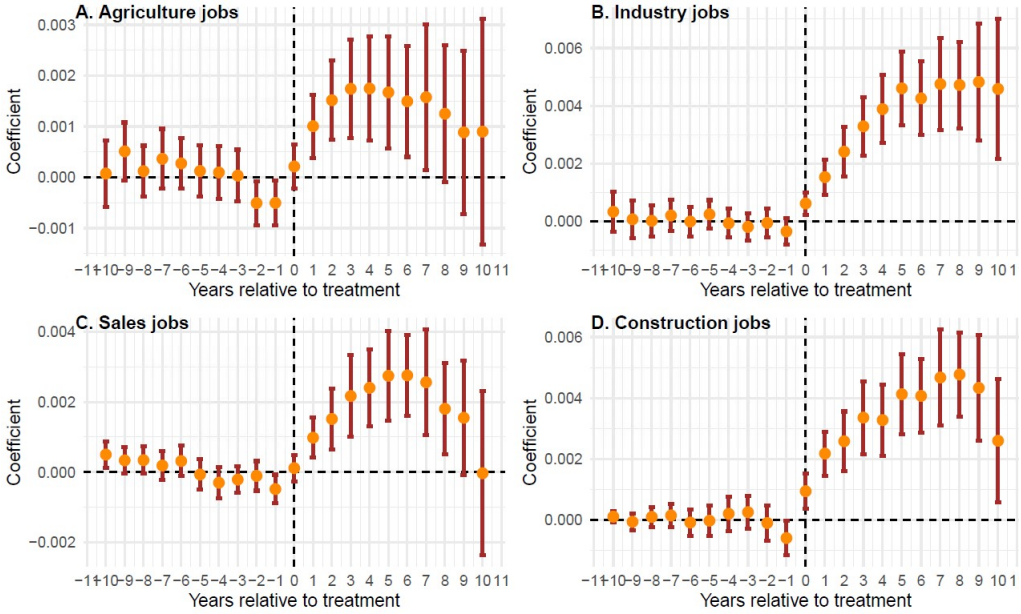
Note. The picture displays a typical cistern distributed through the Cistern First Water Program.

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



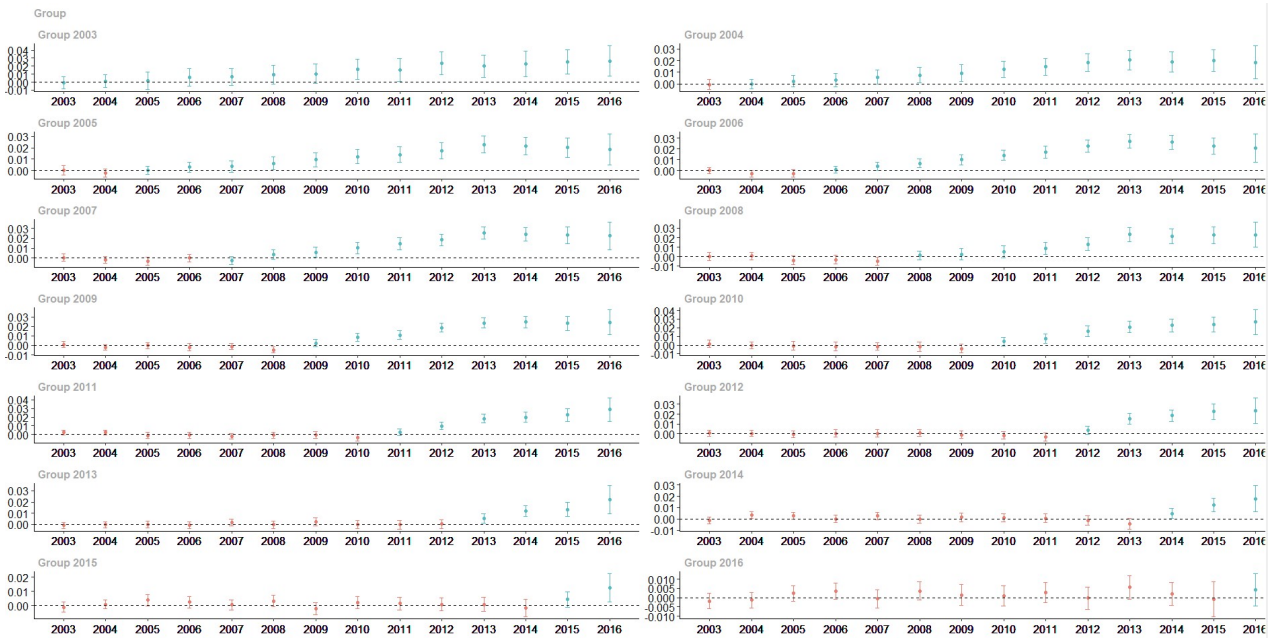
Notes. This figure plots the cumulative sum of the number of cisterns distributed over the years.

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



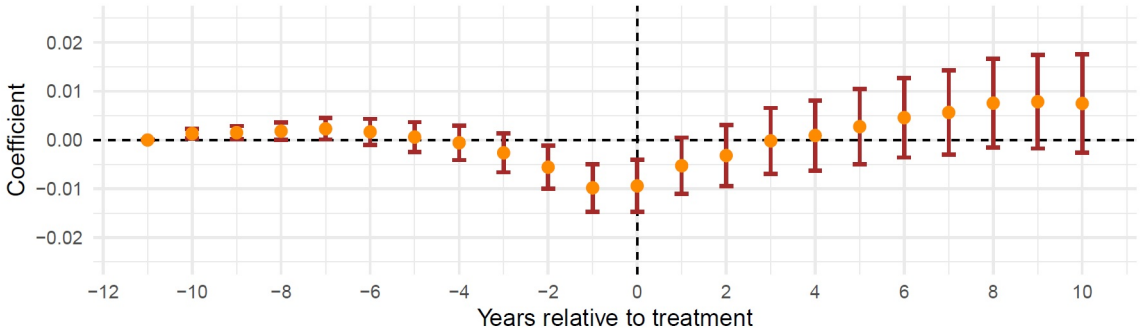
Notes. This figure presents the event-study estimates using the (CALLAWAY; SANT'ANNA, 2021) estimator with individual-level panel data spanning from 2002 to 2016. The control group consists of individuals who have not yet been treated, as well as those who received the cistern in 2017. In each panel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

Figure C.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; SANT'ANNA, 2021) estimator. Results were obtained using the did package in R.

Figure C.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.

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