Labor Coercion and the Accumulation of Human Capital*

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Current version: December 2013

This paper examines the effect of labor coercion on human capital accumulation. We use micro data from Puerto Rico, where unskilled laborers were forced to work for landowners during 1849-1874. Using variation in municipality-level suitability for coffee cultivation and international coffee prices, we estimate the response of schooling to exogenous increases in relative demand for unskilled labor in regimes with and without forced labor. During the coercive regime, increased coffee prices had no effect on individuals' literacy rates in coffee growing regions. Following the abolition of forced labor in 1874, similar changes in coffee prices reduced literacy rates by 12 percent, consistent with a diminished skill premium in the free labor market regime relative to the coercive period.

JEL Codes: J41; O15; N36

Keywords: labor coercion; human capital; historical development

* A previous version of the paper was titled "Endowments, Coercion, and the Historical Containment of Education". We appreciate the discussions with Dwayne Benjamin, Loren Brandt, and James A. Robinson, as well as Maitreesh Ghatak (the editor) and two anonymous referees, whose suggestions greatly improved the paper. We also thank Ken Chay, Ernesto Dal Bó, Stanley Engerman, Berta Esteve-Volart, Fred Finan, Price Fishback, Claudia Goldin, Deepak Lamba-Nieves, Naomi Lamoreaux, Rob McMillan, Ted Miguel, Francisco Moscoso, Petra Moser, Torsten Persson, João Manoel Pinho de Mello, Carlos Serrano, Dan Trefler, and numerous seminar and conference participants for helpful comments and suggestions. We are especially grateful to Miguel Vega, Angel Ríos, María Isabel Rodríguez, Pedro Roig, José Charón, and the personnel at the Puerto Rico Collection of the University of Puerto Rico-Río Piedras Library and the Puerto Rico General Archives for their assistance and support throughout. Emilú Berríos De León, Enrique Bobonis, Aileen Cardona, Nicole Díaz, Jonatham Quiñones Roque, Evangelina Pérez, and Waldemar Pérez provided superb research assistance. Antonio González's ArcGIS expertise proved of invaluable assistance. Research support from the All-UC Group in Economic History, the University of Toronto Connaught Fund, SSHRC, and the Canadian Institute for Advanced Research is gratefully acknowledged. We are responsible for any errors that may remain.

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I. Introduction

Throughout history, many types of labor arrangement have involved the use of coercion – the threat or use of force to compel workers to enter into an employment relationship. Slavery was a common way of organizing labor in plantation economies throughout the Americas and has long been the focus of economic historians.[1] Other forms of forced labor, such as debt peonage and the state-sanctioned forced recruitment of laborers, also played an important role in the hacienda system found in Latin America during the colonial and post-colonial periods.[2] Episodes of coercion are not confined to the historical record: they have persisted in many forms across both industrialized and developing countries throughout the twentieth century (Andrees and Belser 2009).

While the conditions determining the degree and precise form of coercion have been studied extensively, in particular the role of international trade, less is known about the consequences of coercion for economic development.[3] Scholars have argued that coercive labor institutions can lead to socially inefficient outcomes as they involve a costly transfer of resources from workers (e.g. Engerman and Sokoloff 1997; Coatsworth 1999; Conning 2004; Acemoglu and Wolitzky 2010). Consistent with these arguments, empirical studies have found a negative relationship between the historical prevalence of coercion and measures of current economic development such as income and levels of education.[4] In contrast, less empirical analysis has been devoted to identifying the mechanisms that may lead to these differences in human capital accumulation. It is difficult to understate the importance of this channel given that it is arguably one of the most prominent determinants of development in the modern period (e.g. Galor 2005). This paper provides empirical evidence to answer the question of what are the consequences of labor coercion for individuals' education decisions in the context of increasing commodity export trade.

We study legislation by the Spanish government in Puerto Rico that forced free unskilled workers—*jornaleros*—to seek employment on legally titled farms during 1849-1874, followed by abolition of this legislation after 1874. Using micro data on cohorts of individuals across municipalities, we exploit variation in the suitability of coffee cultivation across municipalities and in coffee prices over time to identify exogenous changes in unskilled labor demand following the insight of Domar (1970) that

[1] E.g., Mintz (1969); Fogel and Engerman (1974); Wright (1978); Lockhart and Schwartz (1983).
[2] E.g., McCreery (1994); Alston, Mattiace and Nonnenmacher (2009); Acemoglu and Wolitzky (2010); Dell (2010).
[3] In a seminal study, Evsey Domar (1970) argued that the incentives to coerce workers increase significantly if (shadow) wages rise. Consequently, if export commodity booms increase the relative demand for unskilled labor, this provides suggests a strong link between periods of increased international trade and episodes of labor market coercion. Empirical evidence in the context of U.S. slavery (e.g., Fogel and Engerman 1974; Goldin 1976; Wright 1978; 1986), European serfdom (Postan 1944; North and Thomas 1973; Brenner 1976), and 19th century Britain (Naidu and Yuchtman 2013) is generally consistent with this view. A well-developed literature also documents the deterioration of labor institutions in parts of Latin America during the period of globalization in the late nineteenth century (e.g., Coatsworth 1974; Katz 1974).
[4] Mitchener and McLean (2003) and Lagerlöf (2005) present evidence using income per capita across U.S. states and counties, respectively. Nunn (2008) provides evidence for British colonies in the Caribbean. Finally, Nugent and Robinson (2005) provide evidence on incomes and schooling levels across coffee economies in the Caribbean basin.

the incentive to coerce is increasing in the demand for unskilled laborers. We then examine whether and to what extent the availability of legally sanctioned coercion by landowners against unskilled workers affected how literacy patterns responded to these changes. Consequently, identification of the effect of coercion on human capital accumulation comes from a 'triple difference' strategy that explicitly takes into account the possibility that regions possessing high demand for unskilled labor might have different levels of human capital accumulation regardless of whether labor market coercion exists.

We start by providing suggestive evidence that, during the coercive period, coffee-region local governments allocated more resources toward the enforcement of coercive labor measures. We then show that literacy rates were significantly *higher* among cohorts of schooling-age in coffee growing regions in response to an increase in coffee prices during the coercive regime relative to comparable cohorts in the non-coercive regime. Specifically, during the coercive period, higher coffee prices had no effect on individuals' literacy rates in coffee growing regions, whereas, after the abolition of coercion in 1874, similar changes in coffee prices reduced literacy rates by 12 percent, consistent with a diminished skill premium. These results suggest that the abolition of forced labor had important consequences, eliminating landowners' ability to extract unskilled workers' income but also reducing laborers' incentive to accumulate human capital, as the abolition of coercion of unskilled workers raised the relative wages of unskilled workers by lowering the skill premium.

While our finding of increased human capital accumulation coincident with coercion might seem perverse and surprising, we believe it is intuitive and can be easily rationalized by standard economic theory. Our results are consistent with models where, in the context of a free labor market, positive coffee price changes lead to a decrease in the skill premium and therefore a reduction in human capital investments. However, in a coercive regime, unskilled wages are artificially suppressed and therefore this effect is mitigated as workers avoid coercion and invest in human capital. After these coercive institutions are removed, similar changes in coffee prices reduce literacy rates, consistent with a diminished skill premium. This does not imply that workers are better off as a result of coercion. In fact, unskilled and skilled workers' welfare, as measured by lifetime income, is lower under the coercive labor regime than in a free labor market.

Our results are fully consistent with the negative relationship between the prevalence of historical coercive institutions and long-run levels of human capital accumulation but suggest an alternate interpretation of this correlation.[5] As argued by Domar (1970) and Acemoglu and Wolitzky (2010), labor coercion is more likely to exist in regions that experience high unskilled labor demand. To the extent that certain regions possess fixed or persistent characteristics (e.g. geography) that encourage specialization in

[5] See Engerman and Sokoloff (1997); Acemoglu et al. (2008); Dell (2010); Gallego (2010); Martínez-Fritscher and Musacchio (2010).

the production of unskilled labor-intensive goods, these regions are more prone to historical episodes of coercion, and in the cross-section should also experience a higher demand for unskilled labor. Consequently, these regions will also possess lower demand for education, despite the possibility that, under a forced labor regime, this negative relationship may be partially mitigated due to a higher skill premium.

The research design and the richness of the data allow us to distinguish our explanation for educational outcomes from numerous competing explanations that we assess in the robustness section. We do so by exploiting variation in the suitability for coffee cultivation across otherwise similar municipalities. First, we show that the observed patterns of literacy in response to changes in unskilled labor demand are not due to changed in the availability of schooling, consistent with our demand-side hypothesis. Second, from a purely technological perspective, there are disincentives to establish coffee plantation economies, as there are constant (or even decreasing) returns to scale in coffee cultivation.[6] Third, using unique land ownership distribution data, we show that coffee region municipalities did not experience a greater degree of concentration of land ownership relative to a comparison group of municipalities, as would be the case with the traditional factor endowments-economic inequality hypothesis.[7] We also rule out many other possible explanations for our results including differences in natives' and immigrants' sorting patterns across regions, in transportation cost changes and other technological improvements, and alternate means of the establishment of a coercive political system. In summary, our findings emphasize changes in relative wages and the incentive of elites to create and maintain a coercive labor regime as important mechanisms affecting workers' incentives to accumulate human capital.

The paper is structured as follows: Section II describes the historical background and context. Section III discusses the theoretical background of our study. Section IV describes the data used in the analysis and discusses the empirical strategy. Section V presents the main empirical results of the paper, evidence supporting our identifying assumptions. Section VI assesses alternative explanations. Section VII concludes.

II. Historical Background

This section provides historical detail regarding the Island and municipal institutions against which we conduct our empirical investigation. First, we discuss the 1849 General Laborers' Law – the coercive labor institution under study. Second, we describe the details of coffee cultivation including

[6] See Berry and Cline (1979), Binswanger and Ronsezweig (1986), and Binswanger, Deininger, and Feder (1986).

[7] The factor endowments hypothesis asserts that certain geographic endowments could have generated the incentives for the establishment of plantation economies, and that the resulting differences in economic inequality would influence the development of labor and other economic institutions. For a discussion, see Engerman and Sokoloff (1997), Engerman, Mariscal, and Sokoloff (2002), Acemoglu and Robinson (2005), and Galor, Moav, and Vollrath (2009).

Puerto Rico's role in world coffee markets, the geographic factors influencing coffee cultivation on the island, and the interplay between the two. Finally, we discuss the degree to which local municipalities had control over local administration including enforcement of coercive action, the provision of public schooling, and the collection of tax revenue.

II.A. The 1849 General Laborers' Law

In 1849, the Puerto Rico provincial government established the General Laborers' Law ("*Ley General de Jornaleros"*), instituting the legal capacity to force adult male peasants to work for larger landowners. It entailed a series of measures to control the mobility and work activities of landless peasants and small landowners by establishing a legal category of "*jornaleros.*" This category was composed of all male individuals who could not prove land ownership or did not own more than two "*cuerdas*" of land and had no professional skill. Those classified as *jornaleros* were then forced to seek employment on legally titled farms. Employers were empowered to record work schedules, behavior, and insular movements in small notebooks ("*libretas*") to be carried at all times by the *jornalero* population (Bergad 1983; p. 92). Any *jornalero* found with no labor contract or in breach of one could be denounced as vagrant, with three denunciations leading to prison time.

This law was initially established in response to problems of limited labor supply in the sugar industry, concentrated in coastal municipalities. Throughout the first half of the nineteenth century, economic activity in the Island was centered on African slave labor-based sugar plantations. However, with the Spanish Crown's 1845 agreement with Britain to enforce the prohibition of the Atlantic slave trade and the dwindling slave population, these landowners lobbied successfully for the imposition of alternate forms of labor coercion (Scarano 1984; Dietz 1986).

A significant proportion of all adult males were categorized as *jornaleros*. Based on the population census of 1867, the peak of the coercive labor regime, on average 9 percent of municipality populations under study was classified as subject to the *libreta* system representing approximately 35 percent of the adult male population.[8]

The provincial government eliminated this state-sanctioned coercive labor regime in 1874 despite the sugar and coffee elites' opposition. The derogation was primarily in response to concerns about political unrest throughout the remaining Spanish colonies in the Caribbean including the unsuccessful *Grito de Lares* in Puerto Rico and the Cuban Ten Years' War. Additionally, provincial authorities and the national elite believed that Puerto Rico was under an increasing threat of invasion by the U.S. and that the

[8] This statistic is based on a back-of-the-envelope calculation on the proportion of the overall adult male (16-70 years old) population in these municipalities in 1867 of 25.7 percent, based on the population distribution data from the census of 1887. Since approximately 9 percent of the overall population was classified as *jornalero*, they constituted approximately 35 percent of adult males of working age.

prevalence of various forms of state-sanctioned coercive measures might be seen as justification for American intervention.[9]

There is limited evidence of substantial nominal wage increases among the *jornalero* population following elimination of the coercive regime. Modal wages for the *jornalero* population increased from 5 pesos per month for 1850-1873, to 9 pesos per month in 1874, 12.50 pesos in 1886, and 24 pesos in 1889.[10] The stability of *jornalero* wages during the coercive period and increases following labor market liberalization are suggestive of how powerful a tool coercion was for landowners.

II.B. The Coffee Industry in Puerto Rico throughout the 19th Century

Puerto Rico was a (small) supplier in the international coffee market starting in the late eighteenth century and for extended periods throughout the nineteenth century (Topic 1998). Starting in the mid-1850s coffee exports increased drastically, stimulated by rising international coffee prices (Figure 1, Panel A). During 1871-1881, Puerto Rico coffee exports increased 227 percent to 47.2 million pounds, reaching a peak of 58.0 million pounds in 1896, up fivefold from the mid-1850s.[11] By the turn of the century, the coffee sector had become a major driver of Puerto Rico's economy (Dietz 1986).

Although coffee became central to the local economy during this time, Puerto Rico's role in determining the international price of coffee market was minor. During the mid-1860s, 60 percent of world coffee exports were produced in Brazil. As the dominant producer in the world during the period (Bates 1997), Brazil's exports influenced significant variation in international coffee prices throughout this period (Figure 1, Panel B). In contrast, exports from Puerto Rico constituted less than 4 percent of world exports allowing us to consider international coffee prices as exogenous to local production.

Figure 1, Panel A shows that coffee exports *lag* coffee prices. This is not surprising, as coffee trees require five to seven years after planting to achieve a high yield. This can also be shown quantitatively as the relationship between the price of and exports of coffee is positive and significant at a lag of four to six years. Table 1 presents estimates of models that use the lagged structure of coffee prices to predict Puerto Rico coffee exports for the period 1846-1898. In a model including prices in periods [t, $t - 6$] separately, the elasticity from the annual coffee price in year $t - 6$ has the strongest predictive power. Estimates from parsimonious models that collapse recent past [t, $t - 3$] and more distant past [$t - 4$, $t - 6$] prices indicate that the price elasticity for more distant past prices are large and statistically significant at conventional confidence levels (columns 2-3). We incorporate this timing in our empirical analysis.

[9] This belief partially came from Spanish perceptions regarding national beliefs of the United States following the Union victory in the American civil war. See Chapter 4 in Figueroa (2005).
[10] Data are from various hacienda records in Buitrago Ortiz (1976) and Bergad (1983).
[11] Coffee exports constituted approximately three quarters of total exports from Puerto Rico, whereas sugar during this time period constituted only 20 percent of total exports.

Throughout the second half of the nineteenth century, coffee cultivation was concentrated in the West-Central region of the island, which possessed the most favorable geographic characteristics for cultivation.[12] We focus on high annual rainfall and cool temperatures as factors that led to the geographic concentration of coffee production in this region. Figure 2, Panel A shows a contemporary rainfall precipitation map of Puerto Rico using data for the years 1971-2000 (National Weather Service 2007). Average annual rainfall is highest in the West-Central region, followed by the East-Central region: 90.2 and 74.1 inches, respectively (Table 2, Panel A). Annual rainfall levels above 80 inches are required for high coffee yields. Below this threshold, coffee trees are prone to attacks by the coffee leaf miner (Roberts 1941). As coffee trees produce higher yields in cooler climates, the West-Central region also benefited from cooler average minimum temperatures relative to the East-Central region (Table 2; Panel A). Apart from differences in rainfall and temperature, other geographic, socio-economic, and demographic characteristics across the two groups of municipalities were very similar based on 1828 census data (Table 2, Panel C).

These geographic differences led to the concentration of the coffee industry in the West-Central region, and the production of food crops, cattle ranching, and later some tobacco, in the East-Central. In 1896, 12.3 percent of all land in the West-Central region was under coffee cultivation, relative to only 4.1 in the East-Central region. The relationship between annual rainfall levels and the extent of coffee cultivation is quite strong. Figure 2, Panels A and B, show a strong and positive relationship between contemporary rainfall and historical coffee cultivation. Figure 3 plots the bivariate relationship between a municipality's mean annual rainfall levels between 1899 and 1930 and the share of all land under coffee cultivation for the 24 municipalities in central Puerto Rico, as well as a linear OLS fit. The relationship is strongly positive.[13] This is corroborated by historical accounts of differences in coffee cultivation due to rainfall and temperature differences across municipalities (Bergad 1983; Cabrera Collazo 1988; Picó 1987; 2007; Seda Prado 1996).

Table 1, columns 4-6, evaluates this relationship formally and documents that this relationship is robust to conditioning on other geographic controls including municipality average annual maximum and minimum temperatures, mean altitude, ruggedness as proxied by the mean land gradient, and distance to the nearest port. We exploit these differences in the suitability of coffee cultivation across municipalities to examine the impact of the expansion of the coffee industry on the local enforcement of labor institutions and the sub-national educational outcomes of the population.

II.C. Municipal Government Institutions and the Local Enforcement of the *Jornalero* Law

[12] The West-Central region encompasses the municipalities of Adjuntas, Ciales, Jayuya (part of Utuado at the time), Lares, Las Marías, Maricao, San Sebastián, Utuado, and Yauco

[13] Due to the lack of longitudinal data on the area under coffee cultivation for each municipality, it is not possible to show evidence on the specialization of municipalities in coffee cultivation over time.

Municipal governments had freedom over a wide range of activities in nineteenth century Puerto Rico, including the enforcement of provincial legislation, provision of local public goods, and the collection of property and excise taxes. Municipal governments in Puerto Rico were the only government jurisdiction in which natives gained any political representation until the turn of the century.[14]

The local government executive was composed of mayors and council members throughout the period. Municipal council members were elected by eligible voters, defined as males, 21 years of age or older, who were literate, with a minimum residence period in the municipality of two years, and paying a minimum amount of income and/or property taxes annually (25 pesetas), or who were municipal government employees or professionals. Council members provided a short list of candidates to the Governor for the positions of mayor and lieutenant mayor. The Governor had the power to appoint individuals to these positions. Consequently, local officials were subject to very limited accountability to the majority of the local population, and possessed significant leeway in terms of the administration of municipal activities.

Consistent with this delegation of authority, there was significant heterogeneity in the enforcement of coercive measures across municipalities. Local authorities prepared censuses of *jornaleros* for the enforcement of these regulations and undertook policing and law enforcement duties, as evidenced by the records of anti-vagrancy councils ("*Juntas de Vagos y Amancebados*"). Bergad (1983) provides qualitative evidence that in the coffee-growing municipality of Lares, enforcement was influenced substantially by commodity prices and local labor market conditions. In another coffee-growing municipality, Utuado, there is significant evidence of individuals spending prison time in San Juan as a result of the vagrancy law (Picó 1979). In contrast, Picó (2007) documents that in the East-Central municipality of Cayey, although "…during some years certain rigor in controlling the conduct of landless peasants was observed […], it was quite rare that '*jornaleros*' from Cayey would be sent to 'La Puntilla' [the San Juan prison]."

We provide more systematic quantitative evidence of the enforcement of these coercive measures across municipalities by constructing measures of enforcement of these regulations for a sub-sample of the five central municipalities for which data is available. Based on the monthly acts of the anti-vagrancy councils for the years 1851-1867, we construct two measures of sanctioning of *jornaleros*: an indicator variable for whether a municipal government imprisoned *jornaleros* as a result of accusations of vagrancy, and a broader measure that takes a value of one if there was either imprisonment or if *jornaleros* were formally warned for vagrancy. The Data Appendix provides details of the construction of these *libreta* sanctioning measures.

[14] Useful overviews are provided by Coll y Toste (1909), Flores Collazo (1991) and Trías Monge (1980).

Table 3 presents information on these enforcement measures in three high rainfall municipalities (Comerío, Lares, and Yauco) and in two low rainfall municipalities (Caguas and Juncos). Although only suggestive due to the small sample size, the second row shows that the probability of having a *jornalero* spending time in prison or being warned was nearly twice as high for high rainfall municipalities as for those with low rainfall. In addition, while the probability of any *jornalero* spending time in prison was 0.15 in high rainfall municipalities, there were no occurrences of imprisonment in low rainfall municipalities.[15] We return to this evidence and link it to literacy in the results section.

Evidence of the importance of the coercive labor system for coffee-region municipalities comes from a survey of municipal governments carried out by the provincial government in 1866 regarding the potential abolition of the coercive regime. The Provincial Governor requested that all municipal authorities provide their preferences over the elimination of the coercive regime as well as reasons for this preference.[16] Using binary responses for 16 central region municipalities for which data is available, a simple correlation with annual rainfall levels shows that coffee region municipalities were significantly more likely to be opposed to the elimination of the system with a 10-inch increase in annual rainfall reducing the probability of a reported preference for the elimination of the *libreta* by 16 percentage points.[17] Together, these data corroborate historical accounts that the preference for and enforcement of these coercive labor laws were heavily influenced by commodity prices, suitability for coffee cultivation, and the associated increase in unskilled labor demand at the local level.

The provincial government provided very limited regulation and promotion of public primary education in the Island until the 1860s (Coll y Toste 1909; Osuna 1949; Cuesta Mendoza 1974). Although there were various attempts at establishing an island-wide public primary school system from the 1820s onwards, these plans did not fully materialize until 1865. The central government then instituted a number of reforms to promote the establishment of this system.[18] Although speculative, this may have been again in response to concerns about political unrest throughout the remaining Spanish Caribbean colonies and the increasing threat of invasion by the U.S.

Although guidelines from the central government outlined the need for primary schools in each municipality, the founding, financing, and management of schools remained under the responsibility of municipal governments. Opposition by municipal governments to such legislation led to heterogeneity in

[15] While we have 47 observations, they are only defined over 5 municipalities with unbalanced time series for each municipality between 1851 and 1867. Nor surprisingly, both the estimated difference between high and low rainfall municipalities (column 4) and the correlation of rainfall with these enforcement measures (column 5) are imprecisely estimated.

[16] The main question requested by the Marchesi administration to be answered by each local government was "Should the *libreta* be eliminated or sustained, as is or with any amendment?" (authors' translation).

[17] This is a 51 percent 'effect', given an average positive preference of 31 percent. The estimated relationship is robust to the inclusion of the same geographic controls.. Results available from the authors upon request.

[18] This education law, the Organic Decree of June 10, 1865, instituted a number of reforms to rationalize the curriculum, standardize the system of public primary education, to promote the training and qualification of teachers. However, according to education historians, the legislation was implemented with very limited success.

the founding and management of public primary schools across municipalities during the last third of the nineteenth century. The resulting public system, of limited access and low quality, tended to serve a small subset of non-elite households; wealthy households would frequently hire tutors for their children's primary education. With minor reforms over the course of this time period, the educational system would continue in this manner until the end of the century.[19]

Finally, although local municipalities did not control *de jure* local property tax rates, they had some *de facto* control over its level of enforcement, seemingly to the benefit of larger landowners over smaller ones (e.g., Casanova 1985). These property tax revenues were the main source of income for each municipality. Consistent with a lower tax burden imposed on local landowners based on municipal budget data for the year 1866, we find that municipal governments budgets in higher rainfall municipalities were smaller than in lower rainfall municipalities. The correlation implies that municipalities with 10 in. of greater annual rainfall had budgets that were 19.3 percent smaller in per capita terms.

III. Discussion of Theoretical Mechanisms

To guide our empirical exercise, we describe the main elements of a model of workers' human capital accumulation decisions in a small open economy, under both a free labor market regime and one involving the coercion of unskilled workers. The model presents a framework, in the context of a free labor market, in which positive coffee price changes lead to a decrease in the skill premium and therefore a reduction in human capital investments. However, in a coercive regime, unskilled wages are artificially suppressed and therefore this effect is mitigated as workers avoid coercion and invest in human capital. After these coercive institutions are removed, similar changes in coffee prices reduce literacy rates, consistent with a diminished skill premium. The interested reader is referred our supplemental online appendix for a full treatment.[20]

Individuals decide whether to invest in schooling when young, acquiring skills, and working as skilled laborers in adulthood, or to work as unskilled workers throughout their lifetimes (during young age and adulthood). The existing supply of schools is financed by land tax revenue and determines the effectiveness of educated workers' skills as the latter is increasing in the number of schools per student. Equilibrium educational attainment is determined by both the supply of and the demand for education. On the supply side, more schools per student increase the effectiveness of a skilled worker and therefore the return to schooling. On the demand side, the incentive to obtain an education declines as the skill premium per effective worker falls.

[19] See Osuna (1949), De la Rosa Martínez (1980), Colón Ramírez (1994) for detailed accounts.
[20] This appendix is available on the websites of both authors.

In the absence of coercion, a coffee price boom changes equilibrium educational attainment through two channels: changes in the skill premium, driven by the relative demand for skilled and unskilled workers, and changes in the supply of public education driven by changes in tax revenue. If higher coffee prices increase the relative wage of unskilled workers through Stolper-Samuelson effects, educational attainment can fall due to diminished demand for education.[21]

Under a coercive labor market regime, a landowner and skilled worker ("elite")-controlled government allocates a portion of land tax revenue into the enforcement of coercive labor regulations, allowing landowners to pay to unskilled workers a wage below market-clearing. Greater enforcement of coercive regulations increases the distortion between the two. In response to an increase in the price of coffee, increased coercion results from income effects from greater tax revenue due to higher land value (again due to Stolper-Samuelson forces), and from an increase in the incentive for the elite to coerce due to increased (shadow) wages of unskilled workers as in Domar (1970). All else equal, an increase in coercion can lead to *increased* demand for education relative to the non-coercive regime. This is due to a relatively higher skill premium, as represented by the difference between the market clearing wage for skilled labor and the coercive wage paid to unskilled labor, despite the fact that lesser spending on schools diminishes the effectiveness of education relative to the no coercion case.[22]

Despite the possibility of agents accumulating more human capital, both unskilled and skilled workers are worse off with coercion than without. This is due to coercion avoidance behavior in which more workers become skilled, but the provision of educational capital by the government falls relative to the non-coercive case leading to a diminished effectiveness of education. The elite can be better off under coercion as they receive the wages that are coerced away from unskilled workers. The four key results of the theoretical framework are as follows:

(i) In a non-coercive regime, a higher price of coffee increases the provision of education ($K\uparrow$). Equilibrium educational attainment falls ($E\downarrow$), as demand for education falls more than supply rises.

(ii) In a coercive regime, the provision of education may increase or decrease ($K\uparrow\downarrow$) in response to an increase in coffee prices. This response will be strictly less than in the case without coercion as

[21] The historical record for Puerto Rico suggests that rising coffee prices did in fact exert upward pressure on unskilled wages and land values (Buitrago Ortiz 1976; Bergad 1983).

[22] Even if increased endogenous coercion crowds out expenditure on schooling provision, increased demand for education can outstrip this supply effect leading to a more educational attainment under coercion. The online appendix explicitly considers the endogenous determination of both schooling provision and coercion in response to a change in coffee prices. We do not require that coercion crowd out the supply of schooling for our demand driven literacy results to hold in equilibrium. In a simplified version of the model with exogenously determined provision of public schooling, the predictions on educational attainment result from coffee price effects on the skill premium under the two regimes and on coercive expenditure in the coercive regime.

some government expenditure is allocated to coercion. The change in equilibrium educational attainment will be *strictly greater than* in the case without coercion.

(iii) Because the increased accumulation of human capital under the coercive regime results from avoidance behavior, unskilled workers are worse off despite increased accumulation of human capital. In equilibrium, agents are indifferent about whether they are skilled or unskilled. A lower value of being an unskilled worker equates with a lower present discounted value of being skilled worker due to a lower equilibrium amount of schooling capital per student.

(iv) While landowners do not see the value of their land holdings increase under coercion, their welfare is greater due to the rents extracted from unskilled workers' wages.

The first two predictions can be taken to the data, while the latter two are informative of the welfare consequences of the coercive labor regime. An online supplemental appendix formalizes this model, including a characterization of the elites' maximization problem and the endogenous supply of both schooling and coercion under changing world goods prices.

IV. Data and Research Design

IV.A. Description of the Data

We employ a unique data set to examine in detail the reduced-form relationships under scrutiny. In addition to the geographic and agricultural production data discussed in the Historical Background section, we use the sample of individuals from the Public Use Micro-Sample (PUMS) of the 1910 Puerto Rico Population Census. This provides us with data on literacy, age, municipality of residence, and other socio-demographic information for a representative sample of individuals for the early twentieth century. We link individuals' personal information to data on the municipality where they would have been eligible to enter school for school-eligible cohorts throughout the 1854-1891 period, under the assumption that the municipality where the individual resided was the same as where he or she made the schooling decision.[23] We address the possibility of migration in the Assessment of Alternative Explanations section. Table 4, row 1 reports an average literacy rate of 18.6 percent in this population (ages 25-62 years at the time of the 1910 Census). This is low in comparison to other Caribbean and American countries during the period (Engerman, Mariscal, and Sokoloff 2002). The data also reports information on the individual's gender, ethnicity, and ancestry (native born vs. foreign parent).[24]

We also collected data from multiple primary administrative sources to measure the provision of public elementary schooling as measured by the number of primary schools in each municipality for 1828

[23] We exclude individuals of ages 24 and younger as of 1910, as their literacy outcomes could have been influenced by the U.S. educational reforms of 1898 onwards. See Bobonis and Toro (2007) for details.

[24] The Data Appendix discusses of measurement error issues, self-reported literacy and age misreporting, in particular.

(preceding the expansion of the coffee sector), 1866, 1876-77 (during the coercive period), and 1897 (post-coercion period). Although 1876-1877 was not in the coercive period, we classify the school data with the coercive period, as we expect the stock of schools not to change dramatically within two years following the abolition of the *jornalero* law. Since the number of school-aged children in each municipality for each time period is unavailable, we normalize school availability by the corresponding municipality-level population (Table 3, row 4).[25] We estimate that a small percent of children in the municipalities had access to public primary schools on average during this period.[26]

We have also collected additional data to evaluate alternate explanations for our results. First, we have constructed additional geographic variables to demonstrate whether our results are driven by differences in other geographic determinants of agricultural productivity. Specifically, we calculate the annual minimum and maximum temperatures, mean area weighted land gradient, mean area weighted elevation, and distance to the ports of each municipality. We use these as explanatory variables to demonstrate that our results are not driven by differences in other potential geographic determinants of agricultural productivity.

Second, we also use the 1828 Population Census municipality-level data, which includes detailed demographic information such as the racial and gender composition of the population, the extent of the slave population, and basic demographic data that allow us to construct crude birth and death rates (Córdova 1831-33). We use these data to assess the pre-coffee era demographic composition of municipalities. We also collect data on land and wealth distribution to assess this potential channel. Data on the distribution of land ownership at the municipality level comes from a 25 percent sample of the actual property tax registers for one year in the 1891-1894 period. These tax records contain information on the location, owners, and size of every plot in each municipality during these time periods. For each municipality at each date, we construct the land plot-size ownership Gini coefficient among landed individuals. Since we possess data on the number of landless households in the 1899 census, we can also construct overall land Gini coefficients for this period.

IV.B. Research Design

Our primary investigation compares the literacy decisions of primary school-age cohorts in municipalities with greater rainfall to those in municipalities with lower rainfall levels, with time-varying coffee prices, to measure the effects of the coffee boom on human capital accumulation. We then see how this relationship changes between the non-coercive and coercive regimes. In this sense, we use a 'triple-

[25] We normalize the provision of public primary schools in 1897 by the number of 10-19 year old children in the municipality in 1899 as we have the latter data.

[26] Under the conservative assumption that a public primary school could hold 100 students (since the anecdotal evidence is that these held up to 50 students), 0.40 schools per thousand children would imply 4 seats per 100 school-aged children. Making these assumptions more stringent would reduce the estimated mean capacity of the school system in the central municipalities.

difference' strategy. Specifically, comparing individuals who belonged to cohorts entering school following an increase in coffee prices, we start by estimating the following model:

$$y_{icm} = \theta P^{C}_{c-k} * R_m + \beta_1 R_m + \beta_2 X_{icm} + \gamma P^{C}_{c-k} + \alpha_{(m)} + \varepsilon_{icm}, \quad (1)$$

where y_{imc} is a literacy indicator for individual i in school-entry cohort c in municipality m; P^{C}_{c-k} denotes the international price of coffee k years preceding the individual's school-entry decision at the earliest possible age of entry, six years old; R_m is the municipality-specific continuous measure of average annual rainfall; X_{icm}, are individual-level gender, non-white, and age group indicator variables; and ε_{icm} is the disturbance term, allowed to be correlated at the municipality level. Alternate specifications include additional geographic controls and their interactions with the relevant coffee price level and/or municipality fixed effects (α_m) that control for all time-invariant unobserved determinants of literacy in each municipality. Our procedure produces reduced-form effect estimates of being in a coffee-suitable municipality following a coffee price increase, captured by the θ parameter.[27] Estimating equation (1) separately for school-age cohorts in the coercive and non-coercive regimes allows us to conduct a test of differences of the relationship between coffee prices and literacy outcomes across the coercive and non-coercive labor market regimes.

Because coffee trees require five to seven years after planting to achieve a high yield, any surge in coffee exports follows an increase in coffee prices by approximately this number of years (see Section II.B). To incorporate this timing into the variation in relative demand for unskilled and skilled labor, we use average coffee prices 4-6 years preceding the individual's primary school enrollment decision (denoted as $P^{C}_{\{c-4,c-6\}}$) as our primary measure of coffee prices.[28]

While estimates of equation (1) allow us to establish the empirical relationship between coffee prices and literacy across municipalities of varying suitability for coffee cultivation, it is not obvious that the labor coercion legislation is solely driving the observed patterns, as opposed to other factors that may change the skill premium. To address this directly, we use the subsample of (five) municipalities for which we have *jornalero* legislation enforcement data and estimate a variant of equation (1) in which we include an indicator variable for whether the municipality enforced the legislation (i.e., a *jornalero* spent

[27] An alternative empirical strategy would be to implement an IV approach, in which the possibly endogenous explanatory variable of interest would be a measure of coffee cultivation in each municipality during each time period. This variable would be instrumented with the $P^{C}_{c-6} * R_m$ variable. Unfortunately, we do not have period-municipality-specific measures of coffee cultivation, and thus cannot perform this alternative empirical approach.

[28] Although coffee prices (contemporaneous or lagged) might not matter only at age 6, since children could delay school entry, drop out of school and start working at a later age, or go (back) to school once the coffee boom was over, this specification captures the reduced form effect on the acquisition of literacy skills taking into account individuals' school entry/exit decisions given labor market conditions at the initial time of potential entry. An implicit assumption we make is that youth are disproportionately employed during harvesting of coffee relative to during planting which is consistent with the historical record. See Picó (1979), Bergad (1983), and Dietz (1986).

time in prison due to vagrancy) in the year when the individual would have made the relevant schooling decision. Specifically, we estimate the following model:

$$y_{icm} = \theta_E E_{cm} + \beta_1 R_m + \beta_2 X_{icm} + \gamma P^C_{c-k} + \alpha_{(m)} + \varepsilon_{icm}, \quad (2)$$

where E_{cm} is the indicator variable for if any imprisonment occurred under *jornalero* legislation in municipality m when cohort c was making their relevant schooling decision. Other variables are as defined above. Parameter θ_E captures the empirical relationship between enforcement of the coercive legislation and individuals' literacy outcomes resulting from their schooling decisions. Due to the potential endogeneity and unobserved heterogeneity biases in the estimates of θ_E, we interpret this correlation as only suggestive evidence that coercion is driving our results as opposed to other changes in the skill premium.

To measure the impact of the coffee boom on municipality-level provision of public primary schooling we estimate the following (quasi) differences-in-differences model:

$$y_{mt} = \theta_P Post\_coercion_t * R_m + \theta_C Coercion_t * R_m + \beta_1 R_m + \beta_2 X_m + \gamma_t + \alpha_{(m)} + \varepsilon_{mt}, \quad (3)$$

where y_{mt} is the number of schools per thousand individuals in each municipality m in time period t; $Post\_coercion_t$ and $Coercion_t$ are indicator variable for the respective time periods (i.e., 1867, 1876-1877; and 1897); X_m are the remaining municipality-level geographic controls; γ_t and α_m are period and municipality fixed effects; and ε_{mt} is the disturbance term which is allowed to be correlated within municipalities over time. Because we include municipality and period fixed effects, the effect of the coffee boom is identified by the change in the municipalities with rainfall levels more suitable for coffee cultivation, relative to other municipalities, in 1867 or later relative to 1828.

Our research design relies on the assumption that municipalities with different rainfall patterns would have experienced similar trajectories in the absence of a boom to coffee prices. Although this identifying assumption is not directly testable, the available evidence supports it. Baseline fertility and mortality rates (i.e., crude birth and death rates in 1828) and differences in public school provision were quite similar during the first half of the century (for the former see Table 2, Panel C; for the latter, see Section VI.B). Population trends across these municipalities also do not differ until the 1850s (results not shown), suggesting that these municipalities experienced equivalent development trajectories until the 1850s. We assess potential threats to the validity of our assumptions in the alternative explanations section (Section VI).

Due to the small number of municipalities in the sample, inference based on robust cluster standard errors at the municipality level may lead to over-rejection of the null hypothesis in tests of significance of the parameters of interest. We follow Cameron, Gelbach, and Miller (2008) and construct

p-values from tests based on the wild cluster bootstrap-t, which provide asymptotic refinement. In practice, the results are robust to the test size correction when using the sample of 22 municipalities, but we lose precision in the estimates from the smaller sample of five municipalities with enforcement data. We discuss this in more detail in the following sections.

V. Empirical Results

V.A. Relationship between Adult Literacy and Coffee Prices

This section presents evidence on the relationship between coffee prices and individuals' levels of literacy across higher and lower rainfall municipalities in each of the labor regimes. We start the discussion with a graphical analysis of the patterns in the data. Figure 4, Panel A displays literacy rates by cohort for municipalities above and below median annual rainfall levels. During the coercive regime, cohort literacy rates in the high rainfall municipalities are on average 2.7 percentage points lower (16 percent; p-value = 0.10) than those in below median rainfall municipalities, consistent with the existence of a lower skill premium in coffee growing municipalities. In contrast, for post-labor market liberalization cohorts, literacy rates are on average 9.2 percentage points lower (36 percent; p-value < 0.001) for individuals in high rainfall municipalities. This is consistent with a substantial decrease in the skill premium following the labor reform.

We then examine the relationship between international coffee prices and individuals' levels of literacy across higher and lower rainfall municipalities in each of the labor regimes. We do this generalizing the empirical model (1) presented above, where we allow each cohort to have a (smoothed) potential effect, as follows:

$$y_{icm} = \alpha_m + \gamma_c + \Sigma(R_m \times d_c)\theta_c + \varepsilon_{icm}, \quad (4)$$

where d_c is a variable that indicates whether the individual is in the birth cohort group 1848, 1849,…, 1885; and the other variables are defined as above. Each θ_c coefficient can be interpreted as the effect of residing in a higher-rainfall municipality on a given cohort. By plotting θ_c against coffee prices *four to six years preceding the individuals' school entry decision* ($P^C_{c-4,c-6}$), we examine if differential educational attainment in coffee growing regions is correlated with coffee prices and if this movement varies between coercive and non-coercive periods.

Panel B of Figure 4 illustrates the cohort-specific rainfall correlation estimates (θ_c) from equation (4) (with 95 percent confidence intervals). The birth cohort of 1868, age 6 in 1874 and therefore the last facing coercive legislation, is demarked with a red line. The coefficient estimates in this model fluctuate, and are statistically indistinguishable from zero for cohorts born between 1855 and 1868. This is consistent with a muted disincentive for human capital accumulation in response to coffee price increases

under coercion.[29] In contrast, following the labor market liberalization of 1874, we observe a clear negative relationship between coffee price increases and cohort literacy rates across higher and lower rainfall municipalities. The point estimates indicate, among individuals born between 1873 and 1885, a reduction in literacy rates of 0.25-0.50 percentage points per inch of additional mean annual rainfall. These estimates are significantly different from zero at conventional confidence levels. This is consistent with a stronger disincentive for human capital accumulation in response to coffee price increases under a free labor market.

Table 5 provides regression-based evidence of this relationship using estimation based on equations (1). Columns 1-3 and 4-6 report estimates for school-age cohorts in the coercive and non-coercive regimes, respectively, pooling all cohorts for a given regime and estimating the expression for each group. Columns 1 and 2 show estimates of θ for school-age cohorts during the coercive regime using the $P^{C}_{\{c\text{-}4,c\text{-}6\}}$ coffee price measure. These effects are positive, small, and statistically indistinguishable from zero. The point estimate of the specification excluding geographic controls and municipality fixed effects (column 1) implies that a one standard deviation increase in coffee prices induced a 0.3 percentage point (1.7 percent, from a mean of 15.6 percent) higher literacy rate in municipalities with 10 in. higher annual rainfall levels. The preferred municipality fixed effects estimate (column 3) implies a smaller positive response of 0.2 percentage point (1.5 percent).

In contrast to cohorts during the coercive regime, estimates of θ during the non-coercive regime are negative and significantly different from zero at conventional confidence levels among school-age cohorts. The point estimates of these specifications imply that a one standard deviation increase in coffee prices four to six years preceding the individuals' school entry induced a 0.9-1.0 percentage points (approximately 4.8 percent) reduction in literacy rate in municipalities with 10 in. higher annual rainfall levels. The differential effect across regimes is large – it implies that coercion induced an increase in literacy of 1.2 percentage points (5.9 percent; bottom row) following a one standard deviation increase in coffee prices four to six years preceding the individuals' school entry (in municipalities with 10 in. higher annual rainfall levels). To account for the small number of municipalities we report p-values from significance tests based on both robust cluster standard errors and the wild bootstrap-t procedure. Given the differences in rainfall of approximately 20 inches across coffee and non-coffee central municipalities, these point estimates imply significant *relative increases* in literacy rates as a response to unskilled labor demand shocks preceding the liberalization of labor markets in 1874.[30]

[29] An exception is the 1863 birth cohort, which became of school age in the year 1869 following the main peasant revolt in 1868, and a brief period of a conservative backlash that involved the firing of liberal-oriented school teachers (Moscoso 2003).

[30] To assess whether age heaping biases our estimates, we also estimate models based on equation (1) that include indicator variables for individuals of reported ages 25, 30, 35, …, 60. We find qualitatively and quantitatively similar results that are available from the authors upon request.

It is useful to think about the characteristics of the marginal individuals whose schooling decisions might have been influenced by changes in coffee prices, both during and following the abolition of the coercive labor regime. Although we do not have direct information on the socio-economic background of each individual, we can make an assessment based on ancillary information. Given the high degree of inequality in land ownership among landowners (Gini = 0.75), and the high proportion of landless households as of the 1890s (70 percent), it might be appropriate to consider that the children of very small landowners – those likely to also become *jornaleros*, but to also have an alternative option (i.e., work in their own farm) apart from working as laborers in large landowner farms were those most affected by the hypothesized changes.

V.B. Relationship between Adult Literacy and Enforcement of *Jornalero* Regulation

While there is a clear relationship between coffee prices, rainfall, and literacy, it is not obvious that labor market coercion is driving the observed patterns. Columns 1 and 2 of Table 6 provide direct evidence of this using estimates of equation (2), in which we include a dummy variable indicating whether the relevant cohort making their schooling decision in a municipality at a time when *jornaleros* were spending time in prison due to the anti-vagrancy law for the sub-sample of five municipalities for which we possess enforcement data. We find that literacy rates among school-entry cohorts affected by the enforcement of the *jornalero* regulation increase by 13.2-15.8 percentage points, depending on the specification. These estimates imply that a one standard deviation increase in the level of enforcement (equal to 0.31) increases the probability of literacy by 4.1-4.9 percentage points. Although tests based on robust cluster standard errors reject the null hypothesis of no correlation, we have insufficient precision to reject the null hypothesis of no relationship when constructing tests based on the Cameron, Gelbach, and Miller (2008) wild cluster bootstrap-t procedure due to the small number of municipalities with enforcement data.[31]

We also confirm our baseline relationship for this subsample of municipalities. Columns 3-4 report estimates of equation (1) using the subsample of five municipalities, only for cohorts in years with available enforcement data, whereas columns 5-6 use all coercion-period cohorts in these five municipalities. Columns 7-8 report analogous estimates for the post-coercion period cohorts. Our baseline results hold in this subsample. In particular, the differential effect across regimes is large – it implies that coercion induced an increase in literacy of 1.6 percentage points (6.4-6.7 percent) following a one standard deviation increase in coffee prices four to six years preceding the individuals' school entry (in

[31] The p-value is 0.13 in our preferred municipality fixed effects specification. We have also estimated this equation simultaneously including the broader measure of enforcement that takes warnings into account. The point estimate on imprisonment remains relatively unchanged.

municipalities with 10 in. higher annual rainfall levels; bottom row). However, given the small sample the p-value under the wild cluster bootstrap-t procedure is 0.135.

V.C. Provision of Public Primary Schooling

Although complementary and not necessary for our literacy results, we now investigate whether the coffee boom influenced municipal governments' provision of public primary schooling. Because public primary schooling provision data is not available by cohort, we cannot replicate the exercises of the previous section but, rather, we examine schooling provision in high and low rainfall regions, and how these differences changed over time in response to coffee prices.

Figure 5, Panel A illustrates the time path of public school provision in above average and below average annual rainfall municipalities plotting the unadjusted mean number of schools per thousand individuals, in each time period. The average number of public schools per thousand individuals in the two types of municipality was similar preceding the coffee boom in 1828.[32] In contrast, in the coercive coffee boom years 1867 and 1876, there were a significantly lower number of public primary schools per thousand individuals in the high rainfall region relative to the low rainfall region. The respective mean differences were 0.20 and 0.24 schools per thousand individuals (32 and 39 percent) in 1867 and 1876, respectively. These differences are significant at 95 percent confidence. In contrast, in the non-coercive regime period (in 1897), the difference fell to 0.06 (11 percent) and is not significantly different from zero. Analogous to Figure 4, Panel B of Figure 5 presents the correlation of the number of schools per thousand individuals with rainfall for each year with 95% confidence intervals. Using this measure, we find similar evidence that high rainfall areas possessed relatively fewer schools per thousand individuals in the coercion period and that this difference is strongly mitigated in non-coercion years.

Table 7 presents estimates of this relationship by estimating equation (3). The dependent variable is the number of public primary schools per thousand individuals in the municipality in each time period. The specifications reported in the first three columns use annual rainfall-period interactions as the 'treatment' measure, assuming a homogeneous effect of the program across 1867 and 1876-1877. Column 1 excludes geographic characteristics and indicates that municipalities with 10 in. higher annual rainfall levels experienced a reduction in the provision of schools of 0.104 per thousand individuals (26 percent). Column 2 includes geographic controls; this slightly reduces the point estimate to 0.097 schools (24 percent) per thousand individuals. Our preferred specification with municipality fixed effects implies a reduction of 0.097 schools per thousand individuals (24 percent). Estimates are significant at least at 95 percent confidence and robust to the wild cluster bootstrap-t procedure.

[32] It was approximately 0.023 in the above average rainfall municipalities and 0.053 in the below average rainfall municipalities but with no significant difference.

Columns 4-6 are analogous to columns 1-3 except that they allow for period-specific treatment effects. Including and excluding geographic controls respectively, we find greater and statistically significant effects for coercive regime year 1867 (0.082-0.084 fewer schools per thousand, or 20-21 percent), significant at 90 percent confidence.[33] During the period 1876-1877, two years following the elimination of the coercive labor measures and possibly under transition by the municipal governments in allocating resources for public primary schooling, we find evidence of 0.118-0.130 fewer schools per thousand (29-32 percent). While these latter effects are not significant at conventional confidence levels under the preferred CGM (2008) tests, they are not significantly different from the 1867 estimate.[34] Finally, the estimated impacts are substantially smaller and insignificantly different from zero for the 1897 non-coercive regime period.[35] Our findings indicate that local governments in the coffee-region allocated relatively fewer resources towards the provision of primary schooling during the coercive regime but not after the derogation of these measures.

VI. Assessment of Alternative Explanations

There are multiple geographic or institutional factors that may have played a role in explaining the observed pattern of falling literacy with rising coffee prices during the non-coercive period. We address and rule out eight alternate hypotheses. In addition, we show that they do not affect our estimate of the coefficients of interest for the coercive regime. In order, the alternate explanations we evaluate are centered on: (1) local landowners' efforts to maintain an illiterate workforce, in the absence of forced labor; (2) the geographic sorting of the native born population; (3) geographic sorting of immigrants, (4) land inequality, (5) the consequences of the establishment of a coercive political system, (6) technological and economic changes that may depend on geographic factors correlated with rainfall, (7) competition from the Puerto Rican sugar industry, and (8) 'progressiveness' or 'industriousness' of municipalities.

Each row of Table 8 presents correlations of municipality rainfall with variables described below that evaluate alternate hypotheses. Table 9 presents the coefficient on the coffee price-rainfall interaction term (analogous to Table 5) when including variables related to alternate hypotheses also interacted with coffee prices. Column 7 of Table 9 presents the relationship between literacy and coercion enforcement analogous to Table 6 when including these alternate variables. All columns include CGM (2008) wild cluster bootstrap-t p-values in brackets.

[33] As a robustness check, we have also used the 1867 population census to construct a measure of the number of teachers in each municipality. There is also a negative correlation between the number of teachers and the annual rainfall in the municipality (point estimate = -0.568; significant at 90 percent confidence). Also, there were approximately 1.7 teachers residing in these municipalities, on average; these represented 0.067 percent of the population classified as having an occupation.

[34] P-values for the tests of equality of coefficients for 1867 and 1876-1877 are 0.42, 0.54, and 0.57 for columns 4,5, and 6 respectively.

[35] The coercive period-specific effects are statistically distinguishable from the non-coercive period relationship; p-values of joint significance tests are 0.014 and 0.015.

Local Landowners' Efforts to Maintain an Illiterate Workforce

The post-coercive period divergence in literacy rates might be driven by a decision to close schools by the municipalities that previously experienced the greatest enforcement of *jornalero* regulation. A move to close schools might be driven, for example, by a desire on the part of landowners to increase the population of unskilled workers in response to the removal of coercion. Therefore, in areas where coercion is no longer legal, the municipality could contract the supply of schools, possibly generating the post-coercion reduction in literacy.

Because we observe an imprecisely estimated reduction in the number of schools from 1867 to 1876-1877, it is difficult to dismiss this alternative hypothesis based on the school provision data. To address this concern, we estimate a variant of equation (1) also controlling for the interaction of coffee prices and the 1867 measure of schools per capita, as well as the interaction of coffee prices with 1876 measures of schools per capita, both at the municipality level. While we are using an admittedly coarse measure of schooling provision, the estimates of θ from these specifications should capture the demand side effects of the coffee price changes while holding the supply side constant. The estimates of interest are presented in Table 9, row 1.

Our coercion period estimates suggest that higher coffee prices interacted with rainfall led to a larger but imprecisely estimated increase in literacy when controlling for the provision of education, consistent with an increased demand for literacy holding the supply of schools constant.[36] In contrast, our estimates during the post-coercive period are unchanged. The demand side effect from the triple difference specification is substantially larger (significant at 90 percent confidence).[37] The relationship between coercion enforcement and literacy is also relatively unchanged. This analysis suggests that the main mechanism advanced by the paper—changes in the demand for education—is robust to this supply side consideration.

Geographical Sorting of the Native-Born Population and Differential Returns to Schooling

Geographic sorting of the population during the non-coercive period is an important alternate hypothesis. For instance, a disproportionate share of less skilled individuals might have sorted into high rainfall regions in response to higher coffee prices. If these individuals demanded lower levels of public

[36] Our theoretical framework predicts that controlling for the supply side component, the demand side effect should be stronger under the coercive regime in particular if increased coercion crowds out schooling. However, because we are including an endogenous set of regressors, it might generate bias in our estimates of the partial reduced-form rainfall-coffee interaction relationship with literacy. Finally, it is not possible to characterize the direction of bias under reasonable assumptions on various unobserved relationships in the data.

[37] Finally, the estimates are robust to alternate specifications that allow for cohort trends to vary with the municipality-level provision of schooling in 1867 and 1876. The resulting estimates of θ from municipality fixed effects models for the coercive and post-coercive cohorts are respectively 0.099 (standard error = 0.071) and -0.055 (standard error = 0.027; significant at 90 percent confidence).

schooling due to unobserved differences in the return to education, the demand for education could have been lower.

Although migration across regions did occur, the central government imposed strong restrictions on inter-municipality migration across all regions in the Island during a significant part of the second half of the century. Specifically, a second measure related to the *jornalero* law required authorization from local authorities for peasants to migrate across municipalities (Picó 1979; Figueroa 2005). These measures, enforced by local governments, mitigate some concern of sorting of this population (Picó 1979). However, we assess whether there is evidence of sorting based on several pre-determined observable individual characteristics possibly correlated with unobservable determinants of migration and literacy.[38]

We start by examining whether there are differences in the socio-demographic composition of cohorts across municipalities with varying rainfall levels, distinctively during the coercive and post-coercive periods. Table 4, row 3, columns 5-6, shows that there are very small differences in the gender composition among cohorts born during the coercive period, whereas this correlation disappears among cohorts born afterwards. Moreover, while the proportion of non-white school-age cohorts is consistently lower in higher rainfall municipalities, this correlation does not vary across periods (row 4). Although these observable characteristics strongly predict literacy outcomes, the small compositional differences imply small differences in magnitude in literacy rates across municipalities with varying rainfall levels.[39]

We then examine the relationship between international coffee prices and predetermined characteristics of school-age cohorts such as gender, race, and native ancestry that might proxy for unobserved differences in the demand for education across high and low rainfall municipalities. We do this by estimating variants of the empirical model (4), where we allow each cohort to have a (smoothed) potential effect on the predetermined variable:

$$x_{icm} = \alpha_m^{PRE} + \gamma_c^{PRE} + \Sigma(R_m \times d_c)\, \theta_c^{PRE} + v_{icm}, \tag{5}$$

where x_{icm} is the predetermined indicator variable (i.e. female gender, non-white individual, native father) and the other variables are defined as above. The θ_c^{PRE} coefficient can be interpreted as the marginal probability that individuals from a given cohort c possessed characteristic x in a municipality m with higher rainfall. By plotting θ_c^{PRE} against coffee prices, we can observe whether individuals with certain

[38] This is essentially an indirect test of the unconfoundedness assumption required for consistent estimation of the reduced-form relationships. See Imbens and Wooldridge (2008, pp. 45-46) for a discussion of empirical assessments of this assumption. Obviously, we cannot determine whether there is geographic sorting based on the returns to literacy or other unobserved characteristics of the individuals correlated with their literacy status.

[39] The partial correlation of literacy and rainfall conditional on gender, ethnicity, and paternal ancestry status is -0.018 (standard error 0.008) for coercive period cohorts and -0.037 (standard error = 0.009) for post-coercive period cohorts. Comparing these to the raw correlations (Table 4) implies that the demographic composition differences do not induce a differential correlation across the two groups of cohorts – the differences in the correlations are 0.010 and 0.008, respectively.

demographic characteristics were more likely to reside in higher rainfall municipalities in response to higher coffee prices at the age of school entry.

Figure 6 plots cohort-specific rainfall correlation estimates (θ_c^{PRE}) from equation (5); Panels A, B, and C report the correlation for females, non-white individuals, and individuals with native-born fathers, respectively. There is no clear relationship between changes in the proportion of female individuals across school entry cohorts and changes in coffee price four to six years earlier during the coercive or non-coercive regimes. In addition, although the proportion of non-white school-age cohorts is consistently lower in higher rainfall municipalities, there is no clear relationship of sorting based on individuals of distinct racial categories in response to changing coffee prices. There is also no evidence of sorting based on parental ancestry.[40] In summary, we find no evidence that educational group-specific geographic mobility patterns drive our results of falling literacy in response to higher coffee prices.[41]

Immigrants' Location Patterns

Selective immigration of *foreigners* of varying socio-economic status across the regions of the island could have induced differences in patterns of development if immigrants with higher levels of physical and human capital migrated to the lower rainfall municipalities (Glaeser et al 2004).[42] Such selective immigration of foreigners across different regions would imply that literacy rates should differ across higher and lower rainfall municipalities. Using 1899 Census data on the municipality-level shares of the foreign adult population and foreigners' literacy rates, we find that foreigners composed only 0.6 percent of the population in these municipalities. We also find that foreigners' literacy rates were not significantly different across municipalities with varying rainfall levels (Table 8, row 1). Consequently, we do not find evidence of any differential presence of high-skilled foreigners across low- and high-rainfall municipalities.

One might be concerned that the cross-sectional comparison of aggregated municipality-level averages in the year 1899 drives our lack of evidence of sorting among foreigners. However, cross-sectional comparisons of literacy rates for native-born adult males provide a weighted average of the estimates for the coercive and non-coercive period cohorts' literacy rates correlation with annual rainfall levels (Table 8, row 2). The cross-sectional estimates for this group are qualitatively similar to the

[40] Finally, using models analogous to equation (1) where we additionally control for the interaction of these socio-demographic characteristics and the price of coffee, we find similar estimates of the coffee-price literacy relationship. Additionally, we find no evidence that the rainfall-coffee price interaction predicts differential cohort sizes across municipality-cohort groups. Estimates for each of these specifications are available from the authors upon request.

[41] Finally, to the extent that differential trends in the pre-boom variation in the provision of public schooling capture differential demand for schooling across municipalities based on pre-existing preferences, this does not seem to be driving the literacy results. The analogous (pre-coffee boom schools per capita-conditioned) estimates of the effects of the coffee boom on public school provision and literacy rates are greater in absolute value and precisely estimated (available from the authors upon request).

[42] For instance, Bergad (1983) documents that Catalan and Mallorquín families, highly involved in the coffee cultivation and distribution industries, moved into Lares, whereas Corsican families assented in Yauco (also a coffee region municipality). Similar immigration patterns occurred however in East-Central municipalities, as exemplified by the case of Cayey (Picó 2007).

weighted-average of those estimated based on the individual-level data (see Section V.A). Because we are able to reconstruct our results for natives, it is less likely that data quality issues are driving our findings of differences for literacy rates of foreigners.

Land Inequality

Other lines of inquiry emphasize differences in land ownership concentration as a strong determinant of poor provision of educational public goods and schooling outcomes (e.g., Engerman and Sokoloff 1997; Nunn 2008). However, the stark divergence in agricultural production only led to small differences in the distribution of land ownership across municipalities. Figure 7 presents kernel density and Lorenz curve estimates of the distribution of individual land ownership among landowners for each region (Panels A and B, respectively). The density estimates suggest that land ownership was only slightly more concentrated in the coffee-growing region relative to the food crops region. This is because there is a greater share of landowners with very small plots in the latter region relative to the former (Panel A). However, most differences may be explained by the fact that plot sizes were larger on average in coffee-region municipalities (43.9 and 35.4 acres, respectively; not reported in the tables). Lorenz curves presented in Panel B suggest that land ownership inequality among landowners was only slightly greater in the food crops region than in the coffee region. These distributional differences suggest that the land tenure structure did not diverge dramatically across regions during the coffee boom.

These patterns are confirmed by comparing local-level land inequality more systematically across all municipalities during the period 1891-94 (Table 8, row 3). There is no correlation between the overall land Gini coefficient and annual rainfall levels.[43] In addition, any land stratification differences across higher and lower rainfall municipalities are driven mainly by variation in the degree of land concentration among landed individuals, rather than by differences in the share of the landless population across municipalities. The rainfall–landowners Gini correlation is 2.8 percentage points excluding geographic controls and 0.9 percentage points including these but neither relationship is precisely estimated (row 4). Finally, the correlation between the proportion of households with land in 1899 and annual rainfall is small, negative, and statistically indistinguishable from zero (row 5).[44] These comparisons suggest that the coffee booms of the 1800s did not lead to broad differences in the distribution of land ownership of the sort hypothesized by the factor endowments–economic inequality hypothesis.

[43] The point estimate from the raw correlation suggests that the overall level of land inequality was 0.9 percentage points (1 percent) higher in municipalities with 10 in. higher rainfall levels, whereas the point estimate from the partial correlation suggests a smaller and negative relationship.

[44] Since the sample of municipalities with land distribution data among landowners is a subset of the overall sample of 23 municipalities, the differences in results may be driven by differences in the sample composition. However, note that the differences in the landless households share are similar for this subset of municipalities (row 5, column 3).

Even if inequality in the distribution of land ownership affected the literacy rate of the population, our estimates would be biased upwards. This is because the partial correlation of inequality in land ownership and literacy is *positive* (not reported in the tables) corroborating existing work on the historical relationships between land inequality and development outcomes across local jurisdictions (e.g., Acemoglu et al. 2008; Nunn 2008). Moreover, using models analogous to equation (1) for the sub-sample of municipalities with 1890s land ownership data and controlling for the overall land ownership Gini coefficient and its interaction with the price of coffee, we find similar estimates of the coffee-price literacy relationship (see Table 9, row 2).[45] The relationship between coercion enforcement and literacy is also relatively unchanged. These pieces of evidence are inconsistent with economic inequality as the mechanism explaining these effects.

Political Consequences of the Establishment of a Coercive System

A competing explanation for the fall in literacy under the non-coercive regime is that there was extra-legal coercion. In this case, establishment of an extra-legal local coercive apparatus may have led to intimidation or repression and shifted local public goods provision decisions away from the preferences of poor households – independently of the direct effects on local labor markets. These political dynamics may have been prevalent during periods of export commodity booms, as the rents available to the state increased during these times and could have been channeled towards politically coercive activities (Besley and Persson 2008). In short, the fall in literacy may have been coming from the 'supply side' even during the non-coercive regime.

Consistent with this alternate mechanism there existed a threat of unrest following the *Grito de Lares of 1868*, a major liberal pro-independence revolutionary attempt that originated in the coffee region.[46] This threat induced members of the landowning classes to expend military resources to protect the regime and maintain public order (Bergad 1983; Moscoso 2003). Consequently, a volunteer-based paramilitary group composed of large landowning family members and promoted by the provincial authorities organized itself in 1869 at the municipality level as the Volunteer Corps (VC) (Rosado Brincau 1891).[47] Concurrently, the Provincial Government created the Provincial Civil Guard, which replaced a militia based on draft by lottery (Flores Collazo 1994).

[45] The estimates are robust to the use of the landowners' land ownership Gini coefficient measure (available from the authors upon request). Analogous estimates of the effects of the coffee boom on the provision of public primary schooling are smaller in absolute value, these are still large and precisely estimated (available from the authors upon request).

[46] The political cleavages leading to the insurrection were primarily class-based. As noted by Bergad (1980): "… the leaders of the insurrection were all coffee farmers. The working men who seized Lares were all coffee pickers. And those arrested by the revolutionaries were the major coffee merchants and creditors of the town." See Moscoso (2003) for a contrarian view.

[47] Volunteer Corps members had to satisfy certain eligibility requirements: Spanish citizenship or naturalization; no criminal record; generate earnings and/or have an 'honorable' occupation; and own sufficient resources to support their activities in the Corps. In addition, the eligibility requirement had the intention of promoting the selection of individuals that supported the conservative regime.

To measure the extent of repression following this episode, we coded information on the distribution of VC units across municipalities in 1886 and of the Civil Guard in 1876. The VC data are the share of individuals in a company assigned to a specific municipality and an indicator variable for whether a local VC headquarters was located in that municipality. The Provincial Civil Guard data represent the number of men assigned to a municipality.[48] Using this data we find no evidence of a greater presence of repressive forces in higher rainfall municipalities (Table 8, rows 6-8).

We also estimate models analogous to (1) sequentially allowing for additional interaction terms between the coffee price and these coercive apparatus variables (Table 9, rows 3-5). The point estimates on the coffee price – rainfall interaction for the sample of post-coercive period cohorts are in the [-0.064, -0.066] percentage points range (statistically significant at 95 percent confidence), whereas those for the sample of coercive period cohorts in the [0.017, 0.022] range. All are quantitatively similar to those reported above for both the coercive period and post-coercive period cohorts. The relationship between coercion enforcement and literacy is also relatively unchanged. Consequently, the data show no evidence that political repression was responsible for diminished literacy during the non-coercion period in the municipalities considered.

Technological and Economic Changes Associated with Geographic Factors Correlated with Rainfall

Other technological changes in Puerto Rico, such as an expansion of the transportation system (e.g., railroads), might have differentially influenced product and/or factor markets during the post-coercion period (Cabrera Salcedo 2007). On one hand, if the impact of these technological and economic changes depended on geographic factors correlated with rainfall, such as the degree of ruggedness and the distance to the island's ports, our estimated literacy effects may be biased. On the other, if geographic characteristics such as elevation and land ruggedness are determinants of productivity in the coffee industry, controlling for these factors should make the relationship with rainfall more muted and/or less precisely estimated.

To address these alternative explanations, we estimate models analogous to (1) where we sequentially allow for an additional interaction term between the coffee price and alternative geographic variables: altitude, land gradient, and distance to ports (Table 9, rows 6-8). The point estimates on the coffee price – rainfall interaction for the sample of post-coercive period cohorts are in the [-0.064, -0.066] percentage points range (each significant at 95 percent confidence), whereas those for the sample of coercive period cohorts in the [0.012, 0.020] range. All are quantitatively similar to those reported above for both the coercive period and post-coercive period cohorts, as well as for the differential response

[48] See the Data Appendix for a detailed description of the construction of these variables.

across regimes, although we lose some precision (p-values = 0.200, 0.128, 0.024).[49] While our coercion enforcement literacy correlations (column 7) are still imprecisely estimated, the point estimates are very similar to our benchmark results. These robustness checks help to mitigate possible concerns that the evidence is consistent with broader technological or economic change effects that may be correlated with rainfall or other geographic characteristics.

Specialization of Low Rainfall Municipalities in More 'Progressive' Sectors

The divergence in literacy rates across municipalities may be consistent with low rainfall areas being specialized in sectors with a stronger relative demand for skilled workers, in such a way that coffee price increases would (indirectly) lead to higher literacy rates in our counterfactual municipalities. This might take place as a result of either supply-side or demand-side mechanisms.[50] That said, in order to bias estimates upwards, this effect would need to be coincidental with the 4-6 year lag increase in coffee prices and be more pronounced in the post-coercive than in the coercive period.

To assess this possibility we use the 1867 population census and construct the share of the workforce classified as working in the industrial or commercial sectors to capture heterogeneity in the occupational structure during the coercive period that could be correlated with the relative demand for skilled labor across municipalities. The industrial/commercial occupational share is low on average (approximately 5 percent) and we observe no differences in this occupational share across municipalities with varying annual rainfall levels (Table 8, row 9). We also interact this measure with coffee prices and include it as an additional explanatory variable in our main specification (Table 9, row 9). The point estimates on the coffee price – rainfall interaction are relatively unchanged for both the coercive and post-coercive periods. Finally, the point estimate on *jornalero* regulation is also unchanged, remaining large in magnitude but indistinguishable from zero. These robustness checks help to mitigate possible concerns of upward bias due to this potential mechanism.

Competition for Unskilled Labor from the Puerto Rican Sugar Industry

The model and the empirical evidence up to now have neglected the Puerto Rican sugar industry for various reasons. From a technological perspective, the sugar industry faced incentives to establish plantation economies, due to increasing returns to scale in sugar cane cultivation and processing. These could lead to the confounding of the mechanisms discussed in the paper with those of the land inequality-factor endowments hypothesis. Also, municipalities specializing in sugar were primarily in coastal areas

[49] Results are qualitatively similar if we use a measure of coffee yields preceding its expansion (100 pounds of coffee per cuerda produced in 1828) interacted with coffee prices, for a subsample of 20 municipalities. Results are available from the authors upon request.

[50] On the schooling-demand side, an increase in the demand for skill intensive goods produced in low rainfall municipalities (perhaps serving as consumption goods in the higher rainfall municipalities) could lead to an increase in the skill premium. On the supply side, it could be the result of these commodity price shocks leading to an increase in local governments' equilibrium schooling supply.

and possessed different geographic, technological, or economic characteristics, making them non-comparable to those municipalities located in the central highlands.

We might also be concerned that competition between coffee producers and sugar producers for scarce unskilled labor may have been important during this time period. However, the sugar industry suffered a relative decline during the second half of the nineteenth century and thus may not have been a strong source of competition for the unskilled laborers employed in the coffee industry.[51] To address this concern, we estimate models analogous to (1) including an interaction term between the average rainfall in the municipality and the price of sugar 1-3 years preceding the individuals' primary school enrollment decisions (Table 9, row 10).[52] All estimates are quantitatively similar to those reported above. These robustness checks help to mitigate possible concerns that the evidence is consistent with this source of competition for unskilled laborers across the coffee and sugar sectors.

VII. Conclusion

This paper studies whether changes in the incentive for elites to enforce coercive labor institutions affected individuals' human capital accumulation decisions during coffee booms throughout the second half of the nineteenth century in Puerto Rico. We find that, under a coercive labor regime, local governments in coffee growing regions allocated more resources to the enforcement of coercive measures arguably with the goal of depressing the realized wage of unskilled labor. While this reduced the public provision of education, it also, surprisingly, induced workers to demand significantly more schooling leading to no change in the equilibrium amount of educational attainment in response to rising coffee prices. Following the abolition of these coercive measures in 1874, rising coffee prices correlated with declining literacy rates, consistent with a 'resource curse' in which individuals' perceived opportunity cost of schooling increases during commodity booms.

Our results are consistent with models where, in the context of a free labor market, positive coffee price changes lead to a decrease in the skill premium and therefore a reduction in human capital investment. However, in a coercive regime, unskilled wages are artificially suppressed and therefore this effect is mitigated as workers avoid coercion and invest in human capital. After these coercive institutions are removed, similar changes in coffee prices reduce literacy rates, consistent with a diminished skill premium. This does *not* imply that workers are better off as a result of coercion. In fact, unskilled and skilled workers' welfare, as measured by lifetime income, is lower under the coercive labor regime than in a free labor market.

[51] For a detailed discussion of the size of the sugar and coffee sectors in Puerto Rico throughout the nineteenth century, see Dietz (1986).
[52] Sugar is an annual crop that has at least one growing cycle per year, justifying this lag structure.

In addition, our results raise a fundamental identification issue in assessing the relationship between episodic coercion and the accumulation of human capital. Following the insight of Domar (1970), coercion is likely to be present when demand for unskilled labor is high. However, demand for human capital is also likely to be low when demand for unskilled labor is high. Consequently, when looking at a negative (contemporary) relationship between some measure of human capital and whether coercion has occurred in the past, one must be careful to rule out if that relationship is simply coming from the demand side.

Finally, the paper also provides evidence broadly consistent with North-South models of divergence with endogenous skill acquisition as trade can exacerbate initial skill differences across countries by raising the return to the relatively abundant factor. While we do not consider such mechanisms here, Stokey (1991) considers positive externalities to education such that trade can lead to lower human capital accumulation and economic growth in unskilled labor abundant countries. Although coercion of unskilled workers is not an acceptable institution because of the resulting limitations on the freedom of an individual (Sen 1999), such mechanisms would suggest that policies that increase the skill premium and induce human capital accumulation may be socially beneficial. Empirically considering the long run relationship between historical labor market institutions, human capital accumulation, and growth remains an important next step in this line of research.

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Data Appendix: Sources, Description, and References

Geographic Characteristics:

Average monthly and annual rainfall, 1899-1928 (in.): available at the weather station from Roberts (1941). If there are a non-zero number of weather stations in the municipality, the simple average of rainfall measures is assigned to the municipality. For municipalities with no available weather stations, the simple average of adjacent municipalities' weather measures is assigned to the municipality.

Average altitude (meters), average land gradient (degrees), distance to nearest port (km): GIS data are available from the Government of Puerto Rico Planning Board. Municipality-level averages are constructed using ArcGIS software.

Average maximum and minimum temperature, 1950-2000 (ºC): National Climatic Data Center (NCDC) and non-NCDC data available at The UNC-Chapel Hill Southeast Regional Climate Center. Imputation for municipality-averages following the same algorithm as the one for average monthly and annual rainfall. Link: http://radar.meas.ncsu.edu/climateinfo/historical/historical_pr.html

Coffee Prices, Cultivation and Production; Aggregate Economic Activity:

International coffee prices data: International wholesale coffee export prices are quoted in the UK (London) market, rather than in the domestic one. These data are taken from Sauerbeck, Augustus. "Prices of Commodities and Precious Metals," *Journal of the Statistical Society of London*, vol. 49/3 September 1886 Appendix C, for the years 1860-85. Sauerbeck, A. "Prices of Commodities During the Last Seven Years," *Journal of the Royal Statistical Society*, vol.56/2 June 1893 p.241 ff., for the years 1885-1892. Sauerbeck, A. "Prices of Commodities in 1908," *Journal of the Royal Statistical Society*, 72/1 Mar 1909 for the years 1893-1898.

Number of coffee mills, feet ("pies") of coffee cultivation, coffee production ("quintales"), aggregate private income and wealth: available from Pedro Tomás de Córdova's statistical and qualitative description of geographic and economic conditions across municipalities in the island (Córdova, 1831-33). These data were prepared by municipal governments, as required by the Spanish Crown (and collected by Córdova, an emissary of the Crown) to improve the central government's information regarding economic conditions in the island during a period of Bourbon reforms.

Agricultural land under coffee, sugar cane, 1896: is available from Henry K. Carroll's report to the U.S. Government on economic conditions in the island following the end of the 1898 Spanish-Cuban-American War (Carroll, 1899). These data on rural lands, as declared by their owners for assessment, is considered to be of reasonable quality, since it was collected by property and income tax collection officials during the end of the Spanish regime.

Literacy Data, Socio-Economic, and Demographic Information:

Total population in 1824, 1828; number of sharecroppers, slaves, free blacks, mulattos, whites, year 1828; number of births, deaths, and marriages, year 1828: available from Córdova (1831-33). Population shares are constructed based on total population in 1828; crude rates are constructed using total population in 1828 as denominator.

Total population in 1846, 1860, 1862, 1865, 1867: available from Gaceta de Puerto Rico (1868a).

Adult literacy, gender, age (in years), nationality, father's nationality, mother's nationality, municipality of residence: available from Public Use Micro-Sample (PUMS) of the 1910 Puerto Rico Population Census (Palloni, Winsborough, and Scarano, 2006)

Native and foreign-born adult males' literacy rates, by racial category, year 1899 available from Academia Puertorriqueña de la Historia ("APH") (2003).

Public Primary School Provision:

Number of primary schools in the municipality, years 1828, 1866-67, 1876-77, 1897: available respectively in Córdova (1831-33), Gaceta de Puerto Rico (1868b), Ubeda y Delgado (1878), and APH (2003).

Jornalero Regulation Enforcement, Military and Paramilitary Forces Data:

Number and share of 'jornaleros' in population, year 1867: available from 1867 Census of Puerto Rico, published in Gaceta de Puerto Rico (1868c).

Incidence of and annual share of jornaleros ordered to spend prison time; *incidence and annual share of laborers accused or denounced in the anti-vagrancy councils, 1851-1867*: the counts of jornaleros ordered to spend prison time or denounced in the anti-vagrancy councils were collected from the monthly acts of the anti-vagrancy councils for five municipalities: (Caguas, Comerío, Juncos, Lares, and Yauco). To construct the share of jornaleros prosecuted by the local anti-vagrancy councils, we estimate the number of jornaleros in each municipality throughout the period in the following way. 1) We estimate the proportion of jornaleros in each municipality in years for which we have census counts data (1846, 1860, 1862, 1865, 1867) by assuming that the proportion for each municipality remains constant over time throughout the 1846-1867 period (the jornalero share data is only available in year 1867). 2) We interpolate the share of jornaleros in the municipality within census years by assuming a constant growth rate of the jornalero and total population.

Total population in 1846, 1860, 1862, 1865, 1867: available from Gaceta de Puerto Rico (1868a).

Volunteer Corps (VC) distribution data: Rosado Brinacu (1891) documents the distribution of Volunteer Corps units (companies) across municipalities of the island for the year 1886. Unfortunately, the source does not provide data on the number of men in the VC company in each municipality; it only provides the geographic distribution of VC companies to all municipalities across the island. Therefore, we impute the share of men in a company assigned to each municipality using equal shares for each company. The following information on the 10th VC battalion exemplifies the data available and our imputation method.

> Volunteer Corps - 10th Battalion
>
> Company 1 – Municipality of Coamo (Battalion Headquarters) (1 company)
>
> Company 2 – Municipality of Juana Díaz (1 company)
>
> Company 3 – Municipality of Aibonito (1 company)
>
> Company 4 – Municipalities of Barros (0.5 company), Barranquitas (0.5 company)

Provincial Civil Guard distribution data: Molinero y Gómez Cornejo (1879) documents an analogous distribution of Civil Guard units (companies) across municipalities of the island for the year 1876. Again, the source does not provide data on the number of men in each municipality. Therefore, we impute the share of men in a company assigned to each municipality using equal shares for each company. In some cases, particular units are assigned to '*barrios*' (municipal districts – smallest administrative unit), and we aggregate the coding at the municipality level.

Land Distribution:

Plot size and owner of each plot for each taxed plot in municipality, for one year in 1891-1894 period: available from cadastral land censuses for all municipalities in center of the island. Source: Archivo General de Puerto Rico, Fondo: Administración Provincial (Gobernadores Españoles). Land Gini coefficient for each municipality constructed from the distribution of plot sizes for each individual owner. Source: Archivo General de Puerto Rico, Fondo: Administración Provincial (Gobernadores Españoles). Land gini coefficient for each municipality constructed from the distribution of plot sizes for each individual owner.

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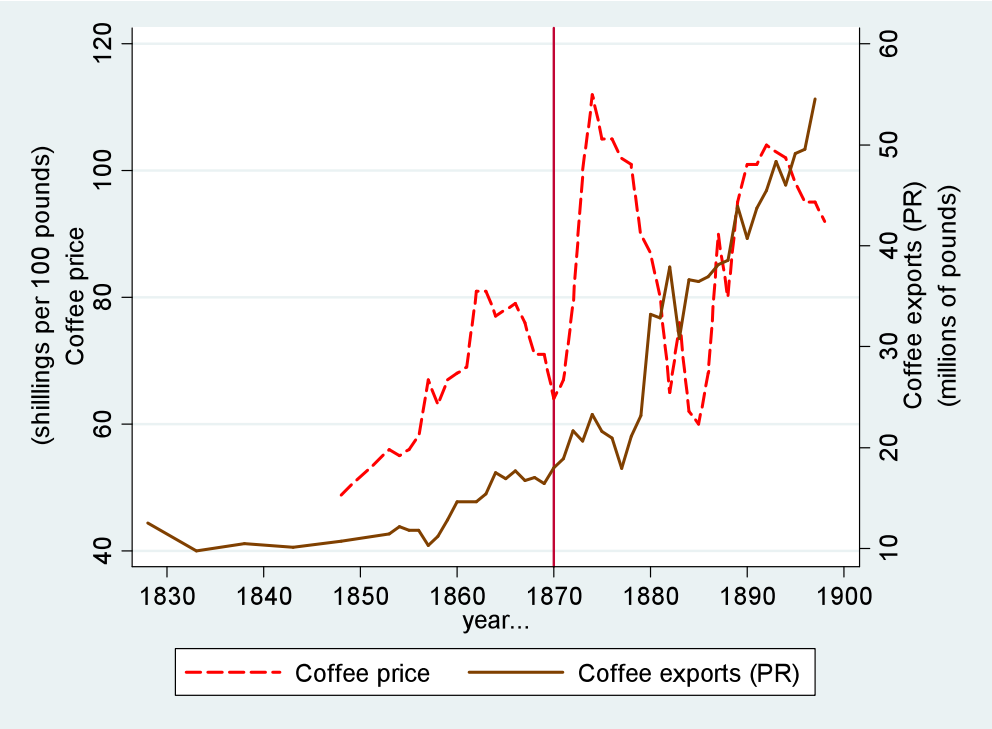
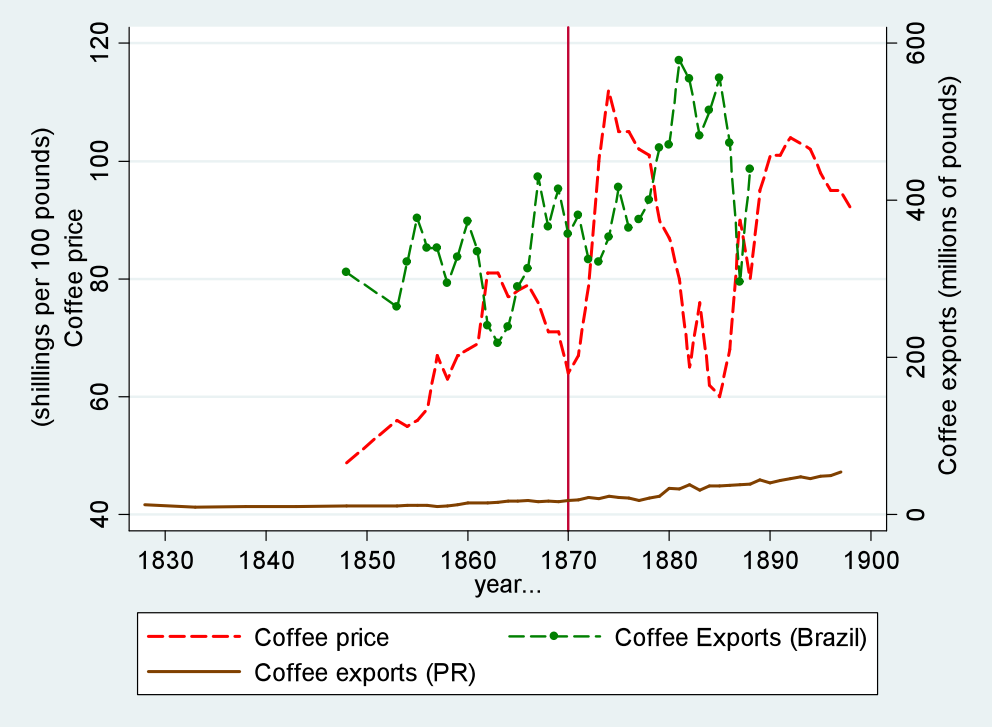
Figure 1: Volume of Puerto Rico Coffee Exports and International Coffee Prices, 1825-1897

Panel A: Coffee Prices and Trends in Puerto Rico Coffee Exports



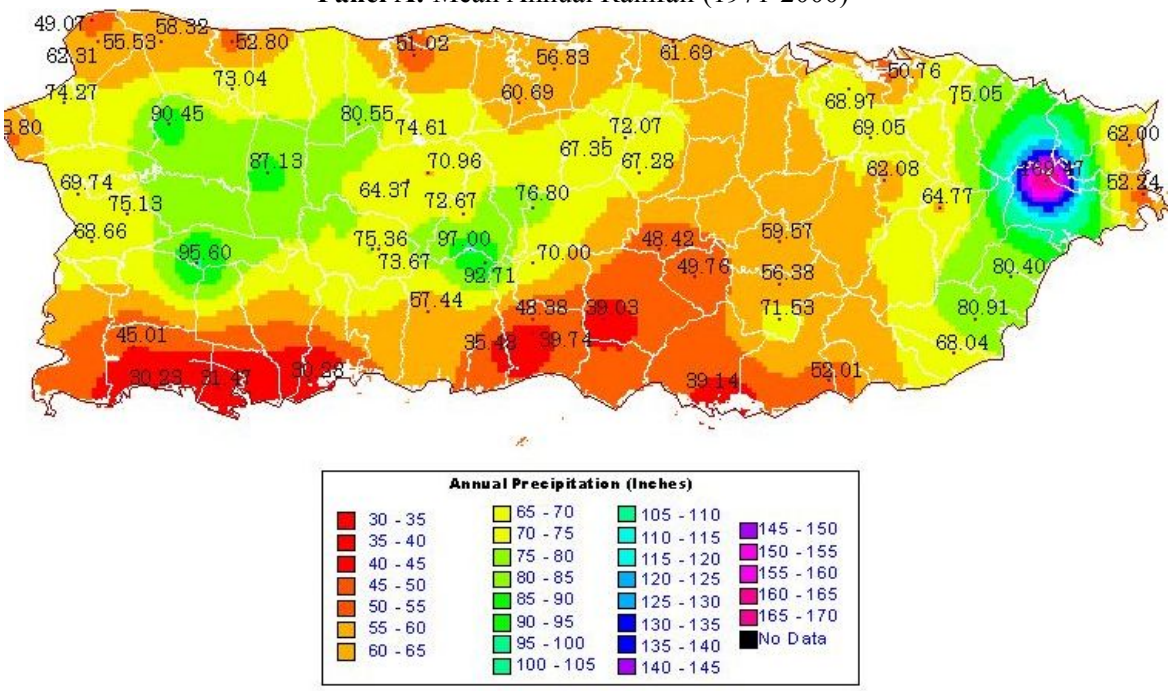
Panel B: Coffee Prices and Trends in Brazil and Puerto Rico Coffee Exports



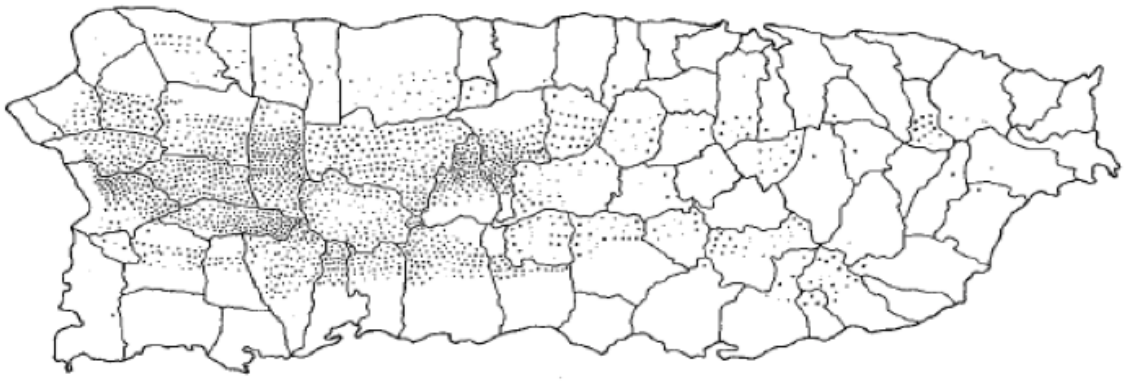
Sources: Coffee exports data – *Boletín Histórico de Puerto Rico,* volume 5, p. 300, averages for the years 1828-32, 1833-37, 1838-42, 1843-47, and 1848-52, available in Dietz (1986); Puerto Rico, Intendencia General de Hacienda, *Balanza Mercantil*, for the years 1853-1860; *Estadística General*, for the years 1862-1898, in Bergad (1983). Wholesale export prices for coffee (quoted in the UK) are taken from Sauerbeck (1886, 1893, 1909). See the data appendix for details.

Figure 2: Geographic Distribution of Mean Annual Rainfall (1971-2000) and Coffee Cultivation (1935) in Puerto Rico

Panel A: Mean Annual Rainfall (1971-2000)



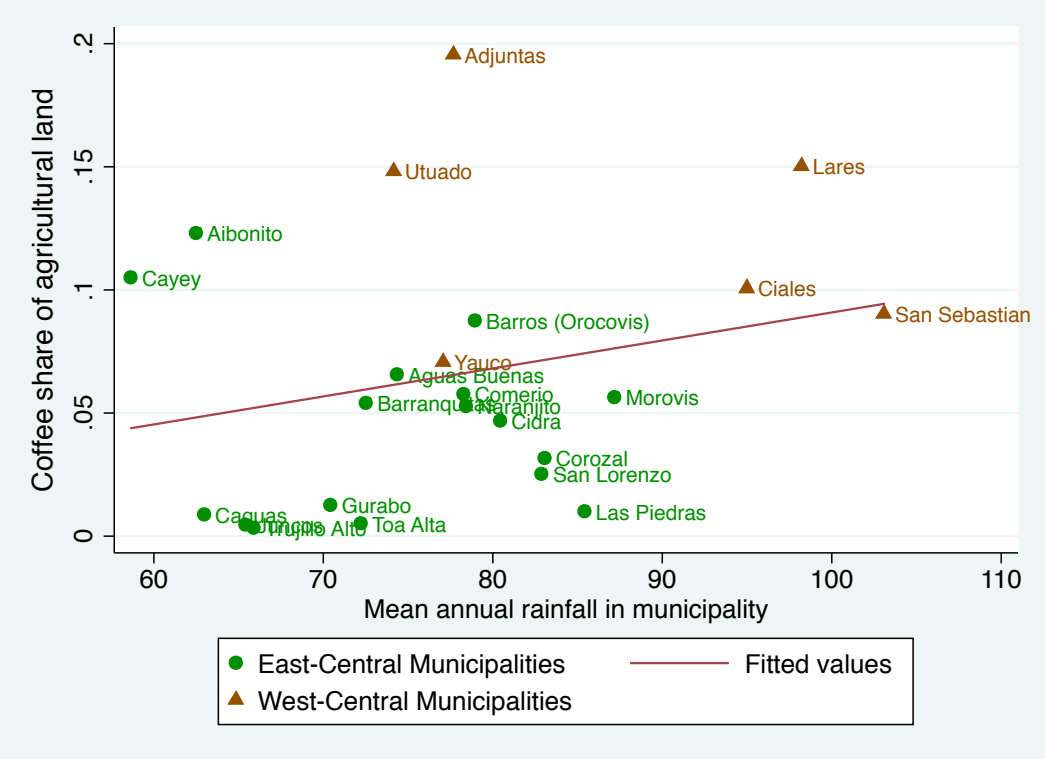
Panel B: Coffee Cultivation (1935)



Notes: In Panel B, each dot represents 100 cuerdas (1 cuerda = 0.97 acres)

Sources: National Weather Service (2007) for Panel A and Bergad (1983), p. xxvii from Roberts (1941) for Panel B.

Figure 3: Mean Annual Rainfall Levels and Coffee Cultivation, Year 1896

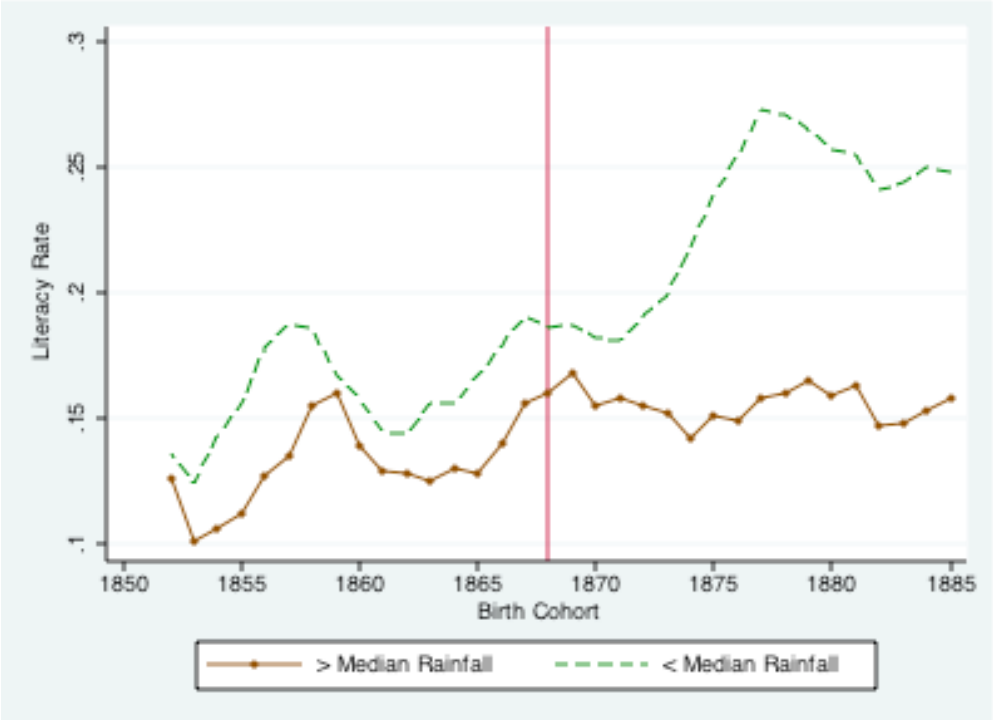


Notes: Each (brown) triangle represents a West-Central municipality and each (green) circle represents an East-Central municipality. The figure plots the share of coffee under land cultivation in 1896 against the mean annual rainfall in each municipality. Linear fit from OLS regression shown in solid line.

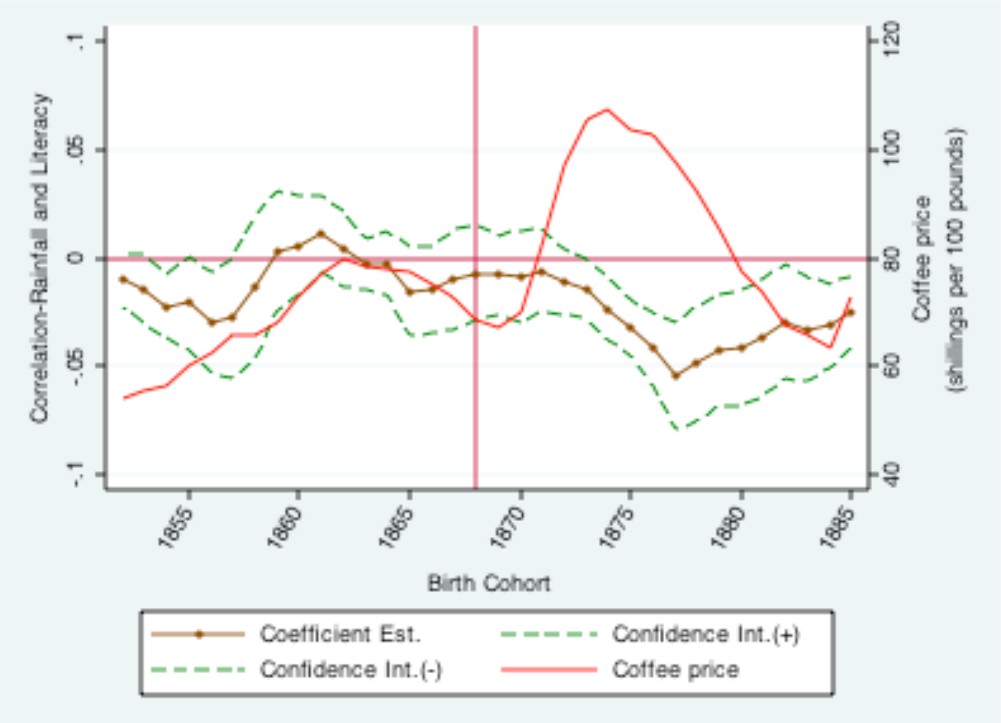
Source: Author's calculations from Carroll (1899) and Roberts (1941). See the data appendix for details on the construction of the variables.

Figure 4: Literacy Rates Differences across Municipalities with Varying Rainfall Levels

Panel A: Literacy Rates by Cohort Group and Average Annual Rainfall Levels



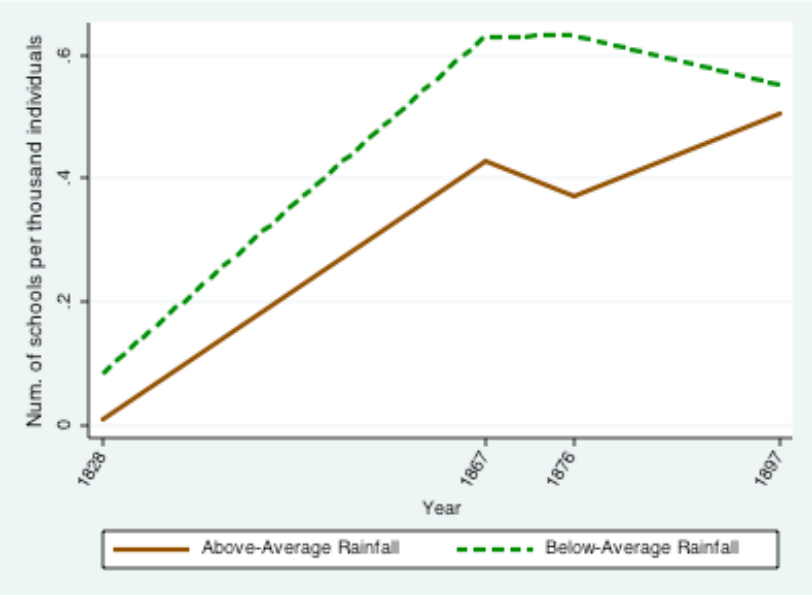
Panel B: Coefficients - Interaction of Cohort Group Indicators and Average Annual Rainfall Levels



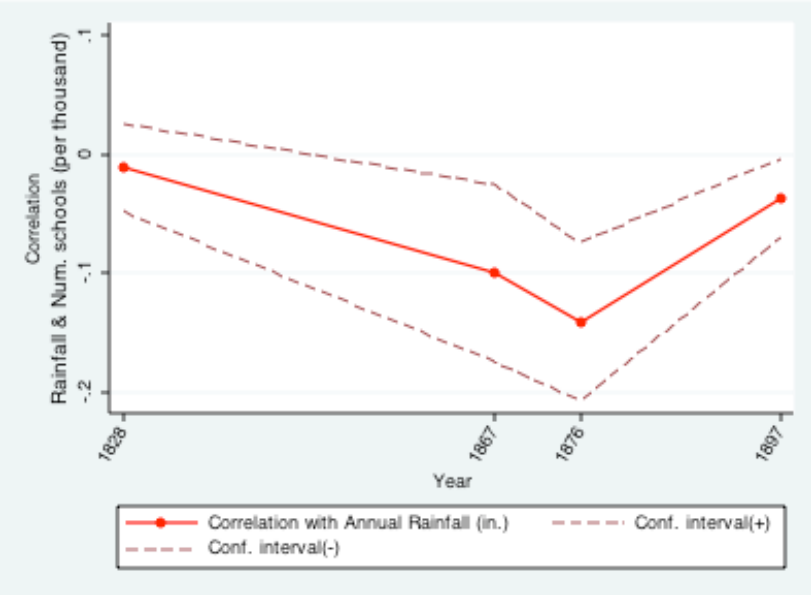
Notes: Panel A – birth cohort-specific literacy rates by (5-year moving averages), by above median and below median average annual rainfall levels. Panel B - values of parameter estimates of cohort-specific correlation with mean annual rainfall in municipality, from OLS regressions and their 95 percent confidence intervals are presented. (Robust standard errors; disturbance terms are allowed to be correlated within municipality, but not across municipalities). Specification includes municipality and year of birth indicator variables.

Figure 5: Trends in number of schools per capita throughout the 19th century

Panel A: Number of schools per capita, by Average Annual Rainfall Levels



Panel B: Correlation with Municipality Average Annual Rainfall Levels

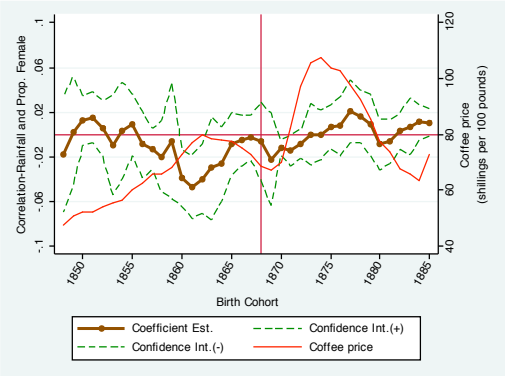


Notes: Panel A depicts trends in number of public primary schools per thousand individuals for the above average (solid brown line) and below average (dashed green line) annual rainfall municipalities. Panel B depicts the correlation in the number of public primary schools per thousand individuals with a municipality's average annual rainfall, depicted in the solid red line with circles, and their 95 percent confidence intervals, depicted in thin dashed lines.

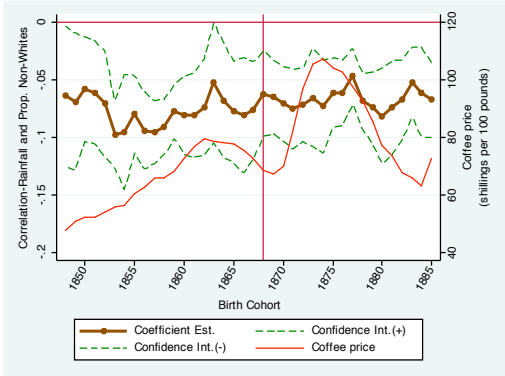
Figure 6: Differences in Pre-Determined Observable Characteristics across Cohorts in Municipalities with Varying Rainfall Levels

Coefficients-Interaction of Cohort Group Indicators and the Municipality-Level Average Annual Rainfall Levels

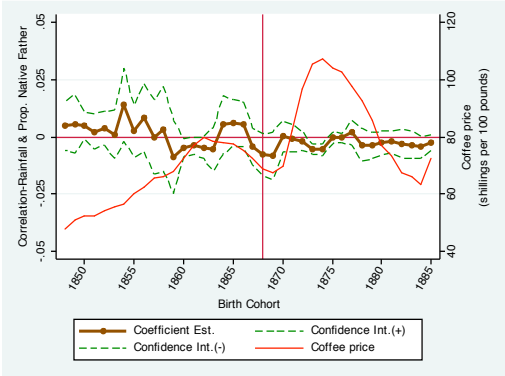
Panel A: Proportion Female



Panel B: Proportion Non-White



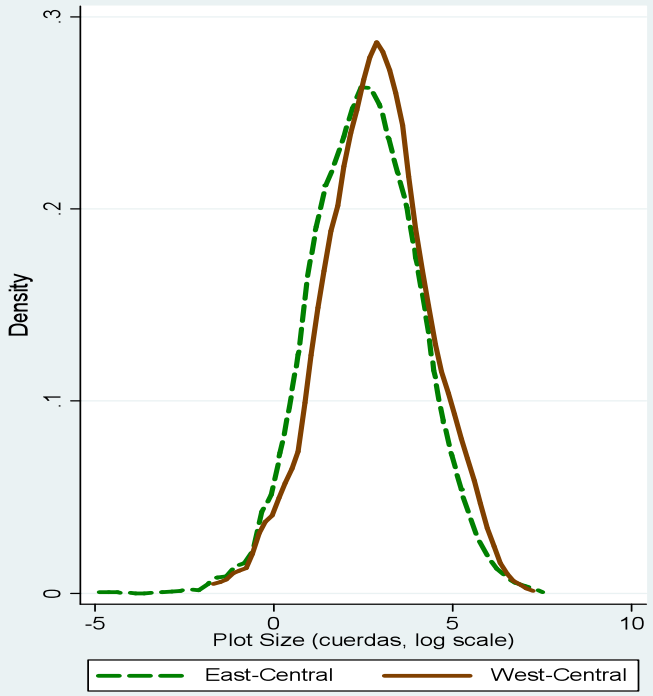
Panel C: Proportion Native Father



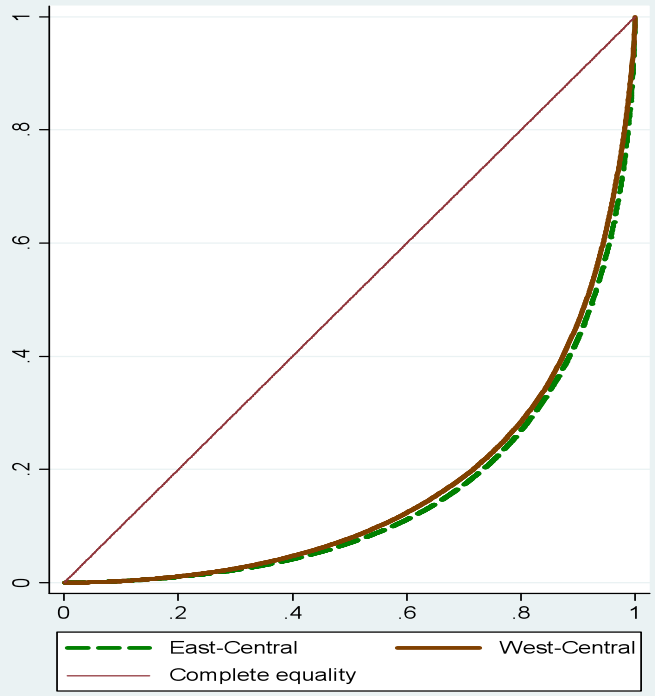
Notes: Values of parameter estimates of cohort-specific correlation with mean annual rainfall in municipality, from OLS regressions and their 95 percent confidence intervals are presented. (Robust standard errors; disturbance terms are allowed to be correlated within municipality, but not across municipalities). Specification includes municipality and year of birth indicator variables.

Figure 7: Distribution of Landholdings across Regions, 1890s

Panel A: Non-parametric kernel densities



Panel B: Lorenz Curves



Notes: Panel A figures present non-parametric kernel density estimates of the distribution of individual land ownership using an Epanechnikov kernel. Panel B presents Lorenz curve of land ownership distribution for each region (coffee region = solid brown line; food crops region = dashed green line). Data are samples from land cadastres for municipalities in West-Central and East-Central regions, varying years (1891-1894).

Table 1: Determinants of Coffee Exports and Coffee Cultivation

Dependent variables:	ln [Coffee exports (PR)] [millions of pounds]			Share of agricultural land under coffee cultivation, year 1896		
Sample:	Years 1846 - 1898			All central municipalities		
	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
ln[Coffee price [t]]	0.83					
	(0.65)					
ln[Coffee price [t − 1]]	0.28					
	(1.04)					
ln[Coffee price [t − 2]]	-0.56					
	(0.86)					
ln[Coffee price [t − 3]]	0.20					
	(0.92)					
ln[Coffee price [t − 4]]	0.13					
	(1.01)					
ln[Coffee price [t − 5]]	0.20					
	(0.91)					
ln[Coffee price [t − 6]]	1.14*					
	(0.60)					
ln[Avg. coffee price [t, t − 3]]		0.56				
		(0.41)				
ln[Avg. coffee price [t − 1, t − 3]]			0.43			
			(0.44)			
ln[Avg. coffee price [t − 4, t − 6]]		1.31***	1.33***			
		(0.36)	(0.40)			
Average annual rainfall (in. x 10)				0.044***	0.044**	0.038**
				(0.019)	(0.017)	(0.018)
Average maximum temperature					-0.009	-0.003
					(0.006)	(0.007)
Average minimum temperature					-0.010	-0.008
					(0.006)	(0.007)
Average altitude (m)						0.000
						(0.000)
Average land gradient (º)						0.006
						(0.008)
Distance to port (km)						0.001
						(0.003)
Mean of dep. variable	-	-	-	0.090	0.090	0.090
Observations	47	47	47	25	25	25

Notes: Heteroskedasticity-robust standard errors in parentheses; significantly different from zero at (*) 90%, (**) 95%, (***) 99% confidence. See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis.

Table 2: Geographic, Economic and Demographic Characteristics, Mid-Nineteenth Century

	West-Central (Coffee) Region (1)	East-Central (Food crops) Region (2)	Difference (Std. Error) (3)	Corr. with mean annual rainfall (Std. Error) (4)
Panel A : Geographic Characteristics				
Average annual rainfall, 1899-1928 (in.)	90.2	74.1	16.1***	-
			(4.2)	
Average altitude (meters)	436.4	331.8	104.7	0.636
			(73.7)	(2.797)
Average land gradient (degrees)	17.6	14.4	3.2**	0.061
			(1.3)	(0.054)
Average maximum temperature, 1950-2000 (°F)	82.9	84.0	-1.2	0.045
			(1.3)	(0.051)
Average minimum temperature, 1950-2000 (°F)	63.2	66.7	-3.5***	-0.034
			(0.7)	(0.038)
Distance to nearest port (km)	24.4	26.0	-1.6	0.036
			(2.8)	(0.108)
Panel B : Coffee Cultivation & Production, Year 1828				
Coffee production (quintales)/ land unit (cuerda)	0.071	0.034	0.037	0.000
			(0.032)	(0.001)
Number of coffee mills	0.40	0.06	0.34	0.020**
			(0.24)	(0.009)
Wealth per capita	94.9	109.3	-14.4	0.403
			(14.8)	(0.813)
Value of production per capita	9.5	6.0	3.4	0.040
			(1.6)	(0.070)
Panel C : Socio-Economic and Demographic Characteristics, Year 1828				
Sharecroppers share of the populaion	0.08	0.13	-0.05	-0.0007
			(0.03)	(0.0018)
Slaves as share of total population	0.08	0.08	0.00	-0.0030***
			(0.02)	(0.0006)
Free blacks or mulattos as share of the pop.	0.33	0.35	-0.02	-0.0069
			(0.07)	(0.0032)
Free blacks as share of the population	0.05	0.07	-0.02	-0.0013
			(0.02)	(0.0011)
White pop. share of the total population	0.51	0.44	0.07	0.0156***
			(0.08)	(0.0034)
Crude Birth Rate	57.8	54.6	3.2	0.12
			(7.5)	(0.30)
Crude Death Rate	23.1	23.2	-0.1	0.08
			(3.3)	(0.13)

Notes: Robust standard errors in parentheses; significantly different from zero at (*) 90%, (**) 95%, (***) 99% confidence. See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis.

Table 3: Descriptive Statistics – *Jornalero* Regulation Enforcement and Public School Provision

	Sample Means					
	All	Annual Rainfall > Median	Annual Rainfall ≤ Median	Difference [(3) - (2)]	Corr. with Annual Rainfall	N
	(1)	(2)	(3)	(4)	(5)	(6)
Jornalero Share of Population, Year 1867	0.092 [0.055]	0.086 [0.072]	0.098 [0.035]	-0.012 (0.024)	-0.010 (0.010)	22
Jornaleros warned or spending time in prison [1/0], 1851-1867	0.468 [0.504]	0.545 [0.506]	0.286 [0.469]	0.260 (0.158)	0.081 (0.062)	47
Jornaleros spend time in prison [1/0], 1851-1867	0.106 [0.312]	0.152 [0.364]	0.000 -	0.152 (0.098)	0.0001 (0.0393)	47
Num. of public primary schools per 1,000 individuals	0.406 [0.276]	0.329 [0.227]	0.484 [0.301]	-0.155*** (0.058)	-0.067** (0.027)	86

Notes: Standard deviation in brackets; robust standard errors in parentheses; significantly different from zero at (*) 90%, (**) 95%, (***) 99% confidence. The data in Row 1 is for the cross-section of 22 municipalities. The data on rows 2 and 3 are for an unbalanced panel across five municipalities during the period 1851-1867. The data in row 4 is an unbalanced panel across 22 municipalities over four time periods. See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis.

Table 4: Descriptive Statistics

	Sample Means				Corr. with Annual Rainfall	
	All	Coercive Period (Cohorts)	Post-coercive Period (Cohorts)	Difference [(3) - (2)]	Coercive Period (Cohorts)	Post-coercive Period (Cohorts)
	(1)	(2)	(3)	(4)	(5)	(6)
Adult Literacy Rate	0.186	0.156	0.199	0.043	-0.008	-0.029***
				(0.011)	(0.007)	(0.008)
Age (in 1910)	37.6	50.4	32.0	-18.5	-0.156	0.025
				(0.1)	(0.114)	(0.035)
Gender (Female = 1, Male = 0)	0.503	0.504	0.503	-0.001	-0.014*	0.003
				(0.011)	(0.007)	(0.002)
Ethnicity (Black/Mulatto = 1, Other = 0)	0.265	0.267	0.264	-0.003	-0.075***	-0.068***
				(0.006)	(0.017)	(0.016)
Native-born father	0.982	0.979	0.984	0.005*	0.000	-0.002
				(0.002)	(0.002)	(0.001)

Notes: Robust standard errors in parentheses; significantly different from zero at (*) 90%, (**) 95%, (***) 99% confidence. See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis.

Table 5: The Effects of the Coffee Boom on Literacy Rates

Dependent variable:	Individual's literacy (1/0) indicator					
Sample:	All Coercion Period Cohorts			All Post-Coercion Period Cohorts		
	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
Avg. rainfall (in. x 10) * Avg. coffee price 4-6 years preceding primary school enrollment decision	0.018	0.017	0.016	-0.066**	-0.064**	-0.065**
	(0.033)	(0.033)	(0.031)	(0.018)	(0.018)	(0.018)
[Robust cluster p-value]	[0.598]	[0.613]	[0.624]	[0.001]	[0.002]	[0.001]
[Wild cluster bootstrap p-value]	[0.664]	[0.662]	[0.674]	[0.014]	[0.014]	[0.014]
Avg. coffee price 4-6 years preceding primary school enrollment decision	Yes	Yes	Yes	Yes	Yes	Yes
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	No	Yes	No	No	Yes	No
Municipality fixed effects	No	No	Yes	No	No	Yes
*ΔLiteracy from 1SD(Coffee price)*10 in. rain*	*0.003*	*0.002*	*0.002*	*-0.010*	*-0.009*	*-0.009*
Differential effect for post-coercion cohort (from pooled regression)				-0.083**	-0.081**	-0.080**
				(0.036)	(0.036)	(0.034)
				[0.030]	[0.033]	[0.031]
[Wild cluster bootstrap p-value]				[0.022]	[0.028]	[0.018]
*ΔLiteracy from 1SD(Coffee price)*10 in. rain*				*-0.012*	*-0.012*	*-0.012*
Mean of dependent variable	0.156	0.156	0.156	0.199	0.199	0.199
N	4749	4749	4749	10760	10760	10760
R-squared	0.09	0.09	0.10	0.07	0.08	0.09

Notes: Coefficient estimates from OLS regressions are reported. Cluster robust standard errors in parentheses; p-values from hypotheses tests based on these and from wild cluster bootstrap-t with H_0 imposed in brackets; disturbance terms are allowed to be correlated across all individuals within a municipality; significantly different from zero at (*) 90%, (**) 95%, (***) 99% confidence. Demographic controls include linear and quadratic terms on age (in 1910), female gender, black/mulatto, and native-father indicators. Geographic controls are the mean maximum and minimum annual temperature, mean altitude, mean land gradient, and distance to nearest port for each municipality.

Table 6: The Effects of the Coffee Boom on Literacy Rates (continued)

Dependent variable:	Individual's literacy indicator (1/0)							
Sample:	Municipalities with Libreta Enforcement Data, Cohorts in							
	Coercion Period, Years w/Enforcement Data		Coercion Period, Years w/Enforcement Data		Coercion Period, All Years		Post-Coercion Period, All Years	
	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)	OLS (7)	OLS (8)
Jornaleros spend time in prison [1/0]	0.132	0.158						
	(0.030)	(0.042)						
Avg. rainfall (in. x 10) *								
Avg. coffee price 4-6 years preceding			0.032	0.067	0.013	0.015	-0.096	-0.097
primary school enrollment decision			(0.240)	(0.243)	(0.043)	(0.040)	(0.025)	(0.026)
[Wild cluster bootstrap p-value]	[0.175]	[0.131]	[0.963]	[0.963]	[0.787]	[0.787]	[0.137]	[0.137]
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	No	No	No	No	No	No	No	No
Municipality fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
N	527	527	527	527	1422	1422	3214	3214
R-squared	0.13	0.14	0.13	0.13	0.12	0.13	0.08	0.09
ΔLiteracy from 1SD↑(Enforcement)	*0.041*	*0.049*						
*ΔLiteracy from 1SD↑(Coffee price)*10 in. ra*	-	-	*0.005*	*0.010*	*0.002*	*0.002*	*-0.014*	*-0.014*
Differential effect for post-coercion cohort							-0.107	-0.112
(from pooled regression)							(0.040)	(0.043)
[Wild cluster bootstrap p-value]							[0.135]	[0.135]
*ΔLiteracy from 1SD↑(Coffee price)*10 in. rain*							*-0.016*	*-0.016*
Mean of dependent variable	0.171	0.171	0.171	0.171	0.184	0.184	0.246	0.246
N	527	527	527	527	1422	1422	3214	3214
R-squared	0.13	0.14	0.13	0.13	0.12	0.13	0.08	0.09

Notes: Coefficient estimates from OLS regressions are reported. Cluster robust standard errors in parentheses; p-values based on wild cluster bootstrap-t tests with H_0 imposed in brackets; disturbance terms are allowed to be correlated across all individuals within a municipality; significantly different from zero at (*) 90%, (**) 95%, (***) 99% confidence. Demographic controls include linear and quadratic terms on age (in 1910), female gender, black/mulatto, and native-father indicators. See notes to Table 4 for description of control variables.

Table 7: The Effects of the Coffee Boom on Public Primary School Provision

Dependent variable:	Number of schools per capita in municipality					
	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
Avg. rainfall (in. x 10) * Year 1867 / 1876	-0.104***	-0.097**	-0.097**			
	(0.024)	(0.024)	(0.029)			
[Wild cluster bootstrap p-value]	[0.008]	[0.010]	[0.016]			
Avg. rainfall (in. x 10) * Year 1867				-0.084*	-0.082*	-0.082*
				(0.036)	(0.037)	(0.042)
[Wild cluster bootstrap p-value]				[0.082]	[0.086]	[0.082]
Avg. rainfall (in. x 10) * Year 1876				-0.130	-0.118	-0.120
				(0.038)	(0.038)	(0.047)
[Wild cluster bootstrap p-value]				[0.260]	[0.228]	[0.274]
Avg. rainfall (in. x 10) * Year 1897	-0.026	-0.023	-0.018	-0.026	-0.023	-0.018
	(0.026)	(0.026)	(0.032)	(0.026)	(0.026)	(0.032)
Average annual rainfall (in. x 10)	-0.011	-0.011		-0.011	-0.010	
	(0.019)	(0.027)		(0.019)	(0.027)	
Period indicators	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	No	Yes	No	No	Yes	No
Municipality fixed effects	No	No	Yes	No	No	Yes
Mean of dependent variable	0.406	0.406	0.406	0.406	0.406	0.406
N	86	86	86	86	86	86
R-squared	0.67	0.72	0.81	0.66	0.71	0.80

Notes: Coefficient estimates from OLS regressions are reported. Cluster robust standard errors in parentheses; p-values from wild cluster bootstrap-t tests with H_0 imposed in brackets; disturbance terms are allowed to be correlated across all individuals within a municipality; significantly different from zero at (*) 90%, (**) 95%, (***) 99% confidence. Demographic controls include linear and quadratic terms on age (in 1910), female gender, black/mulatto, and native-father indicators. Geographic controls are the mean maximum and minimum annual temperature, mean altitude, mean land gradient, and distance to nearest port for each municipality.

Table 8: Tests of Alternate Hypotheses – Correlations with Annual Rainfall Levels

Dependent variables:	Coefficient Estimate on Avg. rainfall (in. x 10)			Mean of dep. variable	N
	OLS (1)	OLS (2)	OLS (3)	(4)	(5)
Adult foreigners' literacy rate, 1899	0.006	0.002	-	0.86	23
	(0.014)	(0.002)			
Native adult males' literacy rate, 1899	-0.013**	-0.013**	-	0.24	23
	(0.005)	(0.005)			
Overall land ownership Gini, 1890s	0.009	-0.002	-	0.92	19
	(0.074)	(0.008)			
Landed HHs land ownership Gini, 1890s	0.028	0.009	-	0.75	19
	(0.017)	(0.021)			
Share of landed households, year 1899	-0.003	-0.026	-0.022	0.70 / 0.69	23 / 19
	(0.020)	(0.021)	(0.028)		
Num. of Provincial Civil Guard Units, 1876	-0.050	-0.058	-	0.92	22
	(0.072)	(0.147)			
Share of Volunteer Guard Unit, 1886	-0.017	-0.039	-	0.70	22
	(0.061)	(0.083)			
Volunteer Guard Headquarters, 1886	0.009	0.012	-	0.09	22
	(0.030)	(0.076)			
Commercial / industrial work occupational share, 1867	-0.004	-0.008	-	0.05	22
	(0.003)	(0.006)			
Geographic controls	No	Yes	Yes		

Notes: Coefficient estimates from OLS regressions are reported. Heteroskedasticity-robust standard errors in parentheses; significantly different from zero at (*) 90%, (**) 95%, (***) 99% confidence. Geographic controls are the mean maximum temperature, mean minimum temperature, mean altitude, mean land gradient, and distance to nearest port for each municipality.

Table 9: Robustness Tests of the Effects of the Coffee Boom on Literacy Rates

	Dependent variable: Individual's literacy (1/0) indicator							
	Coef. Est. Rainfall × Coffee price [4-6 yrs. lag]	Δ*Literacy from 1SD*(P_c)	Coef. Est. Rainfall × Coffee price [4-6 yrs. lag]	Δ*Literacy from 1SD*(P_c)	Δ Effect for post-coercion cohorts	Δ*Literacy from 1SD*(P_c)	Jornaleros spend time in prison [1/0]	Δ*Literacy from 1SD*(*E.*)
Sample:	Coercion period cohorts		Post-coercion period cohorts				Coercion period cohorts	
Additonal control variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Coffee price 6 years pre. primary school enrollment decision ×								
Schools per capita in 1867, 1876-77 (2 variables)	0.144 [0.144]	*0.021*	-0.069** [0.012]	*-0.010*	-0.209* [0.068]	*-0.030*	0.136 [0.232]	*0.042*
Overall Land Gini Coefficient (1890s)	0.007 [0.854]	*0.001*	-0.060** [0.014]	*-0.009*	-0.065* [0.064]	*-0.009*	0.123 [0.504]	*0.038*
Num. Provincial Civil Guard units (n x 10) (1876)	0.017 [0.660]	*0.002*	-0.066** [0.014]	*-0.010*	-0.083** [0.014]	*-0.012*	0.104* [0.086]	*0.032*
Share of Volunteer Guard Unit in Mun. (1886)	0.022 [0.580]	*0.003*	-0.064** [0.018]	*-0.009*	-0.085** [0.026]	*-0.012*	0.166* [0.086]	*0.052*
Volunteer Guard HQ in Mun. (1886)	0.017 [0.692]	*0.002*	-0.065** [0.014]	*-0.009*	-0.082** [0.028]	*-0.012*	0.158 [0.146]	*0.049*
Mean altitude (m. x 10)	0.012 [0.824]	*0.002*	-0.065** [0.016]	*-0.009*	-0.075 [0.200]	*-0.011*	0.150 [0.418]	*0.047*
Mean land gradient (º)	0.020 [0.706]	*0.003*	-0.064** [0.012]	*-0.009*	-0.083 [0.128]	*-0.012*	0.123 [0.232]	*0.038*
Distance to port (km)	0.020 [0.592]	*0.003*	-0.066** [0.014]	*-0.010*	-0.085** [0.024]	*-0.012*	0.126 [0.198]	*0.039*
Commercial / industrial work occupational share, 1867	-0.009 [0.714]	*-0.001*	-0.064** [0.016]	*-0.009*	-0.053* [0.094]	*-0.008*	0.158 [0.464]	*0.049*
Avg. rainfall (in. x 10) × Avg. sugar price 1-3 years pre. school enrollment decision	0.008 [0.866]	*0.001*	-0.096*** [0.004]	*-0.014*	-0.102*** [0.008]	*-0.015*	0.143 [0.194]	*0.045*
Geographic controls	No		No				No	
Municipality fixed effects	Yes		Yes				Yes	
Mean of dependent variable	0.156		0.199				0.171	
N Municipalities[a]	22		22				5	
N Individuals[b]	4749		10760				527	

Notes: Coefficient estimates from OLS regressions are reported. P-values from hypotheses tests based on these and from wild cluster bootstrap-t with H_0 imposed in brackets; disturbance terms are allowed to be correlated across all individuals within a municipality; significantly different from zero at (*) 90%, (**) 95%, (***) 99% confidence. Demographic controls include linear and quadratic terms on age (in 1910), female gender, black/mulatto, and native-father indicators. a,b = the number of municipalities (individuals) in the overall landownership Gini coefficient-Coffee price interaction specification is 18 (9,720 and 4,256 in the post-coercion and coercive period samples, respectively).