Political Institutions, Labor Coercion, and the Emergence of Public Schooling: Evidence from the 19th Century Coffee Boom *

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Abstract: Using unique nineteenth century micro data from municipalities in Puerto Rico, we examine whether the provision of efficiency-enhancing local public goods and the accumulation of human capital were influenced by the feasibility and incentives of elite groups to establish coercive labor institutions. Exploiting variation in the Alizé Trade Winds, which generate greater precipitation in Puerto Rico's west-central region relative to the otherwise similar east-central region - affecting the productivity and profitability of coffee cultivation across municipalities - we find that coffee-region elites and governments were more likely to use resources to enforce labor coercive measures, as documented by greater expenditures in the rural police and in the size of paramilitary forces. In addition, the quality of local governments deteriorated in these municipalities, as measured by a relative decline in the provision of public schooling and relative declines in adult literacy rates, child school enrollment, and child literacy rates. These findings are consistent with a model of labor coercion under an elite-controlled non-democratic regime, in which the returns to education are depressed as a result of the extraction of rents from peasants' wages.

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"Yo soy del cafetal que ayer fue todo,
Hoy lloro al cafetal que ya no es nada."

- Juan Avilés, "El cafetal"

I. Introduction

The recent scholarly debate on comparative economic development – which aims to explain why and how incomes per capita across the globe diverge substantially during the past two centuries (Maddison, 2001) – has centered on the roles played by countries' geographic characteristics and institutional configurations in explaining the patterns and timing of this divergence. In the particular case of the American continent, a growing consensus regarding the divergent economic performance of the northern and southern regions asserts that these countries' development trajectories resulted from differences in economic inequality which emerged during the colonial period and persisted throughout the 19th and 20th centuries.[1]

An emerging challenge to this view claims that differences in the economic advancement of these societies may have resulted from differences in the degree of *political* inequality and in the nature of political competition, as exemplified by the degree of political franchise extension and the entrenchment into power of elite groups (e.g. Acemoglu et al, 2007).[2] In particular, Nugent and Robinson (2005) argue that the structure of landownership across coffee-growing countries in the Americas – and thus economic inequality – were critically determined by the legal environment determining access to land and the existence of coercive institutions, which in turn resulted from differences in the extent of militarization of governments across countries. Determining the relevance of these competing groups of theories has nonetheless remained a challenging task, due to the difficulties in distinguishing the role of political institutions from the role of geographic endowments and economic inequality, as well as the potential influences of alternative explanations such as differences in legal systems or in the ethno-religious composition of populations across countries and regions.[3]

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[1] More specifically, these theories argue that initial conditions or factor endowments (e.g., geography and labor endowments) have been a central determinant of countries' initial land and/or wealth distributions, and that the latter structural conditions have led to differences in the formation of political and economic institutions, such as the extension of voting rights and constraints on government rent-seeking activities (Acemoglu, Johnson, and Robinson, 2001; Engerman and Sokoloff, 1997), the provision of growth-generating public goods, such as schooling (Engerman, Mariscal, and Sokoloff, 2002; Galor, Moav, and Vollrath, 2006), and the development of taxation systems (Sokoloff and Zolt, 2005), thus affecting regions' long-run economic performance.

[2] Political inequality may retard a region's development because governments under the control of elites may provide goods and services targeted to the needs of elite groups (Acemoglu et al., 2007; Bates, 1981). Political inequality may also be associated with the absence of political competition and accountability, which may induce greater levels of rent-seeking by local officials, leading to a lower delivery of public goods (Besley & Burgess, 2002).

[3] A substantial number of competing explanations concentrate on differences in legal systems (La Porta et al., 1999), contemporaneous effects of the tropical disease burden on health and development (Bloom and Sachs, 1998), selective migration of colonizers (with different levels of human and social capital) into different countries (Glaeser et al. 2004), and differences in the ethnic and religious composition of populations across regions (Easterly and Levine, 1997).

The goal of this paper is to examine an important mechanism through which political inequality may have influenced the relative underdevelopment of coffee-producing regions in the Americas: whether the use of government-backed coercion of labor and the provision of efficiency-enhancing local public goods were influenced by the incentives of elite groups to enforce coercive labor institutions. We do so by exploiting a case study – local governments in nineteenth century Puerto Rico – combining unique 19th century individual and municipality-level micro data with quasi-experimental variation in the economic incentives for coffee cultivation across regions.

Puerto Rico enjoys a great degree of heterogeneity across municipalities in terms of their geographic characteristics–precipitation levels, topography, and soil composition–disproportionate to the surface area of the island (Roberts, 1941). In particular, variation in the strength and direction of Trade Winds currents towards the west-central and east-central regions of the island lead to annual precipitation levels to be higher in the former than in the latter region (93 inches and 74 inches of rainfall, respectively). This distinction is crucial for coffee cultivation, since coffee trees require cool temperatures and precipitation levels of a minimum of 80 inches annually for high yields.[4] Therefore, we are able to construct comparable groups of municipalities which differ strictly with respect to rainfall patterns, temperature levels, and subsoil composition as a result of winds patterns, and avoid confounding with other potential geographic determinants of agricultural productivity and economic performance.

In addition, these two regions were relatively unpopulated until 1765 and first colonized during the late 18th century.[5] It was not until the various international coffee booms starting in the 1790s – and especially from the 1860s onwards – that the high precipitation west-central region diverges from the east-central one, arguably as a result of differences in these geographic factors so influential for coffee cultivation. We thus compare municipalities whose precipitation levels made them well-suited for coffee cultivation relative to those better suited for the cultivation of food crops, preceding and during the 1860-1890s coffee boom, to examine whether the greater incentives for coffee cultivation in the western region promoted the enforcement of coercive labor institutions and a lower quality of local governments during the late nineteenth century.

Our results provide evidence consistent with the political institutions hypothesis. We find that the otherwise similar coffee-region municipal governments were more likely to use resources to enforce coercive labor measures, as documented by the greater expenditures in the rural police and the larger size of government-supported paramilitary forces – organizations used to enforce mandatory employment

[4] According to various historical accounts, this was a major factor in the establishment of the coffee industry in the former region and the production of food crops (e.g., plantains, corn, rice, yams) in the latter (Bergad, 1983; Cabrera Collazo, 1988; Picó, 1987).

[5] Producers in the major economic sectors of the Island – cattle ranchers and sugar cane hacendados – had limited incentives to populate the rugged interior (Moscoso, 1999).

contracts and the control of peasant revolutionary movements. In addition, we document that the quality of local governments deteriorated in these municipalities, as measured by a relative decline in the provision of public schooling (based on administrative data for the period) and relative declines in literacy rates and child school enrollment rates. These findings are consistent with a simple theory of government-backed coercion and public goods provision under an elite-controlled non-democratic regime. This class of models asserts that, in non-democratic regimes with the potential for state coercion, since the returns to human capital investments are unlikely to be realized due to imperfect contracting on workers' effort, elite-controlled governments would have lower incentives to use government resources to provide local public goods such as schooling, and instead use these to extract rents from the peasantry.

The richness of the data also enables us to distinguish between a many competing theories of the determinants of long-run development. In particular, the most popular competing theory – the "factor endowments hypothesis" – asserts that the geographic endowments of the coffee region would have generated the incentives for the establishment of plantation economies, partly due to potential economies of scale in the cultivation and distribution of various cash crops. This difference in economic inequality would thus influence the degree of political inequality, the formation of political institutions, and the quality of local governments across municipalities (e.g. Engerman and Sokoloff, 2000). However, as noted by many scholars, there are disincentives to establish coffee plantation economies from a purely technological perspective, as there are constant (or even decreasing) returns to scale in coffee cultivation and processing. Moreover, using unique land registry data for the periods preceding and during the peak of the coffee boom, we show evidence that the coffee region did not experience a disproportionately greater concentration of land among landowners, relative to the comparison group of municipalities. We also present evidence that helps us rule out other competing explanations of our main results, such as differences in natives' migration patterns across regions, in the ethno-linguistic composition of local populations, in the tropical disease burden across municipalities, and pure credit-constraints explanations for the difference in educational outcomes of the peasantry. In summary, our findings point to the incentives of elites under coercive political regimes to create and maintain a coercive regime as the main mechanism for the apparent divergence in local governments' policy choices.

The paper is structured as follows: Section II summarizes the implications of the theoretical framework under study; Section III gives a detailed description of the geographic and political context. Sections IV and V respectively describe the data used in the analysis, and discuss the empirical strategy and main identifying assumptions. The central empirical results of the paper, the pieces of evidence supporting the identifying assumptions, and robustness tests are presented in Section VI. Section VII discusses the relevance of alternative explanations. The paper concludes with a discussion toward the reconciliation of the existing evidence as well as avenues for future research.

II. Non-Democratic Politics, the Regulation of Labor, and Divergent Development

Historical transformations in the organization of economic systems in Latin American have specifically involved surges in stratification during periods of export commodity booms. Exemplary cases abound, such as the formation of landlord estates during the 1850-1870 wheat boom in Chile and the coffee booms in Brazil, Guatemala, El Salvador, Colombia, and Costa Rica during the second half of the nineteenth century.[6] This section presents a simple theoretical framework to formalize how incentives for coffee cultivation, in a context of a non-democratic regime, can promote the establishment of coercive labor market institutions and inhibit the government's provision of productivity-enhancing local public goods. We adapt Nugent and Robinson (2005)'s model of militarization, agricultural organization, and human capital investments to understand how elites in non-democratic regimes may choose to form coercive agricultural systems through government expenditure in 'law enforcing' coercive forces.

Fundamentals

Consider a static small open society. There are two types of agents, an elite of mass one and N identical peasants. Each peasant *i* has a utility function $u(c_{if},e)$ defined over food consumption (c_{if}) and disutility from work effort (e), which is assumed to be dichotomous: $e \in \{0,1\}$. For simplicity, we shall assume that the utility function is linear, so that $u(c_{if},e) = c_{if} - e$. We assume that the elite have preferences defined over their own consumption and that the utility function is also linear, so that: $u^E(c_{if},e) = c_{Ef}$.

There are two goods, food, with price normalized to one, and coffee, with price q, which the country takes as given. Both goods are produced from the only two factors of production in the economy, land (of which there are N units) and labor, which is embodied with effort-adjusted human capital. Essentially, individuals are endowed with human capital (as a result of government investments in education), but the productivity of human capital depends on the individual's effort. We assume that the technology for producing coffee exhibits constant returns to scale (as it has been shown that coffee cultivation does not exhibit increasing returns to scale), and we assume it to be of the Cobb-Douglas type: $G(m,n,e,h) = Ag(m,n(1+eh)) = Am^{\alpha}(n(1+eh))^{\beta}$, where $A > 1$ and $\alpha + \beta = 1$. The food crops production function is analogously assumed to be of the Cobb-Douglas form, and to exhibit decreasing returns to scale: $F(m,n,e,h) = f(m,n(1+eh)) = Am^{\rho}(n(1+eh))^{\gamma}$, where $\rho + \gamma < 1$.

Coffee production can be organized either by a system of coercive labor, where *mandatory* fixed-wage contracts are created with peasants, or via a non-coercive system where payments to labor are based on piece-rates. In any case, the elite collectively owns N plots of land and hires the peasants as workers. Each peasant receives one unit of land and thus individually produces $(1+eh)^{\beta}$. In this non-coercive case, the elite is the monopsony buyer of coffee from peasants and buys the coffee at some price $r < q$,

[6] For a detailed description of the consequences of various agricultural commodity booms on the structure of agrarian organization in Latin America, see Dean (1971), McCreery (1994), Paige (1997), and Williams (1994).

generating profits $\Pi^S = (q-r)m^{\alpha}(n(1+eh))^{\beta}$. Peasants with property rights to land can choose to produce food instead of coffee, and do so depending on the price offered for their coffee crop. The coercive system of agricultural organization creates organizational fixed costs for the elite, C^P, to institute, for instance, judicial organizations to enforce these mandatory labor contracts.

A crucial issue is that the elite must incur the fixed organizational costs in order to establish a coercive system. Once it does this we shall assume that labor repression in the coercive regime is feasible and that the elite can extract a share σ of peasant wages if they invest in government and paramilitary forces of labor repression. The degree of rent-extraction is assumed to be a function of government law enforcement (i.e. rural police) expenditures and of the following form: $\sigma(c) = c/(1+c)$. This is an obvious oversimplification of a model where elite groups may have incentives to enforce monopsonistic labor markets through legal and extra-legal mechanisms in order to extract rents from the peasant workforce.[7]

Government activities in this society are limited to the taxation of property (i.e. a land tax) to provide for law enforcement forces and/or investments in an educational system that generates human capital among the peasantry. We assume that the government tax policy is confined to a proportional land tax, with tax rate τ, and that the cost of providing h units of human capital to all peasants is h in terms of the consumption good. Finally, we assume that the elite has uncontested political power.

Timing of the Game

The structure of the game follows our reading of the historical process, whereby the organization of the agricultural system initially takes place, followed by the elites' use of government resources to generate profits for the group.

1. The elite decides on the organization of the rural economy;
2. The elite makes government taxation (τ), expenditure (h, c), and, in the smallholder regime case, pricing (r) decisions;
3. Peasants make effort decisions, wages and prices are determined, and payoffs for each group are realized.

Equilibrium

We characterize the pure strategy sub-game perfect Nash equilibria of this theoretical framework. Peasants' exert effort in the piece-rate setting if $((1+h))^{\gamma} - \tau(e=1)v - 1 \geq 1 - \tau(e=0)v$. This implies that

[7] Conning (2004) formalizes the argument that local elite groups may have had incentives to encroach land through land grabs and other legal and extra-legal mechanisms in order to extract rents from the peasant workforce. According to Conning (2004), even in a context where the export crop production technology exhibits constant returns-to-scale and is relatively land-intensive, landowners' market power over the supply of land and the demand for labor generate incentives for them to restrict access to land to small landowners and landless peasants. The effect of this control over land is to simultaneously increase the value of land rents and, as a result of a decrease in the marginal productivity of labor in small peasant farms, depress wages.

peasants exert effort level $e^* = 1$ if $h^* \geq [1 + (\tau(e=1) - \tau(e=0))v]^{1/\gamma} - 1$, i.e. if human capital investment is sufficiently high. On the contrary, in the coercive economy case it is clear that peasants will not exert effort $e^* = 0$ because the fixed-wage labor contracts are not effort-contingent.

Anticipating such effort choices, the elite make taxation, expenditure, and pricing decisions in each potential agricultural organization regime. In the smallholder economy, the elite choose *{r, τ, h, c}* as follows:

$$\underset{r,\tau,h,c}{Max} \quad \{[(q-r)A(1+eh)^{\beta}]N - C^S\}$$

$$\text{s.t.} \quad rA((1+eh))^{\beta} - \tau vM \geq (1+eh)^{\gamma} - \tau vM$$

$$h + c \leq \tau vM$$

$$e = 1,$$

which results in the following choices of (i) land tax rate, (ii) government schooling expenditures, and (iii) law enforcement expenditures:

$$\tau^* = \frac{1}{vM}\left[\left(\frac{qA\beta}{\gamma}\right)^{1/\gamma-\beta} - 1\right], \qquad h^* = \left(\frac{qA\beta}{\gamma}\right)^{1/\gamma-\beta} - 1, \qquad c^* = 0.$$

Therefore, in the smallholder economy, government taxes are used to achieve sufficiently large investments in an educational system, which thus increase peasants' productivity in both the coffee and food crops sectors.

In the coercive regime case, the elite choose *{τ, h, c}* as follows:

$$\underset{\tau,h,c}{Max} \quad qAN - (1-\kappa(c))\omega N - (\tau + C(\tau))vN - C^P$$

$$\text{s.t.} \quad \kappa(c) = c/(c+1)$$

$$h + c \leq \tau vN$$

$$e = 0,$$

which results in the following choices of (i) land tax rate, (ii) government schooling expenditures, and (iii) law enforcement expenditures:

$$\tau^* = \frac{1}{vN}\left[\left(\frac{\omega N}{1+C_\tau}\right)^{1/2} - 1\right], \qquad h^* = 0, \qquad c^* = \left(\frac{\omega N}{1+C_\tau}\right)^{1/2} - 1.$$

In contrast to the smallholder economy case, in the coercive regime, since the fixed-wage labor contracts generate zero effort from the peasantry, no resources are directed towards the educational system and instead all government tax revenue is used to extract rents from labor through the enforcement of coercive labor contracts, extracting share $\kappa(c^*) = 1 - \left((1 + C_\tau)/(\omega N)\right)^{1/2}$ from peasant wages.

Given the expected effort responses from peasants and the expected choice of taxation and government expenditure decisions in each regime, the elite decides on the organization of the rural economy given the expected profitability of each regime. Elite profits in the smallholder (Π^S) and coercive (Π^P) regimes are respectively:

$$\Pi^S = \left[\left(\frac{\beta}{\gamma}\right)^{\frac{\beta}{\gamma-\beta}} - \left(\frac{\beta}{\gamma}\right)^{\frac{\gamma}{\gamma-\beta}}\right] N(qA)^{\frac{\gamma}{\gamma-\beta}} - C^S \text{, and}$$

$$\Pi^P = qAN - (1 + C_\tau)^{1/2}(\omega N)^{1/2}\left(\frac{C_\tau}{1 + C_\tau}\right) + 1 - C^P .$$

Defining the difference in relative profitability (from the elites' perspective) of the coercive regime as:

$$\Delta\Pi \equiv \Pi^P - \Pi^S = qAN - (1 + C_\tau)^{1/2}(\omega N)^{1/2}\left(1 - \left(\frac{1}{1 + C_\tau}\right)\right) + 1$$
$$- \left[\left(\frac{\beta}{\gamma}\right)^{\frac{\beta}{\gamma-\beta}} - \left(\frac{\beta}{\gamma}\right)^{\frac{\gamma}{\gamma-\beta}}\right] N(qA)^{\frac{\gamma}{\gamma-\beta}} - (C^P - C^S)$$

elites thus choose to institute a coercive regime if $\Delta\Pi > 0$.

This model then allows us to examine the effect of changes in land productivity and product prices on the likelihood that a coercive regime is established. Is there a greater tendency for non-democratic societies to establish and enforce coercive labor regimes in locations with a greater productivity for export crops? How does this propensity to become a coercive economy change given changes in the relative price of the export crop (i.e. coffee)? The comparative statics of the model indicate that, in these non-democratic societies, coercive institutions are more likely to be established *(i)* in regions with a greater relative productivity for export crops, and, *(ii)* during periods where the relatively profitability of export crops is high.

Proposition 1: $\partial\Delta\Pi/\partial A > 0$ *and* $\partial\Delta\Pi/\partial q > 0$.

Proof: Follows from taking the partial derivative of the relative profitability function with respect to *A, q*.

These are the main predictions examined in the empirical analysis. Specifically, we examine whether municipalities located in regions with greater potential for coffee cultivation (i.e. the coffee region) were more likely to develop, during the 19th century coffee boom, coercive labor systems in which government resources were disproportionately used for the enforcement of coercive labor contracts instead of for the provision of productivity-enhancing local public goods such as education. The next section gives a detailed description of the geographic and political economy context under study, which will aid us in formalizing the empirical tests to be presented below.

III. Geographic Characteristics, Economic and Political Institutions in 19th Century Puerto Rico

III.A. Early Colonial History, Physical Geography, and the 19th Century Coffee Boom

Colonized by the Spanish since 1493, Puerto Rico remained a backwater to the Spanish colonial empire during the sixteenth through eighteenth centuries. Its economy, concentrated in the coast until the early nineteenth century, initially consisted of gold mining during the 1510s-1550s (Sued Badillo, 2001), followed by sugar cane and ginger cultivation during the 1550s-1650s, and cattle farming and leather product manufacturing during the 1650s-1800s (Moscoso, 1999). The island remained sparsely populated and concentrated in coastal areas until the late 1700s, where increases in European immigration, African immigration (i.e. slave labor), and internal growth led to substantial increases in the island's population and a slow displacement of cattle ranchers and small peasants to the interior (Moscoso, 1999; Scarano and Curtis-White, 2005).[8]

The coffee boom, which commenced internationally during the late eighteenth century, led to an increase in coffee cultivation and processing in Puerto Rico (and other Central and South American countries) during various extended periods of time throughout the nineteenth century (Topic, 1998).[9] However, the size of the coffee industry would remain relatively stable throughout the first six decades of the nineteenth century; the volume of coffee exports would revolve around a five-year average as low as 9.78 million pounds and as high as 12.98 million pounds during the 1828-1864 period (Figure 2). Emphasis, interest, and credit would concentrate in the growing sugar industry, especially throughout the 1820s and early 1830s, and again during the early 1870s (Bergad, 1983; Scarano, 1984). But by the 1860s, coffee exports would drastically increase, stimulated by price rises in the international coffee market.[10] By 1881 Puerto Rico coffee exports had risen by 227 percent from 1871, to 47.2 million

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[8] Puerto Rico's native indigenous populations (the Taíno indigenous group) were decimated during the 16th century, and any pre-conquest social organization was unfortunately destroyed at the time.

[9] Already in the late eighteenth century, Fray Iñigo Abbad y Lasierra, in his geographic, civil, and natural history of the island first published in 1788, had noted coffee's role in the contraband trade with foreigners in the 1770s. Additionally, the stimulus provided by the rise in world market prices for coffee after the Haitian revolution led to the general expansion of coffee cultivation, particularly in coastal municipalities (Bergad, 1983; Ledrú, 1863). However, by the first decade of the nineteenth century, the boom conditions of the 1790s subsided as new world market supplies filled the initial demand vacuum created by the sharp decline of Haitian coffee exports.

[10] Coffee trees require five to seven years after planting to achieve high coffee bean yields. It comes as no surprise that the surge in coffee exports thus follows the increase in coffee prices by approximately seven years.

pounds, and had reached a peak of 58.0 million pounds during 1896, a fivefold increase from the late 1850s export volume levels (Figure 2).

Coffee cultivation and processing throughout the second half of the nineteenth century was concentrated in the region most conducive to coffee cultivation and processing – the West-Central region of the island – which encompasses the municipalities of Adjuntas, Ciales, Jayuya (part of Utuado at the time), Lares, Las Marías, Maricao, San Sebastián, Utuado, and Yauco. The central municipalities east of Ciales concentrated in the growth of subsistence agriculture and food crops for the domestic market, as well as cattle ranching (Seda Prado, 1996; Picó, 2007).

This spatial concentration of the coffee industry is not surprising, as the island's physical geography greatly influenced the establishment of the coffee industry in this west-central region. Of particular importance to the island's geography is the variation in the speed and direction of the Alizé Trade Winds towards the West-Central and East-Central regions of the island, which led to annual precipitation levels to be higher in the former (93 inches) than in the latter region (74 inches) (Table 1, Panel A). Mean monthly precipitation patterns differ substantially across the two regions, as evidenced by precipitation data for the 1899-1927 period (Figure 1). Based on cumulative monthly precipitation averages, the West-Central region achieves a threshold level of 80 inches of precipitation during the month of October, whereas precipitation in the East-Central region never reaches this threshold level. This distinction is crucial for coffee cultivation, since coffee trees require high annual precipitation levels for high yields, and coffee tree leaves are prone to attacks by the coffee leaf miner in areas with annual precipitation levels below 80 inches (Roberts, 1941). According to various historical accounts, this was a major factor in the establishment of the coffee industry in the former region and the production of food crops (e.g., plantains, corn, rice, yams) and cattle ranching in the latter (Bergad, 1983; Cabrera Collazo, 1988; Picó, 1987).

Municipalities in the West-Central region also favor coffee cultivation as a result of their cooler temperatures (with an average minimum temperature of 63.2 ºF) relative to the East-Central region (66.7 ºF), as coffee produces higher yields in cooler climates (the difference is significant at 95 percent confidence, Panel A). Apart from this difference in wind and precipitation patterns, municipalities in the Central Mountain Range are very similar in terms of their geographic characteristics, except for the fact that the West-Central region has a higher degree of terrain ruggedness, a factor potentially inhibiting the development of export-oriented agriculture due to higher transportation costs.[11]

Data from a population and economic census of 1828 already shows the increasingly marked differences in coffee cultivation and processing during the period. The *pies* of coffee in cultivation as a

[11] We are currently constructing GIS measures of geological determinants of crop-specific agricultural productivity at the municipality-level (i.e soil composition) (sources: Acevedo & Gierbolini, 1982; Gierbolini 1982a,b; Boccheciamp, 1982a,b; P.R. Government Planning Board).

proportion of the total land under cultivation in the municipality was three times higher in the West-Central high rainfall region relative to the East-Central low rainfall region, and, coffee production – as measured by quintales (100 pounds) per land under cultivation – was substantially higher as well (Table 1, Panel B). The facilities for the processing of coffee beans were also concentrated in the high rainfall region; each western municipality had, on average, 2.5 coffee mills, whereas municipalities in the eastern region only had 0.1 mills on average (Panel B).

By 1896, during the peak of the 1885-1987 coffee boom, 18.7 percent of all agricultural land in the West-Central region was under coffee cultivation, relative to only 4.4 percent of land in the East-Central region (Panel B). Moreover, the relationship between annual precipitation levels and the extent of coffee cultivation is quite strong (Figure 3). Based on a simple linear prediction of the relationship, conditional on other observable geographic characteristics, a difference of 10 inches in annual precipitation levels increased the share of agricultural land dedicated to coffee by 42.6 percent (3.8 percentage points, significant at 99 percent confidence) (Figure 3). This relationship is robust to the exclusion of these geographic controls and the inclusion of the share of blacks and mulattoes in the population in 1899 (see Appendix Table A1) – a potentially important confounding determinant in the analysis (see Section VII). The geographic distribution of coffee cultivation was maintained well into the mid-twentieth century (Roberts, 1941).

The quantitative evidence (currently available for years 1824 and 1828) suggests that municipalities in both regions were relatively sparsely populated preceding the coffee boom, as measured by total population and population density (Córdoba, 1831-33) (Figure 4). Municipality population sizes were 3,900-5,200 on average in the coffee-growing region and 2,500-3,100 in the food crops region during this earlier period – the mean difference is statistically (although not economically) significant. To the extent that municipality population density serves as proxy for aggregate economic prosperity during this pre-industrial period, there is a substantial divergence in prosperity across the two regions following the start of the 1860s-1890s coffee boom (Figure 4).[12] Population densities become approximately 160 percent greater in the coffee region relative to the comparison group of municipalities. These data suggest that preceding the first coffee boom the two regions were similar and had similar development patterns, but eventually diverged during the coffee boom.

The historiographic evidence also indicates that the agricultural organization in both regions consisted mostly of small peasants preceding the coffee boom (Bergad, 1983; Picó, 1979; Picó, 2007; Seda Prado, 1996). The available data on the distribution of socio-economic and demographic groups is consistent with this assessment (Table 2, Panel A). The reported distribution of sharecroppers, slaves, and

[12] For a discussion on the validity of measures of population density as proxy for economic prosperity, see Acemoglu, Johnson, and Robinson (2002) and references therein.

free blacks and mulattos was, on average, equally distributed across regions (Panel A, rows 1-4). Finally, also suggestive of the similitude during the early and mid-19th century is the lack of difference in crude mortality and birth rates. According to the Córdova Report to the Spanish Crown (see discussion below), both regions experienced similar crude birth rates (56.0 and 55.0, respectively) and crude death rates (24.0 and 23.0, respectively) during the late 1820s (i.e. 1828) (Panel A, rows 6-7).

III.B. Local De Jure Institutions and Government Administration [13]

As a Spanish colony throughout the 1500s-1800s, the municipal government in Puerto Rico was the only colonial institution in which natives enjoyed a certain extent of de jure political representation. The political rights of certain population groups were gradually extended at the end of the colonial period, first during a short period (1812-14) and again during the last third of the nineteenth century, following Spain's Glorious Revolution of 1868.

Throughout most of the Spanish colonial period, the local government executive was composed of ordinary mayors ('alcaldes ordinarios') and council members ('regidores'). The number of mayors varied by the size of the municipality; small municipalities had a single mayor and larger ones had two. Mayors were elected by the local council members or named by the Governor for short terms. If elected, their designation was usually subject to confirmation by the Governor. The size of the local council body usually fluctuated between four and six for towns and villages, eight or more in cities. Members were in turn named by the King and/or provincial authorities.[14,15]

Following the Glorious Revolution (in 1868), adult males gained greater political participation in municipal government affairs. Under the new regime, council members were elected by eligible voters, defined as males 1) 21 years of age or older, 2) who were literate, 3) with a minimum residence period in the municipality of two years, 4) who paid a minimum amount (25 pesetas) of (income and/or property) taxes annually, or 5) who were municipal government employees or professionals.[16] Council members would in turn provide a short list of candidates to the Governor for the positions of mayor and lieutenant

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[13] This section draws primarily on the detailed descriptions of Bergad (1983), Coll y Toste (1909), Flores Collazo (1991), Osuna (1949), and Trías Monge (1980).

[14] Initially, conquistadores – through the *Sistema de Capitulaciones* – were given the power to name mayors and council members. In other regions across the Spanish Empire, villagers and property owners were given the right to elect council members.

[15] In addition to mayors and council members, municipal governments were comprised also of other municipal civil employees: the lieutenant mayor ('heraldo'); the local finance minister (in charge of the determination of prices and of the inspection of weights and measures); the bailiff (in charge of police functions); the general solicitor or lawyer of the city; the butler (guard of civic property); the notary public; and the district mayors or commissioners (magistrates of police for rural districts). In many municipalities, the council members and mayors assumed the functions of some of these positions.

[16] Until the approval of the Bill of Autonomy of 1898, the municipal regime was governed mainly by the laws of August 20th 1870 and December 16th, 1876, which governed Spanish municipal life until the liberal reforms of 1880 and 1885, and following the restoration of monarchic rule in Spain, by the Royal Decree of May 14th, 1878. The latter rules included important modifications to the previous legislation which provided greater influence to the provincial government in municipal affairs.

mayor. The Governor had the power to name individuals for these positions; he also had the capacity to name other individuals outside the short list (and non-residents of the municipality) for these executive positions, as well as the power to destitute these.

The mayor and the members of the various municipal boards thus enjoyed some degree of power and responsibilities, from the enforcement of the collection of property and excise taxes, to the allocation of municipal resources for the provision of local public goods (i.e. construction and administration of primary schools, supervision of public works projects and maintenance, hospital administration), the administration of the municipal police, and the enforcement of state-level regulations. This control over municipal activities, in combination with the very limited degree of accountability to the majority of the local population, provided these figures with significant leeway in terms of the administration of the local territory. That said, all municipal statues, as well as municipal government budgets, were subject to confirmation and approval by the provincial government.

Municipal authorities thus had a degree of de jure and/or de facto power over three dimensions that, for purposes of the analysis, were of crucial importance in promoting or inhibiting their development: the allocation of land property rights, some of which had previously been government owned (*terrenos baldíos*), the provision of primary schooling, and the control over the municipal police, an important body for purposes of enforcing coercive measures against landless peasants.

The Allocation of Land Property Rights

Although peripheral to areas affected by the sugar cane boom of the 1820s and 1830s, land speculation was initially an important element for many early settlers in the central region. The high fertility of mountain land had the potential to generate future profitability if infrastructural links were developed to facilitate exports. For this reason, coastal entrepreneurs continually sought grants for *terrenos baldíos* in the region, or purchased undeveloped land at low prices.

Preoccupation with establishing legal titles seems to have grown considerably between 1836 and 1848, a period coinciding with the complete dissipation of *baldíos*. This concern for legal titles coincided precisely with the appearance of immigrant merchants in the west-central and east-central regions, since the latter group provided investment capital and credit to peasants. Formal titles were critical for the provision of credit (using land as collateral), and transactions involving land transfers, debt, and mortgages rose notably in the early 1840s.

Municipal government authorities had a substantial power in influencing the distribution of land in the regions and thus indirectly affecting the control over labor. First, the province-level commissions entitled with the power to grant *baldíos* to individuals who requested them usually asked for the opinion of the municipal government on the desirability of granting land to particular individuals, which could favor members of the local elite to the detriment of the popular classes. Second, since the levying of property taxes were carried out at the local level, the mayor and other members of the Municipal Property Tax Board could used their powers to impose an effectively regressive property taxation system, by disproportionately decreasing the property tax burden of large landowners – Municipal Board members, municipal government employees, and other prominent figures in particular – relative to those of small and medium-landowners (Bergad, 1983; Casanova, 1984). This had two important effects: raising the cash generation needs of squatters and small landowners by imposing tax obligations would make these groups more willing to work for wages as day laborers during peak seasons. Also, local governments were entitled to expropriate land from these groups in cases that these could not pay their respective tax burdens. The third mechanism arguably utilized by local governments was through the administration of judicial procedures: since the mayor and other local officials carried out duties of judges in local judicial procedures over discrepancies of, for instance, land titling, land rental and debt contracts, this provided a legal mechanism for municipal governments to favor the preferences of local elite groups.

Labor Regulation Laws and their Enforcement

In 1849, the provincial government established a General Landless Peasants' Law (*Ley General de Jornaleros*), a measure intended to control the mobility and work activity of landless peasants, particularly in coastal areas – due to scant labor supply in the sugar industry. The law established a legal category of landless peasants (*jornaleros*), composed of all male individuals who could not prove land ownership or some professional skill. Those classified as landless peasants were forced to seek employment on legally titled farms where employers were empowered to record work schedules, behavior, and insular movement in small passbooks (*libretas*) to be carried at all times by the landless peasant population (Bergad, 1983; p. 92). A second measure carried out by the provincial government involved restrictions on peasants' geographic mobility (Picó, 1979; Figueroa, 2005). This measure imposed strong restrictions on inter-municipality migration, requiring authorization from municipal authorities for peasants to migrate across municipalities.

Municipal and municipal district authorities were assigned the rigorous vigilance and enforcement of these measures, which lasted until 1873.[17] This gave substantial latitude to municipal governments to enforce these various measures. Bergad (1983) documents that in the case of Lares, a

[17] As Laird Bergad documents, "[c]lose supervision and rigorous vigilance were practiced by the local authorities. The *libreta* of José de Dios López, a twenty-year-old *jornalero* living in barrio Pezuela, noted six different prison sentences for various offenses including public drunkenness, failure to carry his *libreta*, bad conduct, and breaking a work contract. Most of these sentences were from fifteen to thirty days in the presidio correccional. Similar indications of strict enforcement were found in the notations for many of the *jornaleros*." (Bergad, 1983; pp. 122-123)

municipality in the heart of the coffee region, the enforcement was influenced substantially by market conditions at the local level.

> "In the early 1850s when coffee was just beginning to expand and land was sparsely occupied, laborers were in short supply. This resulted in the official transformation of *agregados* [sharecroppers] into renters with beneficial provisions for both landowners and *arrendatarios* [tenants]. […] But as market forces grew, especially after 1855 when coffee began spreading rapidly, downward pressures on the smallholding and landless population increased. […] The repressive juridical provisions established in 1849 were only utilized as tools of domination when material conditions favored their use." (Bergad, 1983; p. 124)

Picó (1979) describes how the enforcement of the passbook ('libreta') system by municipal authorities – the district mayors or commissioners and the vagrancy councils ('Junta de Vagos y Amancebados') – took place in the west-central municipality of Utuado. According to the law's dispositions, any landless peasant ('jornalero') found without a labor contract would be denounced as vagrant by the district commissioner; three denunciations would entail prison time (in the colonial capital). Municipalities prepared censuses of landless peasants for the enforcement of these regulations and, in the cases of Lares and Utuado, there is significant documentation of individuals spending prison time in San Juan as a result of the vagrancy law (Picó, 1979; Bergad, 1983). On the other hand, 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]."

Municipal governments undertook policing and law enforcement duties, as evidenced by the duties of district commissioners. Additionally, law enforcement increased particularly with the formation of three police corps in the mid-1860s: (i) municipal (urban and rural) police corps – partly in charge of enforcing these mandatory labor contracts and migration restrictions, (ii) a volunteer-based paramilitary group (*Cuerpo de Voluntarios*), and (iii) the Provincial Civil Guard, which in 1869 replaced a militia based on draft by lottery (Flores Collazo, 1994).

Throughout the latter third of the nineteenth century, the municipal police corps was of crucial importance in the enforcement of these various coercive measures. Following various law enforcement reforms in the 1870s, the provincial government decentralized to a great extent both the financing and the organization of local police forces, allowing the administration of municipal police forces to be based on the needs and economic capacity of local governments (Flores Collazo, 1994). In addition to the municipal police, the threat of separatist movements following the *Grito de Lares* – a major liberal pro-independence revolutionary attempt which originated in the west-central region – induced members of the landowning classes to take arms and aid military forces in protecting the Spanish regime and maintaining public order. Promoted by the provincial authorities in 1869, groups of volunteers in different municipalities, composed of large landowning family members, organized themselves at the municipality level as the Volunteer Corps (Rosado Brincau, 1891).[18] We will thus examine the extent to which efforts at enforcing measures against unprivileged groups could have possibly varied at the municipality level, as evidenced by differential efforts at the local level in establishing these coercive forces.

The Provision of Public Primary Schooling

Provincial governments throughout the 19th century provided very limited regulation and promotion of public primary education in the Island until the last three decades of the nineteenth century (Coll y Toste, 1909; Osuna, 1949; Cuesta Mendoza, 1974). Although there were various attempts at establishing an island-wide (albeit limited) public school system since the 1820s onwards, these plans did not fully materialize until 1865, following threats of political unrest throughout the remaining Spanish colonies. However, three parallel education systems operated across the island throughout the nineteenth century: the nascent public system, the religious system, and private elementary education.

During this period of threats of civil unrest caused by discontent with the Spanish regime (and partly due to the end of the U.S. Civil War), the central government institutes in 1865 a number of reforms to promote the establishment of a public primary school system.[19] Under this new legislation, public schools were defined as those supported wholly or in part by public or charitable funds or other funds destined for public education. Importantly, the founding, financing, and management of schools continued under the responsibility of municipal governments, although guidelines from the central government were provided as to the need for primary schools in each municipality (based on data from the 1860 population census). However, numerous historians have documented the opposition of municipal governments to such legislation, as well as the heterogeneity in the founding and management of public primary schools across municipalities during the last third of the nineteenth century (Osuna, 1949; De la Rosa Martinez, 1980; Astacio Rivera, 1991; Colón Ramírez, 1994). The operation of the educational system would continue in this manner, with minor reforms, until the end of the nineteenth century, with the U.S. invasion of Puerto Rico during the 1898 Spanish-Cuban-American War.

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[18] Volunteer Corps members had to satisfy certain eligibility requirements: (i) Spanish citizenship or naturalization, (ii) no criminal record, (iii) generate earnings and/or have an 'honorable' occupation, and (iv) own sufficient resources to support their activities in the Corps. The economic resources requirement was most significant, since the State did not incur expenditures on personnel or military equipment for volunteers. (It would do so following the Volunteer Corps reorganization of 1886, at which point volunteers would be compensated for their time in the Corps at times forces had to be mobilized. Members would be compensated based on the salary scales of the Spanish military in the island (Rosado Brincau, 1891, in Flores Collazo, 1994)). In addition, the eligibility requirement arguably had the intention of promoting the selection of individuals that supported the conservative pro-Spanish regime.

[19] 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.

IV. Data Description

We employ a unique array of data that will help us establish many of the causal pathways under study in great detail. We collected data from various sources on agricultural production in each municipality preceding and during the peak of the 19th century coffee boom. Agricultural and aggregate measures of economic activity for each municipality in 1828 – the number of coffee mills, the extent of coffee cultivation (*pies*), coffee production (*quintales*), aggregate private income and wealth – are 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 Córdoba, an emissary of the Crown) to improve the central government's information regarding economic conditions in the island during a period of Bourbon reforms. Data on the extent of land under coffee, sugar cane, tobacco, food crops cultivation, as well as land for pastures for each municipality in 1896 (in levels and as a share of total agricultural land) 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.

We also collected an array of data on geographic characteristics that influence the productivity of coffee cultivation and of economic activity more generally. Our basic sources of climatic data are: monthly and annual precipitation data for the 1899-1927 period, and 1950-2000 mean maximum and minimum temperature, collected from weather stations across the island (Roberts, 1941; National Climatic Data Center, 2007). Since these climatic conditions are relatively fixed over time, we match this data to the municipality in which the rainfall station is located. We complement this data with topographic measures for each municipality: *(iii)* mean altitude, *(iv)* mean gradient, and *(v)* distance to the nearest port (Puerto Rico Planning Board, 2005).

Our basic sources of data on the distribution of land ownership at the municipality level (again, preceding and during the peak of the 19th century coffee boom) come from two sources: the cadastral (land census) data collected by the provincial government for tax purposes at some point during the 1840-1860s (preceding the coffee boom), and the actual property tax registers of the 1890s. Tax officials collected information on the location, owners, and size of every plot in each municipality during these time periods; we collected the census of land plots for each municipality in the 1840s-60s period and a 25 percent sample of plots for the 1890s period. For each municipality at each date, we construct the land plot-size ownership Gini coefficient among landed individuals. Since we also have data on the number of landless households in the late 1890s, we construct the overall land Gini coefficient for this period. The average land Gini remains quite stable over this thirty period, as it is 0.65 during both the pre-boom and the peak of the boom period of the 1890s (Table 2, Panel A).

We employ a unique set of population socio-economic outcome variables for the late nineteenth century period, ranging from the literacy and child school enrollment rates of the local population, to measures of mortality rates, overall and for various subgroups of the population. We use the Public Use Micro-Sample (PUMS) of the 1910 Puerto Rico Population Census, which provides us with measures of literacy for each individual and of child mortality for each adult female in the household (Palloni, Winsborough, and Scarano, 2006). These detailed data allow us to examine alternative hypotheses about the nature of the local population's differences in socio-economic outcomes. In particular, since the 1910 PUMS reports the individual's age and his/her municipality of residence, we are able to match (under certain assumptions) individuals' personal information to the municipality where he/she was eligible to attend school, for cohorts of school-eligible individuals preceding and during the coffee boom.

The other socio-economic data, available at the municipality level, come from the 1899 Puerto Rico Census of Population (carried out by the U.S. military following the end of the Hispanic-Cuban-American War), and include: 1) school enrollment rates of children ages 6-10 years, 2) literacy rates of children ages 11-20 years, 3) secondary school completion rates of children ages 11-20 years, 4) adult males' literacy rates, 5) adult males' secondary school completion rates, 6) the proportion of households with access to non-educational local public goods (i.e., sewage, potable water, waste management), and 7) adult males' labor force participation and occupational structure (Table 3). The adult male educational and occupational outcomes data are also available by native/foreign born status and, among natives, by racial category (not shown in the table).

In addition, the Report of the Puerto Rico Census of Population to the U.S. War Department also presents municipality-level data on the yearly number of births and deaths in each municipality for the period 1888-1898. These data, in combination with population counts from the 1899 Census, allows us to construct basic demographic rates – yearly crude birth and death rates – for this period (Table 3, Panel A).

We also collected administrative data from various sources to examine the supply of local elementary schooling across regions. We have data on the numbers of schools in the municipality from the 1828 census (Córdoba, 1831-33), the cumulative number of teachers certified by the San Juan Bishopric during 1805-1848 (Coll y Toste, 1909), the number of primary schools in each municipality in 1866, 1876-77, 1897, 1902, and 1907, as well as the number of secondary schools in each municipality in 1897, from multiple primary and administrative sources (Table 3, Panel B).[20]

[20] The municipality-level primary school data sources for 1866, 1876-77, 1897, and 1902 are available in Osuna (1949), Ubeda y Delgado (1878), Carroll (1899), and Report of the Commissioner of Education (1907).

To measure the value of municipal government resources assigned to the rural police, we collected expenditure data from municipal budgets for the 1866-67 period, which includes data on the expenditures assigned to the rural police personnel and materials. Finally, we also coded information on the distribution across municipalities of Volunteer Corps units in 1886 and those of the Provincial Civil Guard in 1876 (Table 3, Panel B) (Rosado Brincau, 1891; Molinero y Gómez Cornejo, 1879). The Volunteer Corps data represent the share of individuals in a company which are assigned to a specific municipality. The Provincial Civil Guard data represent the number of men assigned to a municipality. See the Data Appendix for a detailed description of the construction of these variables.

We also employ a variety of control variables in order to demonstrate that our results are not driven by differences in other potential geographic determinants of agricultural productivity, (i.e., terrain grade, altitude, distance to the coast and ports) as well as other alternative factors that may help explain the differences in local institutional formation and policy choices, such as the degree of ethnic and racial heterogeneity across municipalities, or differences in the extent of the tropical disease burden (Panel D). The 1828 Population Census municipality-level data includes detailed demographic information, such as the racial and gender composition of the population, the extent of the slave population, and basic demographic counts which allow us to construct crude birth and death rates – discussed above. These data are used to assess the pre-late 19th century coffee boom composition of municipalities (Córdoba, 1831-33). Analogous data are available from the 1899 Census of Population (Table 3, Panel D).

V. Research Design

The identification strategy consists of comparing the municipalities with greater precipitation (located in the west-central region) relative to those with lower precipitation (located in the east-central region of the island), which vary with respect to the strength and direction of trade wind currents and thus precipitation patterns. Therefore, comparing the mean differences in municipality-level outcomes across regions with these varying geographic characteristics during periods of export commodity booms allow us to identify the effects of these geographic endowments on the 'quality' of local governments, the extent of land inequality, and the socio-economic outcomes of the local population. We estimate the following series of econometric models:

$$(1) \qquad y_{mdt} = \alpha + \theta G_{md} + \beta X_{md(t)} + \gamma_d + \varepsilon_{mdt}$$

where y_{mrt} are the municipality-level means for various outcome measures in municipality m, district d, at time t; G_{md} is either an indicator variable for municipalities in the West-Central region of the island, or a continuous measure of average precipitation; $X_{md(t)}$ are municipality-level controls contemporaneous to or preceding the outcome measure; and γ_d are administrative region (district) fixed-effects. We also employ an IV strategy – using the discontinuous variation in precipitation (and temperature and subsoil composition) between the west-central and east-central municipalities as exogenous variation for the relative productivity of coffee cultivation, to predict the level of coffee cultivation across municipalities, educational outcomes, and the various government activities and resource allocation choices during the late 19th century. Additionally, in cases where we have comparable outcome data for time periods preceding the coffee boom, we estimate the following difference-in-differences models:

$$(2) \qquad y_{mdt} = \theta\, Post_t{*}G_{md} + \beta_1 G_{md} + \beta_2 X_{md(t)} + \gamma_t + \alpha_{md} + \varepsilon_{mdt},$$

which allows us to control for all time-invariant municipality-level determinants of the outcome variables in question. The series of θ coefficient estimates allow us to test the predictions presented in the theoretical framework; whether municipalities located in regions with greater potential for coffee cultivation (i.e. the coffee region) were more likely to develop, during the 19th century coffee boom, coercive labor systems in which government resources were disproportionately used for the enforcement of coercive labor contracts instead of for the provision of productivity-enhancing local public goods, such as schooling.

Our research design relies on the assumption that, in the absence of a boom to coffee prices (with greater potential for cultivation in a higher rainfall environment), *(i)* municipalities with different precipitation and temperature patterns, or *(ii)* municipalities in both regions, would have experienced similar development trajectories. Although this identifying assumption is not testable, the available evidences supports the design: population density trends, baseline mortality rates, and pre-boom trends in the provision of public schooling were quite similar during the first half of the century, suggesting that these municipalities experienced equivalent development trajectories until the 1860s-90s coffee boom. In addition, the comparison of these groups of municipalities allows us to avoid confounding with other potential geographic determinants of agricultural productivity, (i.e., terrain grade, altitude, distance to the coast and ports) as well as with other alternative factors that may help explain the differences in local de facto institutional formation and policy choices, such as the degree of ethnic and racial heterogeneity across municipalities, differences in the extent of the tropical disease burden, and potential differences in legal systems across municipalities. We discuss these potential threats to validity in the alternative explanations section (Section VII).

VI. Empirical Results

VI.A. Access to Public Primary Schooling

In this section, we show evidence consistent with the argument that the diverging patterns of human capital accumulation during this period were driven by the quality of local governments, in particular, differences in the effectiveness or willingness of municipal governments to provide public primary schooling. Essentially, since municipal governments were responsible for the provision of primary schools, we can compare the provision of public primary schooling in the municipalities across regions to assess the extent to which municipalities provided or were demanded to provide access to schooling to the local population.

The number of public schools per capita in 1828, preceding the coffee boom, was similar across municipalities with varying levels of precipitation (Table 4). The simple correlation between annual rainfall and the number of per capita primary schools during this period suggests that municipalities with annual precipitation levels 10 inches greater had 0.01 (24 percent) fewer schools per thousand individuals, but this relationship is statistically insignificant (Panel A, column 1). This relationship is robust to the inclusion of geographic and demographic controls, and to the use of the west-central region as an IV for annual rainfall levels – the coefficient lies in the (-0.002, -0.046) range (4.6-100 percent range) and remains statistically indistinguishable from zero (Panel A, columns 2-5).[21]

In contrast, we find that the number of public schools, in absolute terms and per child, was substantially lower in the high-rainfall municipalities than in lower-rainfall municipalities, at various points during the coffee boom. During 1876-77, municipalities had on average 0.54 schools per thousand individuals, but municipalities with 10-inch higher rainfall levels had on average 0.12 (22 percent) fewer schools per thousand individuals than the lower rainfall region municipalities (significant at 99 percent confidence) (Panel A, column 6). This relationship is robust to the inclusion of geographic and demographic controls – the point estimate remains at 0.12 fewer schools per thousand individuals (significant at 99 percent confidence; column 7), and to controlling for the black/mulatto (1899) population share (0.099 fewer schools per thousand individuals, significant at 95 percent confidence; Panel A, column 8). For comparability purposes with other specifications, we estimate IV models using the west-central region indicator as an instrument for annual rainfall, and find largely similar results, with estimated impacts in the (-0.083, -0.116) range (16-22 percent), both statistically significant at 99 percent confidence (Panel A, columns 9-10).

To further check robustness, we estimate OLS and IV models where the dependent variable is the 1876-77 to 1828 difference in the number of schools per thousand individuals, and find largely similar

[21] Using data on the cumulative number of teachers assigned to each municipality during the 1805-1848 period, the evidence suggests that there were no significant differences in children's access to basic schooling during the first half of the nineteenth century, consistent with our identifying assumptions (Figure A2). Although this measure does not allow us to ascertain how many teachers were certified in each municipality at one point in time, it allows us to present suggestive evidence regarding potential differences in the assignment of teachers to municipalities across the two regions during the pre-boom period (teacher attrition rates would need to be equivalent across regions for this comparison to be useful). Throughout this period, very limited numbers of primary school teachers were assigned to both the west-central and east-central region municipalities. By 1848, municipalities in the west-central region had been assigned one primary school teacher, on average, and those in the east-central region had been assigned 1.13 teachers; the difference is not significantly different from zero.

results (Panel B, columns 1-5). The OLS point estimates lie in the (-0.118, -0.136) range (24-28 percent) (statistically significant at conventional confidence levels), and the IV estimates decrease slightly in magnitude to approximately 0.7 fewer schools per thousand individuals (15 percent) (significant at 85 percent confidence levels; columns 4-5). This loss in precision may be partly attributable to the fact that the first-stage IV partial correlation is weaker in the first-difference specification, because we have three fewer municipalities.

The evidence on the number of primary schools in 1897, which we normalize by the number of children in the municipality to take into account differences in the distribution of child populations across municipalities, also suggests that children in the coffee region had a lesser access to primary schooling than children in the food-crops region municipalities.[22] Although the Western region had on average 2.75 more schools in absolute terms than Eastern region municipalities (significant at 99 percent confidence, not reported in the tables), this was mostly driven by the greater population size of the region. In fact, the number of school per thousand children was approximately 4.8 percent lower in municipalities with 10 10-inch higher precipitation, with 0.025 fewer schools per thousand children than in municipalities with lower rainfall levels, although this difference is not statistically significant at conventional confidence levels (Panel B, column 6). This relationship is again robust to the inclusion of the 1899 black/mulatto population share as an additional control – the point estimate increases (in absolute value) to 0.034 fewer schools per thousand children (significant at 85 percent confidence; column 7), and to the inclusion of department (e.g. district) fixed effects (-0.070 (6.4 percent) fewer schools per thousand children, significant at 85 percent confidence; column 8). Finally, for comparability purposes with other specifications, we also estimate IV models using the west-central region indicator as an instrumental variable for annual rainfall, and find largely similar results, with estimated impacts in the (-0.032, -0.044) range (6.1-8.4 percent), both statistically significant at least at 90 percent confidence (columns 9-10).

Finally, note that the secondary (post-primary) schools in 1897 were located in the seven major municipalities of the Island, all in the major (coastal) cities – there was no provision of secondary schooling in the central municipalities during this time period.[23] In summary, this evidence is consistent with the hypothesis that local governments in the coffee region provided lower levels of primary schooling than those governments in the food crops region, but offered no differential access to higher education during this period of divergent development. In the following subsection, we present evidence on how these municipality-level differences in the provision of public schooling related to the educational outcomes of these populations during the period.

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[22] Unfortunately, we do not have data on the number of children in each municipality for years 1828 or 1876-77, which would allow us to normalize the primary schooling supply measure to the target population for this earlier years.

[23] The high (post-primary) schools were located in San Juan (the capital), Humacao, Guayama, Ponce, Mayaguez, Aguadilla, and Arecibo; coastal municipalities whose economies depended mostly on sugar cane production and international trade.

VI.B. Child School Enrollment and Literacy

School enrollment rates were extremely low among children ages 5-9 years during 1899 (2.3 percent), partly as a result of the very limited access to schooling during the period. Overall child school enrollment rates were lower by approximately 0.31 percentage points (13.7 percent; significant at 90 percent confidence) in municipalities with 10-inch higher annual rainfall relative to those with lower rainfall (Table 5, Panel A, column 1). The estimated impact on school enrollment rates remains quite stable at around 0.30-0.31 percentage points (13.2-13.7 percent, significant at 95 percent confidence) when including other geographic characteristics and controls for the demographic composition of the population (i.e. the number of children ages 10 and younger in 1899, the number of those 10-20 years old, and the number of adults in each municipality), and the black or mulatto population share in the municipality (Panel A, columns 2-3). The estimates impact increases to 0.41-0.43 percentage points (18.1-18.9 percent) when employing the analogous west-central-region IV specifications (significant at 99 percent confidence; Panel A, columns 4-5).

We find quantitatively similar results for the school enrollment rates of older children in these municipalities. The point estimate from a simple OLS regression indicates that children ages 10-20 years in municipalities with 10-inch higher annual precipitation levels had school enrollment rates 0.20 percentage points (11.1 percent; significant at 90 percent confidence) lower than those children living in lower rainfall municipalities (Panel A, column 6). The estimated impacts increase in magnitude to 0.24-0.26 percentage points (13.3-14.4 percent, significant at least at 90 percent confidence) with the inclusion of geographic and demographic controls (columns 7-8). The comparable IV specifications also lead to larger and more precise estimates of the relationship – school enrollment rates are estimated to be 3.8 percentage points (21 percent; significant at 99 percent confidence) in municipalities with 10-inch higher annual rainfall levels (columns 9-10).

Although the differences in school enrollment rates are suggestive of differences as a result of the variation in access to schooling across these municipalities, we discount these because these enrollment measures were also taken following two important events: (1) the U.S. invasion of Puerto Rico in 1898 and change in sovereignty during the 1898-99 period, and (2) the passing of the San Ciriaco Hurricane in August 1899, which would have strongly affected primary school enrollment rates for the coming years (Schwartz, 1982). We thus turn to evidence on child literacy rates, which should not have been as negatively affected by these two temporary shocks.

Literacy rates among children ages 10-20 were also lower in higher rainfall municipalities (Panel B). The unadjusted effect estimate indicates that the proportion of literate children is 1.2 percentage points (7.3 percent, significant at 95 percent confidence) lower in municipalities with 10-inch higher annual rainfall levels (Panel B, column 1). Again, the estimated impact is robust to the inclusion of the aforementioned controls, in the (1.00-1.34) percentage points (6.1-8.2 percent) range, both significant at conventional confidence levels (Panel B, columns 2-3). The estimates based on the west-central region IV specifications suggest similar differences (-0.92 percentage points, or 5.6 percent; significant at 95 percent confidence), although these are not robust to the inclusion of the 1899 black/mulatto population share control – the point estimate drops to a statistically insignificant -0.37 percentage points (2.3 percent) (columns 4-5). Finally, the analogous estimates for the proportion of semi-literate children also suggest that a smaller share of children ages 10-20 knew to read but not to write; the point estimates lie in the 0.23-0.31 percentage points (15.6-21.0 percent) range, and are all significantly different from zero at the 99 percent confidence level (Panel B, columns 6-10).

Unfortunately, the degree of aggregation of child schooling outcomes for the offspring of native whites, native non-whites, and foreigners does not allow us to provide a detailed picture of the literacy rates differences for the particular populations which may be most relevant to our study: native ("criollo") males and females. We turn to the evidence on adult literacy, since this evidence allows us to construct more reliable estimates of the impacts of the coffee boom by employing a differences-in-differences research design.

VI.C. Adult Literacy

In this sub-section, we examine whether growing up in municipalities with higher annual rainfall levels during the 19th century coffee boom was detrimental to adult individuals' human capital accumulation, as measured by their levels of literacy. We use the sample of native-born individuals ages 25-60 in 1910 (in the 1850-1885 birth cohorts), to examine the effect of growing up in a high-rainfall municipality during the coffee boom (1870-1900) among school-age individuals in that period. Comparing the differences in literacy rates of younger individuals (born in 1861-1885) relative to those of older individuals (born in 1850-1860) across municipalities with varying annual precipitation levels – under the assumption that cross-cohort trends in literacy would not have differ systematically across higher and lower-rainfall municipalities in the absence of the coffee boom – allows us to construct cohort-based differences-in-differences estimates of the coffee boom on the literacy rates of individuals residing in the coffee region relative to those of individuals residing in the non-coffee region.

Table 6 reports estimates of the impact of growing up in municipalities with higher annual rainfall levels during the 19th century coffee boom from this cohort differences-in-differences research design (following equation (2) described in the Section V). A basic specification including only age indicator controls – in addition to the 'treatment' measure (rainfall-young age group interaction) and the annual rainfall measure – indicates that native-born adults in municipalities with 10-inches higher annual rainfall had literacy rates 1.65 percentage points (9.4 percent; significant at 95 percent confidence) lower than those who resided in lower rainfall municipalities (Table 6, Panel A, column 1). This relationship remains quite stable in the 1.66-1.68 percentage point (9.5-9.6 percent) range with the inclusion of other geographic controls or municipality fixed effects (Panel A, columns 2-3). Reassuring of the validity of the research design, we find no significant difference in literacy rates across older cohorts living in higher and lower-rainfall regions, as measured by the coefficient on annual rainfall (the point estimates in the two specifications are respectively 0.53 and 0.35 percentage points (3.0 and 2.0 percent; insignificantly different from zero; Panel A, columns 1-2). Also note that these estimates are qualitatively and quantitatively similar to those using cross-sectional variation in native adults literacy rates using data from the 1899 Puerto Rico Census of Population, which helps us validate the validity of the cross-sectional comparisons (see Appendix Table A2).

Perhaps surprisingly, we find that the differences are of the same order of magnitude for native-born males and females. The point estimate of the impacts for native-born males is 2.02 percentage points (in absolute value) (7.5 percent), and that for females is 1.27 percentage points (13.3 percent) (both in absolute value; significant at 90 percent confidence levels; Panel A, columns 4, 7). Again, this set of estimates is robust to the inclusion of geographic controls or municipality fixed effects (Panel A, columns 5-6, 8-9). Interestingly as well, the differences across municipalities seem to be concentrated among native-born whites. The estimated impacts indicate that literacy rates were 1.79-1.86 percentage points (10.2-10.6 percent) lower among native-born whites in the 10-inches higher rainfall municipalities (significant at 90 percent confidence) (Panel B, columns 1-3) and of the same order of magnitude for native-born white males, although less precisely estimates (Panel B, columns 4-5). In contrast, the estimated impacts for blacks and mulattoes lie in the 0.21-0.31 (0.9-1.4 percent) range and are statistically indistinguishable from zero (Panel B, columns 6-10). These differential impacts by racial categories may be partly explained by the effective segregation of the public school system by race throughout the Spanish colonial period (Osuna, 1949; Bobonis and Toro, 2007).

A robust method to assess the validity of our research design is to make our empirical model more flexible, by allowing for potential effects among cohorts exposed as well as for those not exposed to the school expansion. This can be done by generalizing the empirical model presented above, where we allow each two-year cohort to have a potential effect from the expansion, as following:

$$y_{icm} = \alpha_m + \gamma_c + \sum_c (G_m \times d_c)\theta_c + X_{icm}\delta + \varepsilon_{icm}, \qquad (3)$$

where d_c is an indicator variable that indicates whether the individual is in the two-year cohort group, for cohort groups ages 25-26, 27-28, 29-30, …, 59-60 years in 1910, 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. This specification allows us to assess whether individuals in older cohorts, those 51-52 years and older (in 1910), in higher-rainfall municipalities have lower literacy rates than individuals of the same age groups residing in lower rainfall municipalities, and whether the effects of the coffee boom are increasing in the years of exposure of different cohorts (decreasing in age).

Figure 5 shows graphically the value of the coefficient estimates (the solid line) and confidence intervals (the dashed lines) for each two-year cohort group. The coefficients on this model fluctuate around zero for older cohorts until they reach ages 39-40, where they start increasing in size and fluctuate around 2.5-3.0 percentage points afterwards. Among the latter age groups, the coefficient estimates are significantly different from zero, which shows evidence of our expected impacts by cohort as a result of the timing of the coffee boom. In summary, this control experiment and the flexible analysis shows evidence in favor of our research design.

VI.D. Use of Local Resources for Coercion of Labor and the General Citizenry

In this subsection, we examine the hypothesis that, in addition to the disincentives for providing efficiency-enhancing public goods such as schooling, elite-controlled municipal governments employed resources to enforce coercive labor institutions. Local governments and elite groups in the higher rainfall region disproportionately allocated public and private resources for coercive purposes.

Based on the IV estimates, local governments in municipalities with 10-inches higher annual rainfall levels assigned on average 464.5 more pesos (169 percent) for the urban and rural police personnel expenditures than those with lower rainfall (significant at 85 percent confidence; Table 7, Panel A, column 1). This relationship, although somewhat imprecisely estimated, is robust to the inclusion of a large set of geographic controls (except for annual minimum temperature, another important determinant of coffee cultivation). The point estimates lie in the 162.3-467.5 pesos (59 - 170 percent) range (Panel A, columns 2-6). The differences between west-central and east-central regions from reduced form estimates indicate a divergence in these municipal budget clauses of 297.1-650.1 pesos (108 – 237 percent) (Panel B, columns 1-6). These differences are not purely the result of possibly larger municipal budgets for the west0central region, as the relationship holds if we examine differences in budget expenditure shares (Panels A and B, columns 7-12). This quantitative evidence is consistent with the historiographic evidence, which indicates that the extent of enforcement of the various measures of labor coercion – the 'libreta' system and migration restrictions – varied significantly across the two regions.

Based on our measure of the distribution of government-backed paramilitary group (Volunteer Corps) units in 1886, we find that the share of individuals in a company assigned to each municipality was 26.6 percentage points (44 percent) greater in the coffee growing region relative to the food crops region (significant at 95 percent confidence, Table 8, column 1). The estimate increases in magnitude and is robust to the inclusion of the black/mulatto population share and department fixed effects as controls (columns 2-3).[24] Additionally, there is limited suggestive evidence that the Corps' unit headquarters were more likely to be located in municipalities in the coffee region, although the coefficient estimates are imprecisely estimated (column 4-6).

Finally, we examine whether the allocation of paramilitary and law enforcement forces were primarily driven by the strategic decision-making at the provincial government-level. We carry out an indirect test of this hypothesis by testing whether the assignment of the Provincial Civil Guard- a military body under the direct control of the provincial level government was also concentrated for strategic reasons in the West-Central region. Although the point estimate on the differences in the number of Civil Guard members assigned to each municipality is positive, we cannot reject that the difference is statistically significant in most specifications (columns 7-9). Therefore, the evidence points towards class-based social conflicts under a coercive political regime as the main determinant for the apparent divergence in local governments' policy choices, as documented by the size of paramilitary forces intended to ensure the control of labor across municipalities.

VII. Assessment of Alternative Explanations

The scholarly debate has identified a multiplicity of other institutional configurations which may have played a role in explaining the patterns in the data. For instance, in addition to the potential role of economic inequality in influencing the emergence of educational systems, other alternatives, such as contemporaneous effects of the tropical disease burden on the health of these local populations (e.g. Bloom and Sachs, 1998), selective migration of colonizers with different levels of human and social capital into different regions (Glaeser et al. 2004), or differences in the ethnic and religious composition of populations across regions (e.g. Easterly and Levine, 1997) may have played a role in explaining he divergence in educational outcomes. In this section, we present a series of tests of our underlying counterfactual assumption to show that we can in fact rule out these alternative explanations.

Land Inequality

The stark stratification in agricultural production led to a slight divergence in the distribution of land ownership across municipalities, if any. Figure 6 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 kernel density estimates suggest that land ownership was only slightly more concentrated in the coffee-growing region relative to the land ownership distribution in the food crops region, as there is a greater share of landowners with very small plots in the latter region relative to the

[24] We do not include the other demographic characteristics for the year 1899, as these are likely to be endogenous to the size of these law enforcement forces during an earlier period (i.e. 1886).

former (Figure 6, Panel A). In addition, the graphs suggest there was a slightly greater share of large landowners in the coffee-region municipalities. However, most of these 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). The Lorenz curves presented in Panel B suggest that, if anything, inequality in land ownership among landowners was greater in the food crops region than in the coffee region. These distributional differences would suggest that the land tenure structure did not diverge dramatically across regions during the coffee boom.

These patterns are confirmed by comparing municipality-level land inequality levels more systematically across all municipalities in the two regions during the 1891-94 period. IV estimates of the relationship between annual precipitation and the overall land Gini coefficient for the twenty (20) municipalities with available land tenure data (using the west-central region indicator as instrumental variable) indicate that an increase in annual precipitation of 10 inches results in a moderate increase in inequality of 3.5 percentage points (3.8 percent, significant at 95 percent confidence) (Table 9, Panel A, column 1). This relationship is somewhat muted to 1.3 percentage points (1.4 percent) and 1.7 percentage points (1.8 percent), and loses some precision, with the incremental inclusion of geographic and demographic controls (Panel A, columns 2-3).

These marginal differences in land inequality seem to be driven by differences in the share of the landless population across municipalities, rather than in the degree of inequality among landowners. Analogous IV estimates indicate that in municipalities with 10-inches higher annual precipitation levels, the landless peasant population share increased by 4.9 percentage points (7.0 percent; significant at 85 percent confidence) (Panel A, column 4). Nonetheless, the estimated relationship again loses precision with the inclusion of a control for the municipality-level black/mulatto population share (Panel A, column 5), and using the complete sample of municipalities (column 6). In contrast, the analogous estimates for landowners' Gini coefficients provide no evidence of significant differences in inequality among landowners. The point estimates suggest increases in inequality of 0.2 and 1.3 percentage points (0.3 and 1.7 percent, respectively), and are insignificantly different from zero (columns 7-8). In sum, these comparisons suggest that there were no stark differences in land inequality as a result of the coffee boom in the late 1800s.

The Tropical Disease Burden, Sanitation-Related Public and Private Goods, and Health Risks

Since Puerto Rico is a relatively small island located entirely within the tropics, the magnitude of the tropical disease burden should not vary substantially within regions of the country. Moreover, this assumption is indirectly verifiable, since mortality rates did not vary significantly across municipalities during the early 19th century, preceding the establishment of public health infrastructure during the late 1800s-early 1900s. Crude death rates estimates from the 1828 Córdova Report indicate that these centered around 23.5 deaths per thousand individuals per year and were not significantly higher in the high rainfall region (Table 2, Panel A). This evidence, although somewhat crude, provides us with some confidence that there were no significant differences in health risks that could have affected these populations preceding the coffee boom.

In addition, exploiting the 1910 PUMS data on child survival for each native-born adult female and the cross-cohort variation in child survival rates across municipalities, we assess whether there was a divergence in the health status of the population throughout the coffee boom period – evidence which would suggest that the divergent patterns of literacy could be partly driven by differential changes in the health status of the population. We find no evidence in favor of this hypothesis – the estimates indicate that child survival rate differences were small: 0.2 percentage points (0.28 percent) higher in municipalities with 10-inches greater annual rainfall, and insignificantly different from zero (Table 10, Panel A, column 1). Our inference is robust to a specification which includes municipality fixed effects, which captures time-invariant effects of the tropical disease burden across municipalities (Panel A, column 2). Moreover, the effects for native-born whites, the subgroup for whom we find substantial literacy effects, also suggest no differences in child survival: the point estimates are in the (-0.22, -0.33) percentage point (-0.30, -0.43 percent) range, and are both statistically insignificant (columns 3-4).

Finally, note that the lack of a difference in child survival rates is not driven by potentially lower (and more positively-selected) fertility in the higher rainfall municipalities, a pattern found during recessionary periods in the United States (e.g. Dehejia and Lleras-Muney, 2004). Female fertility is estimated to be higher during the coffee boom: younger women in 10-inches higher rainfall municipalities had on average 0.144 more children (2.9 percent) than those younger women living in lower rainfall municipalities (statistically significant at 95 percent confidence, column 5). Estimates for the sub-samples of native-born whites (columns 6-7) and blacks/mulattos (columns 8-9) are of the same order of magnitude but less precisely estimated. These pieces of evidence provide us with confidence that there were no significant differences in health risks that could have affected these populations preceding and throughout the coffee boom. Therefore, we need not to be concerned about differences in the tropical disease burden affecting these historical development patterns (Bloom and Sachs, 1998; Bleakley, 2002; 2006; Gallup, Sachs, and Mellinger, 1999).

We next turn to the evidence regarding households' access to sanitation-related public goods at the local level. Since municipal governments were also responsible for the provision of sanitation-related public services (i.e., water access, sewage, solid waste management), we can also assess whether there was differential access to publicly-provided sanitation services and infrastructure (Table 10, Panel B). Using data from the 1899 Census on the municipality-level proportion of households with access to publicly-provided waste collection services, we find in our preferred regression-adjusted specification that households in the coffee region had on average a 10.8 percentage points lower access to public waste collection services than those in the food crops region municipalities (significant at 90 percent confidence) (Panel B, column 3). This difference in the provision of local services conducive to improving local sanitary/health conditions may have been a factor influencing unobservable dimensions of health status, such as morbidity, which could help explain the divergence in literacy rates.

However, households in the coffee region had, on average, greater access to potable water infrastructure at the turn of the century. In particular, 1.3 percent of households in the coffee growing regions report having access to an aqueduct in 1899, whereas only 0.1 percent of those in the food crops municipalities reported so (the difference is significantly different from zero at 95 percent confidence levels; Panel B, column 4). Moreover, although including the demographic controls variables reduces the precision of the estimate, the coefficient estimate on the conditional difference remains quite stable, at around 1.3 percentage points (Panel B, columns 5-6). Finally, we find that households' access to some modern form of human fecal management infrastructure (i.e., cesspools, sewer) was actually greater in the coffee- region than in the east-central region. Estimates suggest that access to cesspools or sewers was 6.3 percentage points (39 percent, significant at 95 percent confidence) higher in coffee municipalities than food crops municipalities (not reported in the tables). However, most of the difference is driven by the greater household access to cesspools – usually privately owned (Panel B, columns 7-9). In addition, the treatment effect estimate is quite imprecisely estimated and varies in sign and magnitude substantially with the inclusion of demographic control variables.[25] Overall, this evidence provides very limited support for the view that a more limited provision of public-health or sanitation-related public goods would have been an important driver of the diverging patterns in literacy across municipalities.

Racial/Ethnic Fractionalization

African slave populations were concentrated in coastal areas – those areas particularly suited for the production of sugar cane (Scarano, 1984). According to various historians, slave labor was seldom used in the coffee plantations and food crops sector in Puerto Rico (Picó, 1979; Bergad, 1983; Seda Prado, 1996). Moreover, this anecdotal evidence is confirmed by the racial composition statistics from the 1928 and 1899 population censuses; ethnic heterogeneity was actually lower in the high-rainfall coffee region than in the lower-rainfall food-crops growing region. The share of the non-white population in 1828 were 49 percent and 56 percent respectively in the coffee and food crops regions, and the slave population was relatively small (8 percent) in both (Table 2, Panel B). By 1899, the black and mulatto population share is substantially and statistically significantly lower in the high-rainfall region than in the

[25] Unfortunately, we do not have data on the exact proportion of households who privately owned cesspools during this time period, or its distribution across the household wealth distribution within a municipality. Knowledge of this data would allow us to assess whether it was wealthier households, less likely to be credit constrained, who would be able to invest in this infrastructure.

lower rainfall region (22 and 40 percent, respectively) (Table 3, Panel D). Finally, Puerto Rico's native indigenous populations were essentially decimated during the 16th century, and any pre-conquest social organizations were unfortunately destroyed at the time. In summary, to the extent that racial and ethnic fractionalization independently leads to the formation of suboptimal political institutions and to the suboptimal provision of local public goods (Easterly and Levine, 1997; Alesina, Baqir, and Easterly, 1999) – it may bias our estimates towards not finding any differences across regions.

Geographical Sorting of the Native-Born Population

There could have been a high degree of geographic sorting of the population during this period, leading to estimates of differences in literacy (and child mortality) outcomes of the population to be driven by individuals' geographic sorting into jurisdictions based on their unobserved characteristics and preferences. For instance, this would be the case if there were a greater demand for unskilled labor in the coffee region (e.g. for coffee picking) relative to the food crops region, causing a disproportionate share of unskilled and perhaps illiterate individuals to sort into the former region. Moreover, these individuals could also demand lower levels of public goods (i.e. schooling) since the demand for education may have been lower among this population.

It is undoubtedly true that some degree of migration occurred across regions. However, during a great part of the second half of the 19th century strong restrictions on inter-municipality migration for the landless population across all regions in the island (to promote the creation of local labor market monopsonies) were put in place by the central government and enforced by local governments. These restrictions reduce concerns of selective sorting, at least of the landless population (Picó, 1979). Also, to the extent that higher-skilled individuals (or individuals with other unobserved characteristics correlated with schooling levels) were more likely to move or stay away from the higher-rainfall coffee region, we should also observe differences in the higher education completion rates of natives across the two regions. These should not be directly affected by differences in schooling access because no secondary schools were located in the central region of the island at the time. However, the data suggests otherwise; higher education completion rates were low in both regions (1.1 percent among native adult males), and there were no significant differences across regions in these schooling rates (Table 11, Panel A, columns 1-4). Also, as shown in Section VI.C above, the literacy rates of 40-49 year old adults, individuals who could have sorted from the coffee region it this were driven by selective migration due to the lower returns to schooling in coffee cultivation, are not significantly different from zero across higher and lower-rainfall municipalities. These pieces of evidence support the view that educational group-specific geographic mobility patterns are not driving our results.

Immigrants' Location Patterns

Selective migration of foreigners of varying socio-economic status across the regions of the island could have induced differences in the patterns of development, to the extent that immigrants with higher levels of physical and human capital could have migrated to the food crops region. 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 West-Central municipalities, as exemplified by the case of Cayey (Picó, 2007). Therefore, another potential piece of evidence in favor of the geographic sorting hypothesis would suggest that foreigners' socio-economic characteristics (i.e., schooling levels) would differ across the west-central and east-central regions. Using 1899 Census data on the municipality-level shares of the foreign adult population and foreigners' literacy rates, we find that foreigners composed 1.0 percent of the population in these regions (on average), and were more likely to reside in the western region, only by 0.5 percentage points (Table 3, Panel D). However, foreigners' literacy and high school completion rates were not significantly lower (or higher) in the coffee-producing region than in the food crops-producing region (Table 11, Panel A, columns 5-8; Panel B, columns 1-8). We conclude that, to the extent that economic opportunities could have led to some degree of sorting of the population, this does not seem to drive the differences in the educational status of the native-born population across the two groups of municipalities. This evidence also suggests that the potential selective migration of foreigners with different levels of human capital into different colonies recently proposed by Glaeser et al. (2003) may not have been prevalent in this context.

Political Conflict between Landowners and Industrialists

Political conflict due to the diverging interests of landowners and industrialists could explain the existing results approach the issue in two regards. First, to the extent that the costs of political repression and coercion are lower in the agricultural sector of the economy relative to the industrial sector, then regions with more prominent agricultural sectors are more likely to use repression against labor to maintain political and economic rents (e.g. Acemoglu and Robinson, 2005). Second, landed elites may block school reforms if human capital-promoting reforms adversely affect land rents, thus retarding industrialization and the region's economic development (Galor, Moav, and Vollrath, 2006). To the extent that these incentives increase in municipalities with higher land values, this could explain the lower provision of growth promoting local public goods.

The latter theory thus predicts that the industrialization of the coffee-region municipalities should have been delayed as a result of this conflict, and thus the share of the population in non-agricultural sectors should have been lower in the high-rainfall region relative to the lower-rainfall region. To test this prediction, we compare the local male populations' occupational distribution across regions using the 1899 Census of Population data. However, we do not find evidence that the shares of the adult male population participating in the commercial, manufacturing, or services sectors were smaller in the high land inequality municipalities relative to the lower land inequality (Table 12). In particular, the difference in the share of the adult male population participating in the agriculture, fishing, or mining sectors (45.5 percent, on average, for control group municipalities) varies between 1.8 and 4.5 percentage points, but is never statistically significant from zero (Table 12, Panel A).[26]

VIII. Conclusion

Using unique historical data from municipalities and municipal governments in Puerto Rico, we examine the political institutions and regulation hypotheses of comparative long-term economic development: geographic endowments, particularly rainfall patterns (as a result of the Alizé Trade Winds currents), affected the local development and the 'quality' of local government activities at the naissance of the nineteenth century international coffee boom. The quasi-experimental variation based on the combination of climate-based precipitation levels and the rise in international coffee prices allows us to examine whether municipalities whose precipitation levels made them well suited for coffee cultivation – relative to those better suited for the cultivation of food crops – experienced lower 'quality' of governments during the growth of the coffee industry in Puerto Rico.

From a methodological perspective, the study contributes to the literature by exploring how de jure local political institutions – in particular, the political rights of the citizenry in local government and the powers of municipal governments – and their nuanced interaction with particular geographic conditions, crucially affected economic and political development during the late Spanish colonial period in the Americas. As proposed by Pande and Udry (2005) and utilized in this context by research such as Naritomi, Soares, and Assunção (2007), the study exploits the fact that that incentives provided by the de jure institutional context varied with individuals' economic conditions and political status, to understand the mechanisms through which geographic endowments or de jure institutional differences may have impinged on the American colonies' paths to prosperity. We see this as an important contribution to the current research program that uses micro-data based research to understand in greater detail the determinants of political and economic development during the colonial period and its implications for current outcomes.

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[26] Among foreign-born males, however, we do find a significant difference in the occupational sector shares across regions (see Appendix Table A3). This evidence is consistent with the historical evidence that Spanish and other foreigners became the most prominent large landowners in the region (Picó, 1979; Bergad, 1983). Since foreigners constituted at most one percent of the population during the period, we read this evidence as consistent with foreigners disproportionately selecting to participate in the agricultural sector in these municipalities rather than as evidence that the agricultural sector was more prominent in the West-Central municipalities. However, future work will more closely examine the extent to which ethnic/national cleavages could have driven an important aspect of the degree of political and social conflict in the coffee region.

References

Abbad y Lasierra, Iñigo (1788). Historia geográfica, civil, y natural de la Isla de San Juan Bautista de Puerto Rico. Reprint. Río Piedras: Editorial Universitaria, 1970.

Acemoglu, Daron, Simon Johnson, and James A. Robinson (2001). "The Colonial Origins of Comparative Development: An Empirical Investigation", *American Economic Review*, 91(5), pp. 1369-1401.

Acemoglu, Daron, Simon Johnson, and James A. Robinson (2002). "Reversal of Fortune: Geography and Institutions in the Making of the Modern World Income Distribution", *Quarterly Journal of Economics*, 118, 1231-1294.

Acemoglu, Daron, and James A. Robinson (2005). Economic Origins of Dictatorship and Democracy. Cambridge University Press: Cambridge, UK.

Acevedo, Gilberto and Roberto Gierbolini (1982). Soil Survey of Arecibo Area Northern Puerto Rico, San Juan: U.S. Department of Agriculture Soil Conservation Services / College of Agricultural Sciences, UPR Mayaguez Campus.

Alesina, Alberto, Reza Baqir, and William Easterly (1999). "Public Goods and Ethnic Divisions", *Quarterly Journal of Economics*, 114(4), 1243-1284.

Astacio Rivera, Carmen Hilda (1991). El proceso educativo en Manatí de 1880-1895. Masters Thesis: History Department, University of Puerto Rico.

Benjamin, Dwayne, Loren Brandt, and John Giles (2006). "Inequality and Growth in Rural China: Does higher Inequality Impede Growth?", unpublished manuscript, University of Toronto.

Bergad, Laird (1983). Coffee and the Growth of Agrarian Capitalism in Nineteenth-Century Puerto Rico. Princeton University Press: Princeton, New Jersey.

Berry, Albert, and William R. Cline (1979). Agrarian Structure and Productivity in Developing Countries. ILO, Geneva.

Binswanger, Hans P. and Mark Ronsenzweig (1986). "Material and Production Relations in Agriculture," *Journal of Development Studies*, 22, 503-539.

Binswanger, Hans P. Klaus Deininger and Gershon Feder (1986). "Power Distorsions, Revolt, and Reform in Agricultural Land Relations," In Behrman, J. and Srinivasan, T.N. (eds.) Handbook of Development Economics, Volume III, Amsterdam, pp. 2659-2772.

Bleakley, Hoyt (2007). "Disease and Development: Evidence from Hookworm Eradication in the American South", *Quarterly Journal of Economics*, 122(1), 73-117.

Bleakley, Hoyt (2006). "Malaria in the Americas: A Retrospective Analysis of Childhood Exposure", unpublished manuscript, University of Chicago.

Bloom, David E. and Jeffrey D. Sachs (1998). "Geography, Demography, and Economic Growth in Africa", *Brookings Papers on Economic Activity*, 1998(2), pp. 207-295.

Bobonis, Gustavo J., and Harold J. Toro (2007). "Modernization and Its Consequences: The Effects of U.S. Educational Policy on Puerto Rico's Educational Stratification," *Caribbean Studies* (forthcoming).

Boccheciamp, Rafael A. (1982a). Soil Survey of San Juan Area of Puerto Rico, San Juan: U.S. Department of Agriculture Soil Conservation Services / College of Agricultural Sciences, UPR Mayaguez Campus.

Boccheciamp, Rafael A. (1982b). Soil Survey of Humacao Area of Eastern Puerto Rico, San Juan: U.S. Department of Agriculture Soil Conservation Services / College of Agricultural Sciences, UPR Mayaguez Campus.

Bourguignon, Francois, and Thierry Verdier (2000). "Oligarchy, democracy, inequality, and growth," *Journal of Development Economics*, 62, pp. 285-313.

Bulmer-Thomas, Victor (1994). The Economic History of Latin America since Independence. Cambridge University Press: Cambridge, UK.

Cabrera Collazo, Rafael L. (1988). Los peninsulares y la transición hacia el siglo XX en la zona central no-cafetalera de Puerto Rico: El caso de Corozal, 1890-1905. Masters' Thesis, History Department, University of Puerto Rico.

Carroll, Henry K. Report on the Island of Porto Rico. Washington: Government Printing Office, 1899.

Casanova, Carlos (1985). Propiedad agraria y poder en el municipio de Manatí, 1885-1898. Masters Thesis, History Department, University of Puerto Rico.

Coll y Toste, Cayetano (1970 [1909]). Historia de la Instrucción Pública en Puerto Rico hasta el año de 1898. Bilbao, España: Editorial Vasco Americana.

Coll y Toste, Cayetano (1914). "Bando de Policía y Buen Gobierno de 1824," in *Boletín Histórico de Puerto Rico,* San Juan: Volume II, pp. 32-44.

Colón Ramírez, Héctor (1994). Educación y sociedad: la región central de Puerto Rico, 1880-1920. Doctoral Thesis: History Department, University of Puerto Rico.

Córdova, Pedro Tomás de (1831-33). Memorias geográficas, históricas, estadísticas y económicas de la Isla de Puerto Rico, 6 volúmenes. San Juan: Imprenta del Gobierno.

Cubano Iguina, Astrid (2006). Rituals of Violence in Nineteenth-Century Puerto Rico: Individual Conflict, Gender, and the Law. Gainsville: University of Florida Press.

Cuesta Mendoza, A. (1974). Historia de la educación en Puerto Rico: 1512-1826. AMS Press: New York.

Dean, Warren (1971). "Latifundia and Land Policy in Nineteenth Century Brazil," *Hispanic American Historical Review*, 51, pp. 606-625.

Dehejia, Rajeev, and Adriana Lleras-Muney (2004). "Booms, Busts, and Babies' Health", *Quarterly Journal of Economics*, 119(3), 1091-1130.

De la Rosa Martinez, Luis (1980). Historia de la instrucción pública en Vega Baja: 1814-1910. Vega Baja: Sebuco.

Dietz, James (1986). Economic History of Puerto Rico: Institutional Change and Capitalist Development. Princeton: Princeton University Press.

Easterly, William and Ross Levine (1997). "Africa's Growth Tragedy: Policies and Ethnic Divisions", *Quarterly Journal of Economics*, 112(4): 1203-1250.

Engerman, Stanley L., and Kenneth L. Sokoloff (1997). "Factor Endowments, Institutions, and Differential Growth Paths among New World Economies: A View from Economic Historians of the United States", in Haber, S.H. (ed). How Latin America Fell Behind. Stanford, CA: Stanford University Press.

Engerman, Stanley L., Elisa V. Mariscal, and Kenneth L. Sokoloff (2002). "The Evolution of Schooling Institutions in the Americas: 1800-1925", unpublished manuscript, UCLA.

Feyrer, James, and Bruce Sacerdote (2007). "Colonialism and Modern Income – Islands as Natural Experiments", *Review of Economics and Statistics* (forthcoming).

Flores Collazo, María Margarita (1994). "Expansión del poder estatal y la militarización del sistema de orden público en el Puerto Rico del siglo 19," *Op.Cit., Boletín del Centro de Investigaciones Históricas*, 5, pp. 201-246.

Gallup, John Luke and Jeffrey D. Sachs, with Andrew D. Mellinger (1999). "Geography and Economic Development", CID Working Paper No. 1, Center for International Development, Harvard University.

Galor, Oded, Omer Moav, and Dietrich Vollrath (2006). "Inequality in Land Ownership, the Emergence of Human Capital Promoting Institutions, and the Great Divergence", unpublished manuscript, Brown University.

Gierbolini, Roberto (1982a). Soil Survey of Ponce Area of Southern Puerto Rico, San Juan: U.S. Department of Agriculture Soil Conservation Services / College of Agricultural Sciences, UPR Mayaguez Campus.

Gierbolini, Roberto (1982b). Soil Survey of Mayaguez Area of Western Puerto Rico, San Juan: U.S. Department of Agriculture Soil Conservation Services / College of Agricultural Sciences, UPR Mayaguez Campus.

Glaeser, Edward L., Rafael La Porta, Florencio López-de-Silanes, and Andrei Shleifer (2004). "Do Institutions Cause Growth?", unpublished manuscript, Harvard University.

La Porta, Rafael, Florencio Lopez-de-Silanes, Andrei Shleifer, and Robert Vishny (1999). "The Quality of Government," *Journal of Law, Economics, and Organization*, 15(1) pp. 222-79.

Ledrú, Andrés Pedro (1863). Viaje a la isla de Puerto Rico en el año 1797. San Juan: Imprenta Militar de J. González.

Maddison, Angus (2001). The World Economy: A Millennial Perspective. OECD: Paris.

McCreery, David J. (1994). Rural Guatemala, 1760-1940. Stanford, CA: Stanford University Press.

Molinero y Gómez Cornejo, Andrés (1879). Compilación de las disposiciones referentes a la Guardia Civil de Puerto Rico. Puerto Rico, Establecimiento Tipográfico del Boletín.

Moscoso, Francisco (1999). Agricultura y Sociedad en Puerto Rico, Siglos 16 al 18: un acercamiento desde la historia. San Juan, P.R.: Instituto de Cultura Puertorriqueña.

Naritomi, Joana, Rodrigo R. Soares, and Juliano J. Assunção (2007). "Rent Seeking and the Unveiling of 'De Facto' Institutions: Development and Colonial Heritage within Brazil", unpublished manuscript, Univeristy of Maryland.

Nugent, Jeffrey B. and James A. Robinson (2005). "Are Factor Endowments Fate?", unpublished manuscript, Harvard University.

Osuna, Juan José. (1949). A History of Education in Puerto Rico. Río Piedras, P.R.: Editorial de la Universidad de Puerto Rico.

Palloni, Alberto, Halliman H. Winsborough, and Francisco Scarano. Puerto Rico Census Project, 1910 [Computer File]. ICPSR04343-01-v1. Madison, WI: University of Wisconsin Survey Center [producer], 2005. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2006-01-16.

Pande, Rohini, and Christopher Urdy (2005). "Institutions and Development: A View from Below," in Blundell, Richard and Torsten Persson, Proceedings of the 9th World Congress of the Econometric Society, Cambridge University Press: Cambridge, U.K.

Paige, Jeffrey M. (1997). Coffee and Power: Revolution and the Rise of Democracy in Central America. Harvard University Press: Cambridge, MA.

Picó S.J., Fernando (1979). Libertad y Servidumbre en el Puerto Rico del siglo XIX. Ediciones Huracán: Río Piedras, Puerto Rico.

Picó S.J., Fernando (2007). Cayeyanos: Familias y Solidaridades en la Historia de Cayey. Ediciones Huracán: Río Piedras, Puerto Rico.

Picó, Rafael (1987). Nueva Geografía de Puerto Rico. Río Piedras: Ediciones Huracán.

Roberts, Ray Carlton (1941). Soil Survey of Puerto Rico. United States Department of Agriculture: Washington, D.C.

Report of the Commissioner of Education for Puerto Rico (1907). San Juan: Department of Education.

Rodrik, Dani, Arvind Subramanian, and Francesco Trebbi (2004). "Institutions Rule: The Primacy of Institutions over Geography and Integration in Economic Development", *Journal of Economic Growth*, 9(2): pp. 131-165.

Rosado Brincau, Rafael (1891). Bosquejo histórico de la Institución de Voluntarios. La Habana: Imprenta de la Capitanía General.

Scarano, Francisco (1984). Sugar and Slavery in Puerto Rico: The Plantation Economy of Ponce, 1800-1850. University of Wisconsin Press: Madison, Wisconsin.

Schwartz, Stuart B. (1982). "The Hurricane of San Ciriaco: Disaster, Politics, and Society in Puerto Rico, 1899-1901." *Hispanic American Historical Review*, 303-334.

Seda Prado, Jorge (1996). El campesinado en Puerto Rico a fines del siglo XIX y principios del XX: El caso de Toa Alta, 1894-1910. Ediciones Huracán: Río Piedras, Puerto Rico.

Sokoloff, Kenneth L. and Eric M. Zolt (2005). "Inequality and the Evolution of Institutions of Taxation: Evidence from the Economic History of the Americas", unpublished manuscript, UCLA.

Sued Badillo, Jalil (2001). El Dorado borincano: la economía de la Conquista: 1510-1550. Ediciones Puerto: San Juan, PR. 515pp.

Topic, Steven C. (1998). "Coffee," in Steven C. Topic (ed.), The Second Conquest of Latin America: Coffee, Henequen, and Oil during the Export Boom, 1850-1930. University of Texas Press: Austin.

Ubeda y Delgado, Manuel (1878). Isla de Puerto Rico: Estudio histórico y estadístico. Puerto Rico: Establecimiento Tipográfico del Boletín.

Williams, Robert G. (1994). States and Social Evolution: Coffee and the Rise of National Governments in Central America. University of North Carolina Press: Chapel Hill, NC.

Appendix: Data Sources and Description

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 precipitation 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 Córdoba, 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, tobacco, food crops cultivation; land for pastures, 1896: available for each municipality from (Carroll, 1899).

Socio-Economic Status 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.

Adult literacy rates, English literacy rates, female fertility (number of children ever born), number of surviving children, 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)

School enrollment rates of children ages 6-10 years, literacy rates of children ages 11-20 years, secondary school completion rates of children ages 11-20 years, year 1899; adult males' literacy rates, adult males' secondary school completion rates, by racial category, nationality, year 1899; proportion of households with access to non-educational local public goods (i.e., sewage, potable water, waste management); adult males' labor force participation and occupational structure, by racial category, nationality, year 1899: available from Academia Puertorriqueña de la Historia ("APH") (2003).

Primary School Provision and Municipal Budget Allocations:

Number of schools in the municipality, year 1828: available in Córdova (1831-33).

Number of teachers certified by the San Juan Bishopric during 1805-1848: available in Coll y Toste (1909).

Number of primary schools in each municipality, year 1876-77: available in Ubeda y Delgado (1878).

Number of primary schools in each municipality, year 1876-77: available in Ubeda y Delgado (1878).

Number of primary schools in each municipality, year 1897: available in APH (2003).

Budget-based revenue and expenditure data, year 1866-67: available from "Resúmen de los Presupuestos Municipales de Gastos e Ingresos de la Isla de Puerto Rico para el año económico de 1866-67.", Archivo Histórico Nacional de Madrid, Fondo de Ultramar. Data Includes budget assigned to rural police personnel and materials expenditures as well as public schooling expenditures.

Military and Paramilitary Forces:

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)

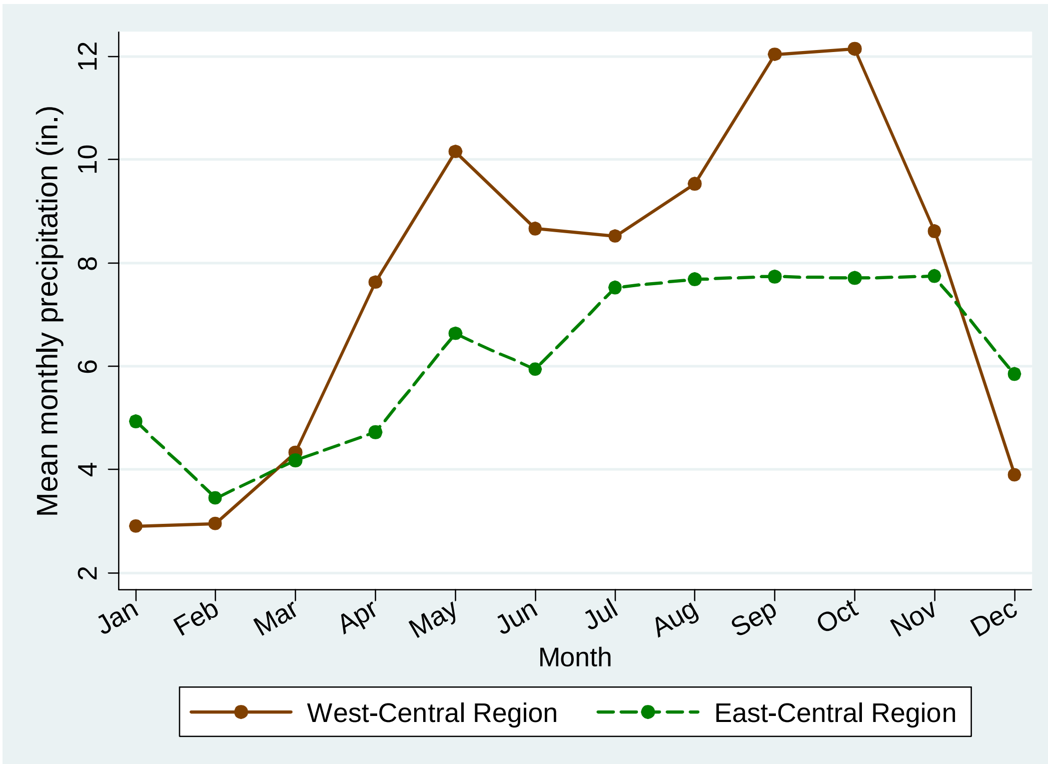
Provincial Civil Guard distribution data: Molinero y Gómez Cornejo (1879) documents an analogous distribution of Civil Guard units (companies) across municipalities of the island for the year 1876. Again, the source does not provide data on the number of men in each municipality. Therefore, we impute 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 1845-1860 period: available from cadastral land census or land tax registries, for the following municipalities: Aibonito (cadastre - year 1854), Barranquitas (tax registry - 1846), Caguas (cadastre - 1860), Cayey (cadastre - 1860), Cidra (cadastre - 1860), Comerío ("Sabana del Palmar") (cadastre - 1853), Gurabo (cadastre - 1860), San Lorenzo ("Hato Grande") (cadastre - 1860), Lares (tax registry - 1854), Morovis (cadastre - 1857), Toa Alta (cadastre - 1860), Utuado (cadastre - 1856). 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.

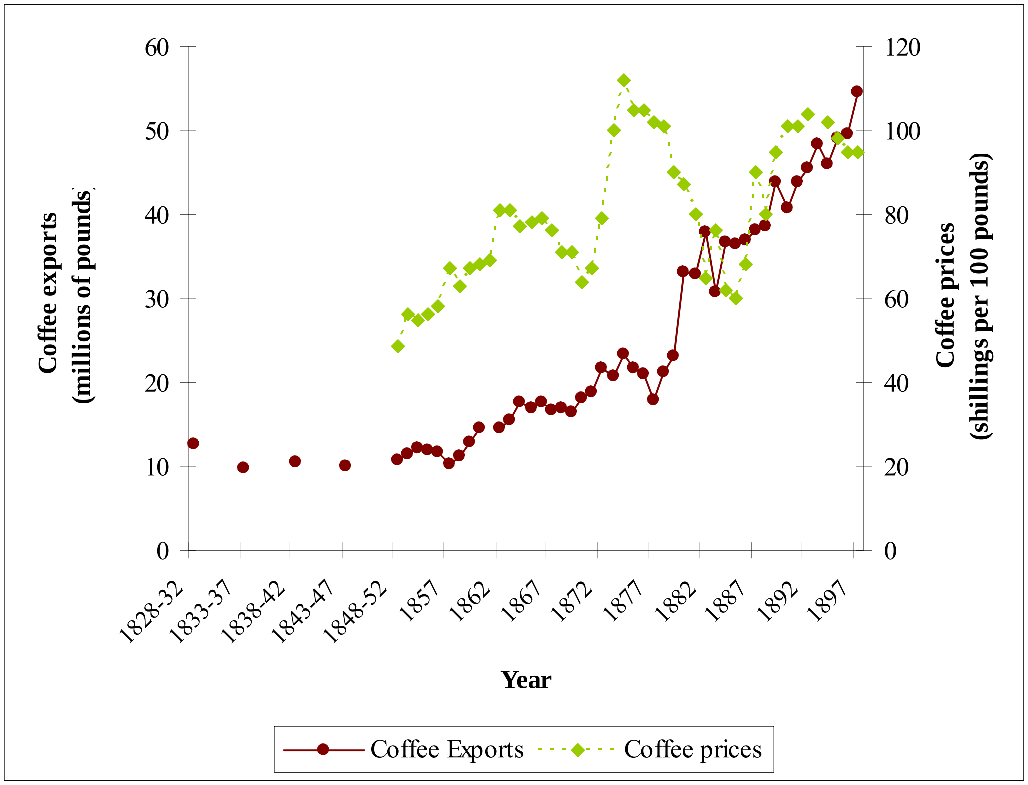
Plot size and owner of each plot for each taxed plot in municipality, for one year in 1891-1894 period: available from cadastral land censuses for all municipalities in center of the island. Source: Archivo General de Puerto Rico, Fondo: Administración Provincial (Gobernadores Españoles). Land gini coefficient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

Figure 1: Monthly Rainfall Patterns across Regions, 1899-1927



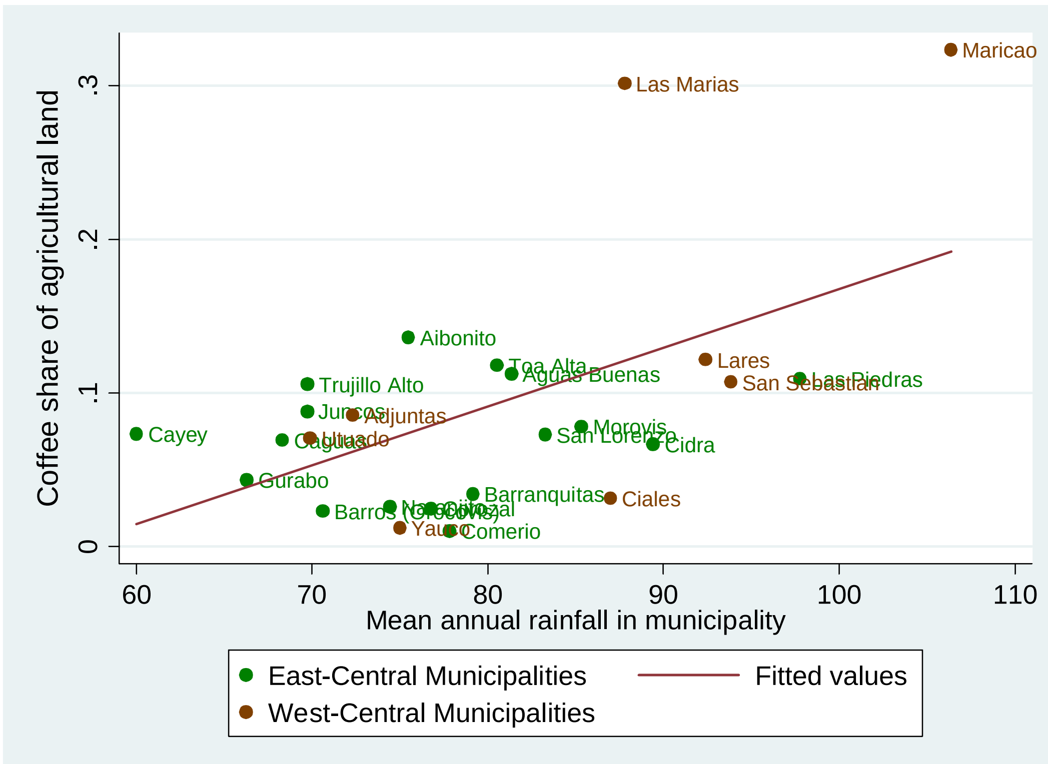
Source: Author's calculations from Roberts (1841).

<u>Figure 2</u>: Volume of P.R. Coffee Exports and International Coffee Prices, 1825-1897



<u>Sources</u>: 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.

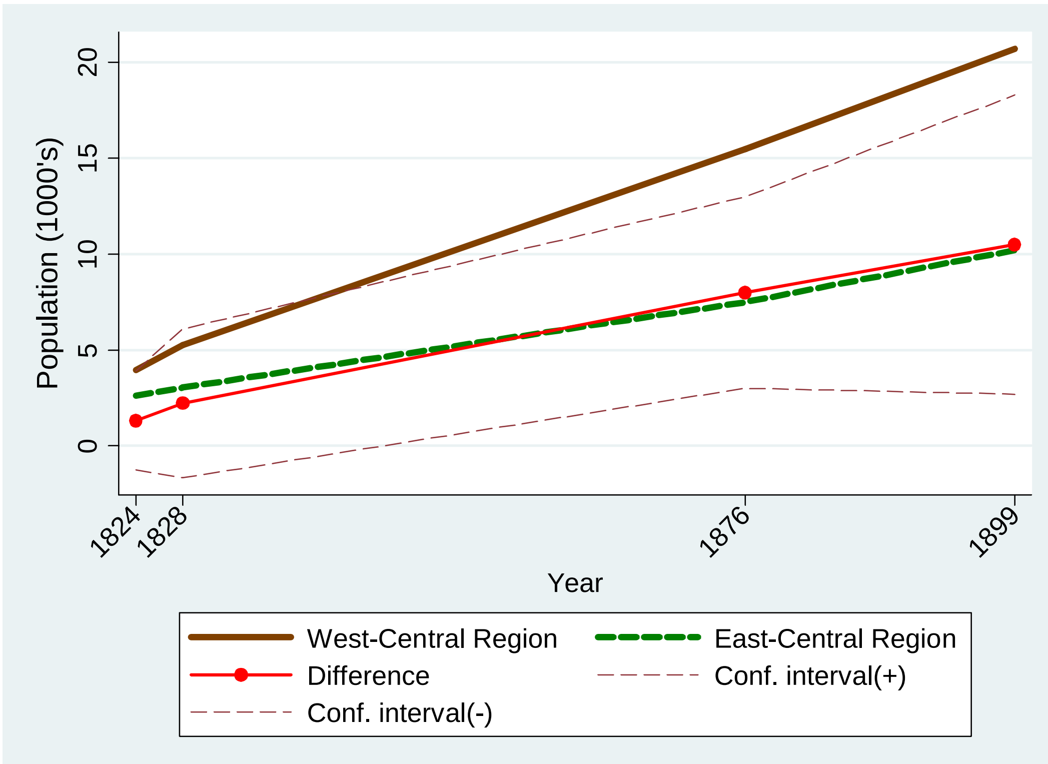
<u>Figure 3</u>: Mean Annual Precipitation Levels and Coffee Cultivation, Year 1896



<u>Notes</u>: Each dot represents a municipality. Plotted are residuals (adjusted by sample means) from multivariate regression which condition on the following geographic variables: mean annual maximum and minimum temperatures, mean altitude, mean degree of ruggedness (gradient), and distance to the nearest port municipality.

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

Figure 4: Trends in Municipality-Level Population Sizes throughout the 19th Century



Sources: Author's calculations from Córdova (1831-33), Ubeda y Delgado (1878), and Census of Porto Rico (1899).

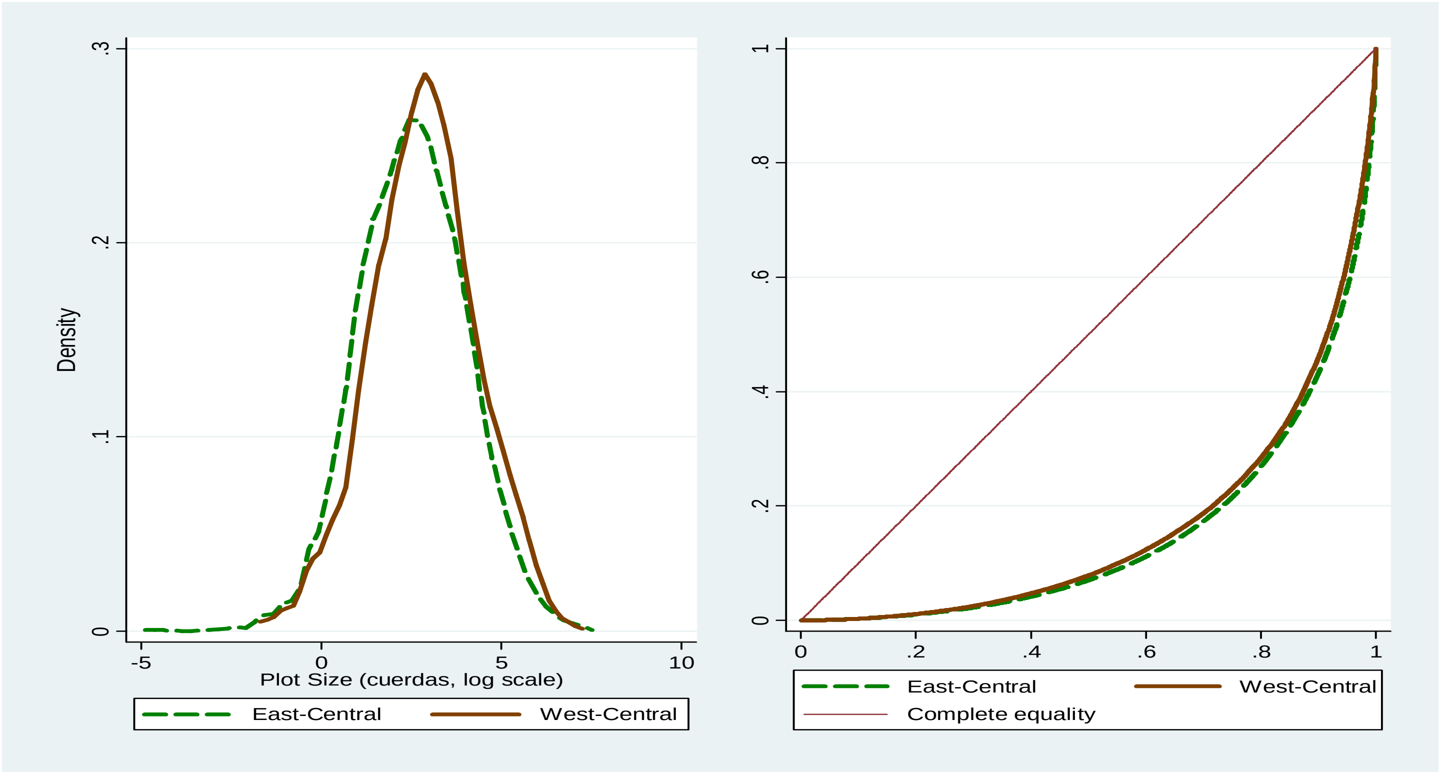
<u>Figure 5</u>: Literacy Rates Differences across Municipalities with Varying Rainfall Levels

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

<u>Notes</u>: Values of coefficient estimates 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 6: Distribution of Landholdings across Regions, 1890s

Panel A: Non-parametric kernel densities **Panel B:** Lorenz Curves



Notes: These figures present non-parametric kernel density estimates of the distribution of individual land ownership using an epanechnikov kernel.

Sources: Authors' calculations from land cadastres for municipalities in West-Central and East-Central regions, varying years (1891-1894).

Table 1: Geographic Characteristics, Coffee Cultivation, and Population - Municipalities in 1899

	West-Central Region (1)	East-Central Region (2)	Difference (Std. Error) (3)	N (4)
Panel A: Geographic Characteristics				
Average annual rainfall, 1899-1928 (in.)	90.2	74.1	16.1*** (4.2)	26
Average altitude (meters)	436.4	331.8	104.7 (73.7)	26
Average land gradient (degrees)	17.6	14.4	3.2** (1.3)	26
Average maximum temperature, 1950-2000 (ºF)	82.9	84.0	-1.2 (1.3)	26
Average minimum temperature, 1950-2000 (ºF)	63.2	66.7	-3.5*** (0.7)	26
Distance to nearest port (km)	24.4	26.0	-1.6 (2.8)	26
Panel B: Coffee Cultivation & Production				
Coffee (feet) / cuerda, yr. 1828	10.0	3.4	6.6 (2.9)	26
Coffee production (quintales)/ land (cda.), yr. 1828	0.166	0.034	0.132 (0.055)	26
Number of coffee mills, yr. 1828	2.5	0.1	2.4 (0.8)	26
Wealth per capita, yr. 1828	100.9	108.3	-7.4 (14.8)	26
Value of production per capita, yr. 1828	10.7	6.0	4.6 (1.6)	26
Coffee cultivation share of total agr. land, yr. 1896	0.187	0.044	0.143 (0.031)	26

Notes: 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: Land Distribution, Socio-Economic Characteristics, and Racial Composition across Regions

	West-Central Region (1)	East-Central Region (2)	Difference (Std. Error) (3)	N (4)
Panel A: Socio-Economic and Demographic Characteristics				
Sharecroppers share of the populaion, yr. 1828	0.08	0.13	-0.05 (0.03)	24
Slaves as share of total population, yr. 1828	0.08	0.08	0.00 (0.02)	24
Free blacks or mulattos as share of the pop., yr. 1828	0.33	0.35	-0.02 (0.07)	24
Free blacks as share of the population, yr. 1828	0.05	0.07	-0.02 (0.02)	24
White pop. share of the total population, yr. 1828	0.51	0.44	0.07 (0.08)	24
Crude Birth Rate, yr. 1828	56.0	55.0	1.0 (5.0)	22
Crude Death Rate, yr. 1828	24.0	23.0	1.0 (3.0)	22
Panel B: Land Distribution (Gini Coefficient)				
Period 1845-1860	0.695	0.641	0.054 (0.043)	11
Period 1845-1860, including period effects	-	-	0.033 (0.049)	11
Land Ownership Gini Coefficient, period 1891-1894	0.687	0.634	0.053** (0.024)	21

Notes: 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: Socio-Economic Status and 'Quality' of Local Government Outcomes Descriptive Statistics

	Mean [Std. Dev.]	West-Central Region	East-Central Region	Difference (Std. Error)
	(1)	(2)	(3)	(4)
Panel A: Educational and Health Outcomes, 1890s				
School Enrollment Rate, Children Ages <10	0.023	0.016	0.026	-0.009 (0.004)
Proportion read, not write, Children Ages > 10	0.016	0.012	0.017	-0.005 (0.002)
Literacy Rate, Children Ages > 10	0.133	0.141	0.129	0.012 (0.014)
Higher Education Completion Rate, Children Ages > 10	0.0019	0.0023	0.0017	0.0006 (0.0006)
Adult Literacy Rate	0.186	0.190	0.184	0.006 (0.013)
Adult Higher Education Completion Rate	0.0061	0.0062	0.0060	0.0003 (0.0019)
Crude Mortality Rate, 1888-1898	25.9 [10.8]	32.5 [13.0]	22.8 [7.8]	9.7 (1.3)
Crude Birth Rate, 1888-1898	28.7 [10.9]	33.0 [12.1]	26.6 [9.7]	6.4 (1.4)
Panel B: 'Quality' of Local Governments				
Primary Schools				
Number of schools per 1,000 individuals, year 1876-77	0.506 [0.217]	0.357 [0.090]	0.566 [0.225]	-0.209 (0.096)
Number of schools per 1,000 individuals, year 1897	0.541 [0.170]	0.471 [0.216]	0.576 [0.137]	-0.105 (0.072)
Number of schools per 1,000 children, year 1897	0.815 [0.238]	0.663 [0.221]	0.892 [0.212]	-0.229 (0.093)
Access to sewage (prop. of households, yr. 1899)				
Use of cesspool or sewer	0.162	0.205	0.142	0.063 (0.028)
Use of cesspool	0.157	0.192	0.141	0.051 (0.028)
Acess to sewer	0.005	0.014	0.001	0.012 (0.006)
Source of Water (prop. of households, yr. 1899)				
Cistern	0.371	0.468	0.322	0.146 (0.111)
Aqueduct	0.035	0.003	0.051	-0.048 (0.041)
Spring	0.055	0.095	0.031	0.064 (0.034)
River	0.536	0.431	0.593	-0.163 (0.125)

Notes: 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.

<u>Table 3</u>: Socio-Economic Status and 'Quality' of Local Government Outcomes Statistics (cont.)

	Mean [Std. Dev.]	West-Central Region	East-Central Region	Difference (Std. Error)
	(1)	(2)	(3)	(4)
Panel B: 'Quality' of Local Governments (cont.)				
Prop. HHs for which garbage collected by mun., Yr. 1899	0.086	0.065	0.096	-0.031
				(0.036)
Size of Public Order / Law Enforcement Forces				
Share of Volunteer guard Company in Municipality, 1886	0.69	0.95	0.59	0.36
	[0.30]	[0.30]	[0.23]	(0.11)
Volunteer Guard Company Headquarters in Mun., Yr. 1886	0.346	0.250	0.059	0.191
				(0.140)
Number of Units in Provincial Civil Guard, Yr. 1876	10.27	18.69	6.30	12.39
	[15.05]	[25.27]	[2.86]	(6.06)
Panel C: Males' Occupational Distribution, yr. 1899				
Agriculture, fishing, and mining	0.465	0.486	0.455	0.030
				(0.019)
Commerce and transportation	0.026	0.024	0.027	-0.002
				(0.005)
Manufacturing	0.023	0.024	0.022	0.002
				(0.005)
Services (Professional, Domestic & Personal)	0.044	0.045	0.044	0.001
				(0.010)
No lucrative occupation	0.442	0.421	0.452	-0.031
				(0.014)
Panel D: Racial and Gender Composition, Yr. 1899				
Share pop. all white, 1899	0.651	0.742	0.608	0.134
				(0.066)
Share pop. native white, 1899	0.644	0.732	0.603	0.129
				(0.066)
Share pop. foreign, 1899	0.006	0.010	0.005	0.005
				(0.002)
Share pop. black or mulatto, 1899	0.337	0.219	0.392	-0.173
				(0.065)
Share pop. black, 1899	0.040	0.016	0.051	-0.035
				(0.013)
Share pop. mulatto, 1899	0.297	0.203	0.341	-0.138
				(0.062)
Overall female/male ratio, yr. 1899	1.003	0.990	1.010	-0.020
	[0.033]	[0.031]	[0.036]	(0.014)
Foreign whites female/male ratio, yr. 1899	0.163	0.208	0.142	0.066
	[0.091]	[0.102]	[0.079]	(0.037)

Notes: 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.

<u>Table 4</u>: Access to Public Primary Schooling, Late 19th Century

	Dependent variables:									
Panel A	*Num. of schools per capita, (in thousands), year 1828*					*Num. of schools per capita, (in thousands), year 1876-77*				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	OLS	OLS	OLS	IV	IV	OLS	OLS	OLS	IV	IV
Avg. annual rainfall in mun. (in. x 10)	-0.011	-0.030	-0.004	-0.046	-0.002	-0.119***	-0.121***	-0.099**	-0.116***	-0.083***
	(0.024)	(0.029)	(0.024)	(0.032)	(0.026)	(0.030)	(0.027)	(0.026)	(0.025)	-0.0245
Black/Mulatto Population Share			0.534***		0.561***			0.438*		0.480***
			(0.164)		(0.130)			(0.204)		(0.159)
Geographic and Demographic Controls	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
First-stage F-statistic				[23.5]	[15.8]				[23.5]	[15.8]
Observations	21	21	21	21	21	21	21	21	21	21
Mean of dep. variable	0.046	0.046	0.046	0.046	0.046	0.536	0.536	0.536	0.536	0.536
Implied diff. [coffee]-[food crops] regions	-0.018	-0.049	-0.006			-0.192	-0.195	-0.159		

Panel B	*Difference in Num. of schools per capita (in thousands), years 1828-1876*					*Num. of schools per 1,000 children, year 1897*				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	OLS	OLS	OLS	IV	IV	OLS	OLS	OLS	IV	IV
Avg. annual rainfall in mun. (in. x 10)	-0.118**	-0.130***	-0.136***	-0.071+	-0.075+	-0.025	-0.034+	-0.070+	-0.032*	-0.044**
	(0.046)	(0.036)	(0.040)	(0.045)	(0.049)	(0.019)	(0.021)	(0.044)	(0.017)	(0.019)
Black/Mulatto Population Share			-0.012		-0.048		-0.14	-.496**		-0.175
			(0.254)		(0.190)		(0.16)	(0.20)		(0.128)
Geographic and Demographic Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Department FEs	No	No	No	No	No	No	No	Yes	No	No
				[9.2]	[7.2]				[30.8]	[21.9]
Observations	18	18	18	18	18	24	24	24	24	24
Mean of dep. variable	0.489	0.489	0.489	0.489	0.489	0.526	0.526	0.526	0.526	0.526
Implied diff. [coffee]-[food crops] regions	-0.190	-0.209	-0.219			-0.041	-0.055	-0.113		

<u>Notes</u>: Coefficient estimates from OLS and IV regressions are reported. Standard errors in parentheses; significantly different from zero at (+) 85%, (*) 90%, (**) 95%, (***) 99% confidence. Demographic controls are the number of dwellings in 1899, the number of children ages 10 and younger in 1899, the number of those 10-19 years old, and the number of adults in each municipality. Geographic controls are mean max. and min. annual temperature, mean altitude, mean land gradient, and distance to nearest port. See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis.

Table 5: Child Schooling and Literacy Outcomes, Year 1899

	Dependent variables:									
	School Enrollment Rate, Children Ages <10 years					*School Enrollment Rate, Children Ages 10-20 years*				
Panel A	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	OLS	OLS	OLS	IV	IV	OLS	OLS	OLS	IV	IV
Avg. annual rainfall in mun. (in. x 10)	-0.0031*	-0.0031**	-0.0030*	-0.0041***	-0.0043***	-0.0020*	-0.0026**	-0.0024*	-0.0038***	-0.0038***
	(0.0015)	(0.0013)	(0.0015)	(0.0013)	(0.0015)	(0.0011)	(0.0010)	(0.0012)	(0.0010)	(0.0012)
Black/Mulatto Population Share			0.0011		-0.0035			0.0052		0.00012
			(0.0131)		(0.0106)			(0.0099)		(0.0083)
Geographic and Demog. Controls	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
First-stage F-statistic				[30.8]	[21.9]				[30.8]	[21.9]
Observations	25	25	25	25	25	25	25	25	25	25
Mean of dep. variable	0.023	0.023	0.023	0.023	0.023	0.018	0.018	0.018	0.018	0.018
Diff. [coffee]-[food crops] regions	-0.005	-0.005	-0.005			-0.003	-0.004	-0.004		

Panel B	*Literacy Rate, Children Ages 10-20*					*Proportion who read, not write Children Ages 10-20*				
Avg. annual rainfall in mun. (in. x 10)	-0.0119**	-0.0134***	-0.0100**	-0.0092**	-0.0037	-0.0023***	-0.0028***	-0.0027***	-0.0031***	-0.0030***
	(0.0051)	(0.0041)	(0.0041)	(0.0040)	(0.0043)	(0.0006)	(0.0005)	(0.0006)	(0.0005)	(0.0006)
Black/Mulatto Population Share			0.0683*		0.0911***			0.0027		0.0017
			(0.0352)		(0.0300)			(0.0053)		(0.0042)
Geographic and Demographic Controls	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
First-stage F-statistic				[30.8]	[21.9]				[30.8]	[21.9]
Observations	25	25	25	25	25	25	25	25	25	25
Mean of dep. variable	0.164	0.164	0.164	0.164	0.164	0.015	0.015	0.015	0.015	0.015
Diff. [coffee]-[food crops] regions	-0.019	-0.022	-0.016			-0.004	-0.004	-0.004		

Notes: Coefficient estimates from OLS and IV regressions are reported. Standard errors in parentheses; significantly different from zero at (+) 85%, (*) 90%, (**) 95%, (***) 99% confidence. Demographic controls are the number of dwellings in 1899, the number of children ages 10 and younger in 1899, the number of those 10-19 years old, and the number of adults in each municipality. Geographic controls are mean max. and min. annual temperature, mean altitude, mean land gradient, and distance to nearest port. See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis.

Table 6: Native Male Adults' Literacy Rates – Cohort Differences, Year 1910

	Dependent variable: Literacy rate								
Panel A	*All adults, ages 25-60*			*Male adults, ages 25-60*			*Female adults, ages 25-60*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Age 25-49 x Avg. annual rainfall in mun. (in. x 10)	-0.0165**	-0.0166**	-0.0168**	-0.0202*	-0.0204*	-0.0188*	-0.0127*	-0.0125*	-0.0132*
	(0.0074)	(0.0075)	(0.0077)	(0.0107)	(0.0107)	(0.0109)	(0.0068)	(0.0069)	(0.0066)
Avg. annual rainfall in mun. (in. x 10)	-0.0053	-0.0035		0.0002	-0.0016		-0.0111**	-0.0071	
	(0.0060)	(0.0069)		(0.0091)	(0.0101)		(0.0045)	(0.0064)	
Age Indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	No	Yes	No	No	Yes	No	No	Yes	No
Municipality Fixed Effects	No	No	Yes	No	No	Yes	No	No	Yes
Observations	16259	16259	16259	8068	8068	8068	8191	8191	8191
Mean of dep. variable	0.175	0.175	0.175	0.225	0.225	0.225	0.126	0.126	0.126
Implied diff. [coffee]-[food crops] regions	-0.027	-0.027	-0.027	-0.033	-0.033	-0.030	-0.020	-0.020	-0.021

Panel B	*White adults, ages 25-60*					*Black and mulatto adults, ages 25-60*			
	---------------*All*---------------			----------*Males*----------		---------------*All*---------------			---*Males*---
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Age 25-49 x Avg. annual rainfall in mun. (in. x 10)	-0.0181*	-0.0186*	-0.0179*	-0.0181	-0.0192^{+}	-0.0026	-0.0021	-0.0031	-0.0011
	(0.0092)	(0.0094)	(0.0093)	(0.0125)	(0.0124)	(0.0064)	(0.0065)	(0.0065)	(0.0010)
Avg. annual rainfall in mun. (in. x 10)	-0.0129^{+}	-0.0068*		-0.0089	-0.0039	-0.0122*	-0.0132*		-0.0015
	(0.0080)	(0.0088)		(0.0106)	(0.0120)	(0.0056)	(0.0077)		(0.0011)
Age Indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	No	Yes	No	No	Yes	No	Yes	No	Yes
Municipality Fixed Effects	No	No	Yes	No	No	No	No	Yes	No
Observations	12402	12402	12402	6163	6163	3856	3856	3856	1904
Mean of dep. variable	0.175	0.175	0.175	0.257	0.257	0.225	0.225	0.225	0.137
Implied diff. [coffee]-[food crops] regions	-0.027	-0.027	-0.027	-0.029	-0.031	-0.033	-0.033	-0.030	-0.002

Notes: Coefficient estimates from OLS regressions are reported. Standard errors in parentheses; significantly different from zero at (+) 85%, (*) 90%, (**) 95%, (***) 99% confidence. Geographic controls are mean max. and min. annual temperature, mean altitude, mean land gradient, and distance to nearest port. See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis.

Table 7: Municipal Government Expenditures in Urban/Rural Police, Year 1865

	Dependent variables:											
	Rural/Urban Police PersonnelExpenditures, 1865-66						*Rural/Urban Police PersonnelExpenditures Share, 1865-66*					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: IV Estimates												
Mean Annual rainfall (in. x 10)	464.5+	410.6+	467.5*	454.2+	385.7	162.3	0.024+	0.021+	0.024*	0.022	0.019	0.009
	(291.8)	(241.0)	(252.4)	(296.1)	(263.9)	(240.2)	(0.015)	(0.012)	(0.013)	(0.015)	(0.013)	(0.013)
Annual Max Temperature		Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes
Mean Altitude			Yes	Yes	Yes	Yes			Yes	Yes	Yes	Yes
Mean Slope Gradient				Yes	Yes	Yes				Yes	Yes	Yes
Distance to Port					Yes	Yes					Yes	Yes
Annual Min Temperature						Yes						Yes
First-stage F-statistic	[8.4]	[11.2]	[10.1]	[7.4]	[8.2]	[6.0]	[8.4]	[11.2]	[10.1]	[7.4]	[8.2]	[6.0]
Observations	23	23	23	23	23	23	23	23	23	23	23	23
Mean of dep. variable	274.7	274.7	274.7	274.7	274.7	274.7	0.018	0.018	0.018	0.018	0.018	0.018
Panel B: Reduced Form Estimates												
Coffee region indicator	624.1**	590.6**	650.1***	578.8**	544.6**	297.1	0.032**	0.030**	0.033**	0.028**	0.027*	0.016
	(240.4)	(236.0)	(221.1)	(235.7)	(252.9)	(379.7)	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.020)
Annual Max Temperature		Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes
Mean Altitude			Yes	Yes	Yes	Yes			Yes	Yes	Yes	Yes
Mean Slope Gradient				Yes	Yes	Yes				Yes	Yes	Yes
Distance to Port					Yes	Yes					Yes	Yes
Annual Min Temperature						Yes						Yes
Observations	23	23	23	23	23	23	23	23	23	23	23	23
Mean of dep. variable	274.7	274.7	274.7	274.7	274.7	274.7	0.018	0.018	0.018	0.018	0.018	0.018

Notes: Coefficient estimates from OLS and IV regressions are reported. Standard errors in parentheses; significantly different from zero at (+) 85%, (*) 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 8: Size of Law Enforcement/Public Order Corps, Late 19th Century

	Dependent variables:								
	Share of Volunteer Guard (Unit) in Municipality, 1886			*Ind. for Volunteer Guard Company Headquarters in Municipality, 1886*			*Number of Units in Provincial Civil Guard, 1876*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Panel A: IV Estimates									
Mean Annual rainfall (in. x 10)	0.154+	0.107	0.100	0.111	0.113	0.097	1.84*	1.60	1.58
	(0.093)	(0.096)	(0.095)	(0.083)	(0.104)	(0.101)	(0.98)	(1.22)	(1.23)
Geographic Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Distance to Port	No	No	Yes	No	No	Yes	No	No	Yes
Observations	25	25	25	25	25	25	24	24	24
Mean of dep. variable	0.69	0.69	0.69	0.12	0.12	0.12	7.4	7.4	7.4
Panel B: Reduced Form Estimates									
Coffee region indicator	0.266**	0.254	0.242	0.144	0.269	0.234	3.63**	3.86	3.89
	(0.117)	(0.189)	0.194	(0.184)	(0.245)	(0.245)	(1.68)	(2.67)	(2.77)
Geographic Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Distance to Port	No	No	Yes	No	No	Yes	No	No	Yes
Observations	25	25	25	25	25	25	24	24	24
Mean of dep. variable	0.69	0.69	0.69	0.12	0.12	0.12	7.4	7.4	7.4

Notes: Coefficient estimates from OLS and IV regressions are reported. Standard errors in parentheses; significantly different from zero at (+) 85%, (*) 90%, (**) 95%, (***) 99% confidence. Geographic controls are mean max. and min. annual temperature, mean altitude, mean land gradient, and distance to nearest port. See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis.

Sources: Authors' calculations based on coding of documentation in Rosado Brincau (1891) and Molinero y Gómez Cornejo (1879). See the data appendix for details on the construction of the variables.

Table 9: Differences in the Distribution of Land Ownership across Municipalities, Late 19th Century

	Dependent variables:							
	Overall Land Ownership Gini Coefficient,			Share of Landless Households			Land Gini Coefficient among Landed HHs,	
Sample:	-----Land Own. Sample-----			--Land Own. Sample--		--Overall--	--Land Own. Sample--	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: IV Estimates								
Average annual rainfall, 1899-1928 (in. x 10)	0.035**	0.013+	0.017*	0.049+	0.051	0.025	0.002	0.013
	(0.014)	(0.009)	(0.008)	(0.033)	(0.036)	(0.025)	(0.021)	(0.014)
Black/Mulatto Population Share			0.195***		0.139			0.597***
			(0.074)		(0.312)			(0.125)
Geographic Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic	[10.0]	[8.5]	[7.8]	[8.5]	[7.8]	[12.0]	[8.5]	[7.8]
Observations	20	20	20	20	20	25	20	20
Mean of dependent variable	0.921	0.921	0.921	0.700	0.700	0.703	0.747	0.747
Panel B: First Stage Regressions	Dependent variable: Average annual rainfall, 1899-1928							
West-Central region indicator	16.16***	27.17**	25.29**	27.17**	25.29**	24.19***	27.17**	25.29**
	(5.10)	(9.30)	(9.09)	(9.30)	(9.09)	(6.96)	(9.30)	(9.09)
Observations	20	20	20	20	20	25	20	20
Panel C: Reduced Form Estimates								
West-Central region indicator	0.057***	0.035	0.042*	0.133+	0.130	0.060	0.005	0.034
	(0.012)	(0.024)	(0.022)	(0.085)	(0.090)	(0.065)	(0.070)	(0.050)
Observations	20	20	20	20	20	25	20	20

Notes: Coefficient estimates from OLS and IV regressions are reported. Standard errors in parentheses; significantly different from zero at (*) 90%, (**) 95%, (***) 99% confidence. Geographic controls are mean max. and min. annual temperature, mean altitude, mean land gradient, and distance to nearest port. See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis. See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis.

Table 10: Child Survival, Female Fertility, and Access to Sanitation-based Public and Private Goods, Late 19th Century

	Dependent variables:								
Panel A	*---------------Child survival rate---------------*				*------------------------Female fertility------------------------*				
	All Females		*White Females*		*All Females*		*Native-Born Whites*		*Black/ Mulattas*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Age 30-49 x Annual rainfall in mun. (in. x 10)	0.0021	0.0019	-0.0022	-0.0033	0.144**	0.145**	0.119	0.106	0.096
	(0.0054)	(0.0052)	(0.0064)	(0.0063)	(0.057)	(0.055)	(0.088)	(0.083)	(0.153)
Annual rainfall in mun. (in. x 10)	0.0083		0.0074		-0.102		-0.086		-0.025
	(0.0078)		(0.0079)		(0.102)		(0.134)		(0.145)
Age Indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Municipality Fixed Effects	No	Yes	No	Yes	No	Yes	No	Yes	No
Observations	7056	7056	5361	5361	8170	8170	6218	6218	1952
Mean of dep. variable	0.742	0.742	0.754	0.754	4.98	4.98	4.96	4.96	5.05
Diff. in [coffee]-[food crops] regions	0.003	0.003	-0.004	-0.005	0.232	0.233	0.191	0.171	0.155

	Dependent variables:								
Panel B	*Prop. HHs for which municipality collects garbage, year 1899*			*Proportion of households with access to aqueduct, year 1899*			*Proportion of households with cesspool, year 1899*		
Coffee region indicator	-0.031	-0.129**	-0.108*	0.012**	0.013	0.013	0.051*	-0.049	-0.055
	(0.036)	(0.054)	(0.060)	(0.006)	(0.010)	(0.011)	(0.028)	(0.036)	(0.041)
Black/Mulatto Population Share			0.091			0.004			-0.025
			(0.112)			(0.021)			(0.076)
Geographic and Demographic Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Observations	25	25	25	25	25	25	25	25	25
Mean of dep. variable	0.096	0.096	0.096	0.001	0.001	0.001	0.141	0.141	0.141

Notes: Coefficient estimates from OLS regressions are reported. Standard errors in parentheses; significantly different from zero at (+) 85%, (*) 90%, (**) 95%, (***) 99% confidence. Geographic controls are mean max. and min. annual temperature, mean altitude, mean land gradient, and distance to nearest port. See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis.

Table 11: Natives' Higher Education Completion Rates and Foreigners' Literacy and Schooling, Late 19th Century

	Dependent variables:							
	Higher education completion rate, Native adult males ages 21 and older				*Proportion who read, not write, Foreigners ages 21 and older*			
Panel A	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS	(7) OLS	(8) OLS
Coffee Region Indicator	-0.002	0.000	0.006	0.000	-0.002	-0.010	-0.014	-0.010
	(0.003)	(0.005)	(0.004)	(0.007)	(0.006)	(0.008)	(0.009)	(0.016)
Black/Mulatto Population Share			0.033***	0.040***			-0.023	-0.023
			(0.009)	(0.012)			(0.017)	(0.026)
Demographic Controls	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Department FEs	No	No	No	Yes	No	No	No	Yes
Observations	25	25	25	25	25	25	25	25
R-squared	0.02	0.08	0.47	0.62	0.01	0.14	0.22	0.28
Mean of dep. variable (in food crops region)	0.011	0.011	0.011	0.011	0.007	0.007	0.007	0.007
	Literacy Rate, Foreigners ages 21 and older				*Higher education completion rate, Foreigners ages 21 and older*			
Panel B								
Coffee Region Indicator	-0.015	-0.004	0.008	0.098	0.002	0.002	0.001	-0.036
	(0.031)	(0.048)	(0.052)	(0.072)	(0.018)	(0.029)	(0.032)	(0.048)
Black/Mulatto Population Share			0.062	-0.036			-0.005	-0.023
			(0.103)	(0.116)			(0.063)	(0.078)
Demographic Controls	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Department FEs	No	No	No	Yes	No	No	No	Yes
Observations	25	25	25	25	25	25	25	25
R-squared	0.01	0.14	0.15	0.55	0.00	0.04	0.04	0.39
Mean of dep. variable (in food crops region)	0.864	0.864	0.864	0.864	0.048	0.048	0.048	0.048

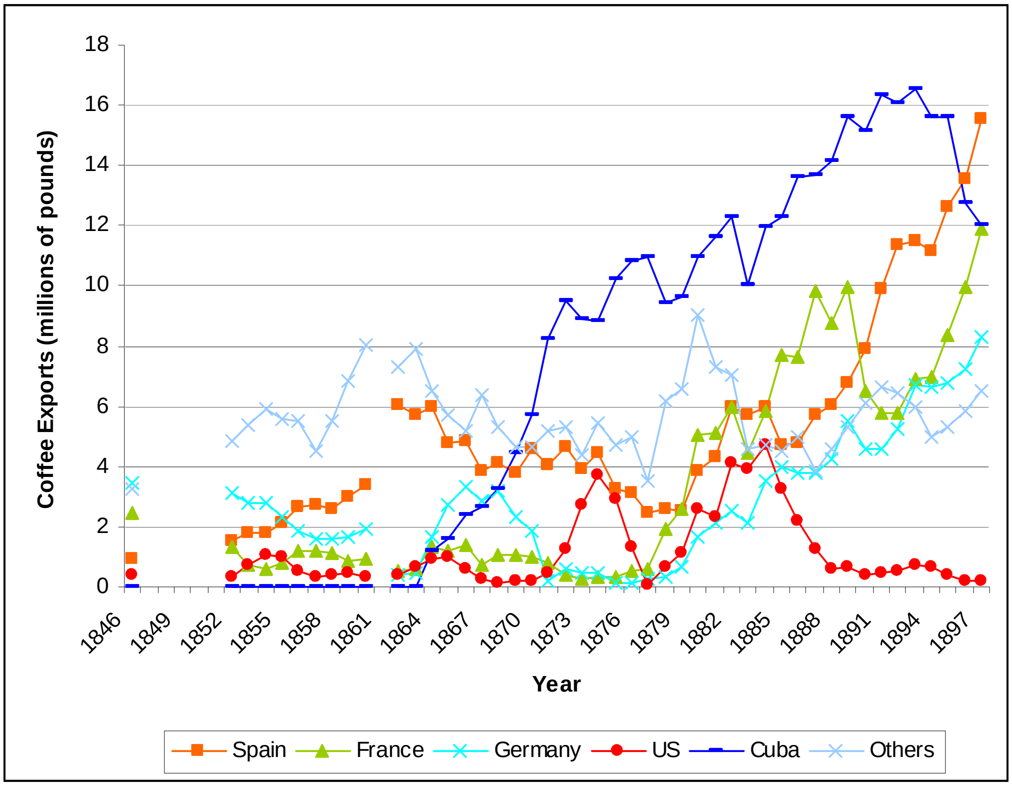
Notes: Coefficient estimates from OLS regressions are reported. Standard errors in parentheses; significantly different from zero at (+) 85%, (*) 90%, (**) 95%, (***) 99% confidence. Demographic controls are the number of children ages 10 and younger in 1899, the number of those 10-19 years old, and the number of adults in each municipality. Geographic controls are mean max. and min. annual temperature, mean altitude, mean land gradient, and distance to nearest port. See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis.

Table 12: Occupational Distribution of Adult Males across Regions, Late 19th Century

	Dependent variables: Prop. of adult males employed in							
	Agriculture, fishing, or mining, year 1899				*Commerce or transportation, year 1899*			
Panel A	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Coffee Region Indicator	0.030	0.045	0.018	0.035	-0.002	-0.015**	-0.008	-0.008
	(0.019)	(0.030)	(0.029)	(0.042)	(0.005)	(0.007)	(0.006)	(0.010)
Black/Mulatto Population Share			-0.141**	-0.232***			0.033**	0.032*
			(0.057)	(0.067)			(0.012)	(0.016)
Demographic Controls	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Department FEs	No	No	No	Yes	No	No	No	Yes
Observations	25	25	25	25	25	25	25	25
R-squared	0.10	0.13	0.34	0.62	0.01	0.31	0.50	0.65
Mean of dep. variable (in food crops region)	0.455	0.455	0.455	0.455	0.027	0.027	0.027	0.027
Panel B	*Manufacturing, year 1899*				*Services (Professional, domestic or personal), year 1899*			
Coffee Region Indicator	0.002	-0.014**	-0.010	-0.013	0.001	-0.014	-0.007	-0.007
	(0.005)	(0.006)	(0.006)	(0.010)	(0.010)	(0.014)	(0.015)	(0.026)
Black/Mulatto Population Share			0.021*	0.029*			0.036	0.065
			(0.011)	(0.016)			(0.030)	(0.042)
Demographic Controls	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Department FEs	No	No	No	Yes	No	No	No	Yes
Observations	25	25	25	25	25	25	25	25
R-squared	0.01	0.45	0.53	0.62	0.00	0.16	0.22	0.37
Mean of dep. variable (in food crops region)	0.022	0.022	0.022	0.022	0.044	0.044	0.044	0.044

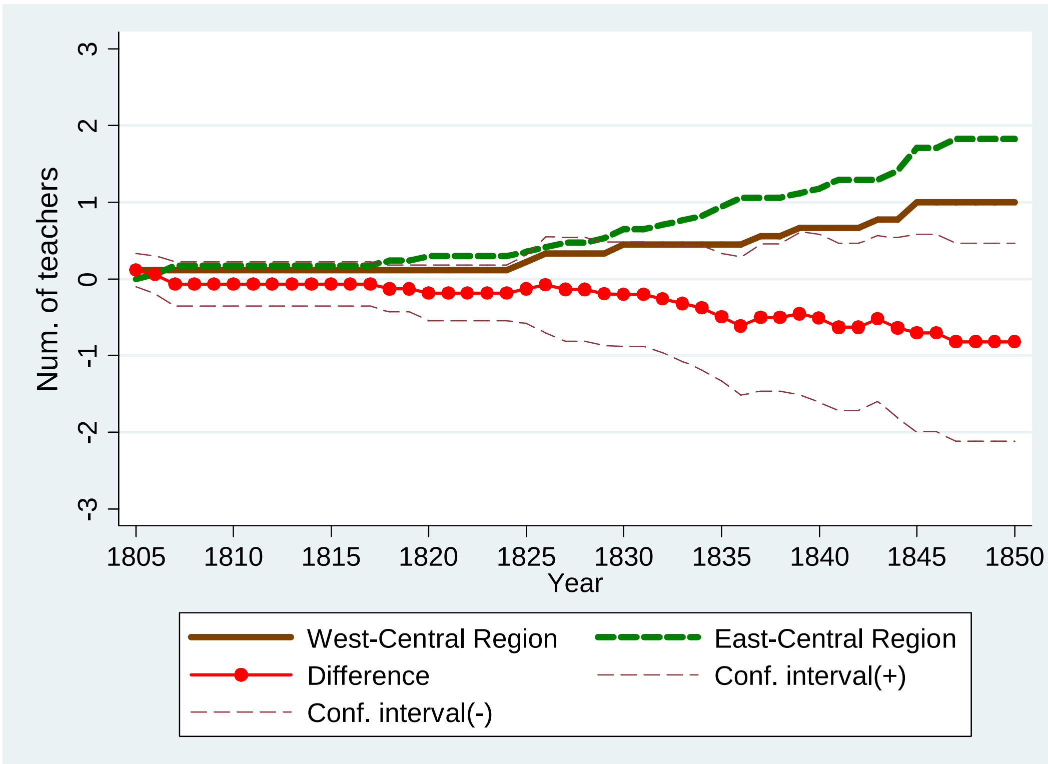
Notes: Coefficient estimates from OLS regressions are reported. Standard errors in parentheses; significantly different from zero at (+) 85%, (*) 90%, (**) 95%, (***) 99% confidence. Demographic controls are the number of children ages 10 and younger in 1899, the number of those 10-19 years old, and the number of adults in each municipality. Geographic controls are mean max. and min. annual temperature, mean altitude, mean land gradient, and distance to nearest port. See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis.

Figure A1: Destination of Puerto Rican Coffee Exports, 1846-1897



Sources: Puerto Rico, Intendencia General de Hacienda, *Balanza Mercantil*, for the years 1853-1860; *Estadística General*, for the years 1862-1898, in Bergad (1983). See the data appendix for details.

<u>Figure A2</u>: Cumulative Number of Teachers Assigned to Municipalities, 1805-1850 Region-Level Averages



<u>Sources</u>: Author's calculations from Coll y Toste (1909).

Table A1: Precipitation Levels and Coffee Cultivation, Year 1896

	Dependent variable: Share of agricultural land under coffee cultivation, year 1896								
Sample	Overall	Overall	Overall	Land Ownership	Overall	Overall	Overall	Land Ownership	Land Ownership
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS	OLS	OLS	OLS	IV	IV	IV	IV	IV
Panel A: OLS and IV Estimates									
Average annual rainfall, 1899-1928 (in.)	0.0044***	0.0038**	0.0040**	0.0030**	0.0083***	0.0070***	0.0080***	0.0060***	0.0062***
	(0.0013)	(0.0014)	(0.0020)	(0.0010)	(0.0023)	(0.0021)	(0.0027)	(0.0018)	(0.0020)
Black/Mulatto Population Share			0.001	-0.049			0.135		0.088
			(0.133)	(0.176)			(0.149)		(0.176)
Geographic Controls	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
First-stage F-statistic					[15.6]	[12.1]	[8.2]	[8.5]	[7.8]
Observations	25	25	25	20	25	25	25	20	20
Panel B: First Stage Regressions	Dependent variable: Average annual rainfall, 1899-1928								
West-Central region indicator					17.26***	24.19***	22.17**	27.17**	25.29**
					(4.37)	(6.96)	(7.73)	(9.30)	(9.09)
Observations					25	25	25	20	20
Panel C: Reduced Form Estimates	Dependent variable: Share of agricultural land under coffee cultivation, year 1896								
West-Central region indicator					0.143***	0.170***	0.178***	0.164***	0.157**
					(0.031)	(0.049)	(0.054)	(0.051)	(0.052)
Observations					25	25	25	20	20

Notes: Coefficient estimates from OLS and IV regressions are reported. Standard errors in parentheses; significantly different from zero at (+) 85%, (*) 90%, (**) 95%, (***) 99% confidence. Geographic controls are mean max. and min. annual temperature, mean altitude, mean land gradient, and distance to nearest port. See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis.

Table A2: Native Male Adults' Literacy Rates, Year 1899

	Dependent variables:									
Panel A	*Literacy rate, White adult males ages 21 and older*					*Proportion who read, not write, White adult males ages 21 and older*				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	OLS	OLS	OLS	IV	IV	OLS	OLS	OLS	IV	IV
Avg. annual rainfall in mun. (in. x 10)	-0.0279***	-0.0274**	-0.0094**	-0.0298***	-0.0083**	-0.0020***	-0.0023***	-0.0024***	-0.0030***	-0.0034***
	(0.0079)	(0.0105)	(0.0043)	(0.0099)	(0.0042)	(0.0006)	(0.0006)	(0.0007)	(0.0001)	(0.0001)
Black/Mulatto Population Share			0.356***		0.360***			-0.0029		-0.0064
			(0.037)		(0.029)			(0.0060)		(0.0051)
Geographic and Demog. Controls	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
First-stage F-statistic				[30.8]	[21.9]				[30.8]	[21.9]
Observations	25	25	25	25	25	25	25	25	25	25
Mean of dep. variable	0.201	0.201	0.201	0.201	0.201	0.009	0.009	0.009	0.009	0.009
Diff. [coffee]-[food crops] regions	-0.045	-0.044	-0.015			-0.003	-0.004	-0.004		
Panel B	*Literacy rate, Black and mulatto adult males ages 21 and older*					*Proportion who read, not write, Black and mulatto adult males ages 21 and older*				
Avg. annual rainfall in mun. (in. x 10)	0.0070	0.0036	0.0050	0.0023	0.0037	-0.0008	-0.0013*	-0.0009	-0.0017**	-0.0013*
	(0.0057)	(0.0041)	(0.0046)	(0.0039)	(0.0045)	(0.0008)	(0.0007)	(0.0008)	(0.0007)	(0.0008)
Black/Mulatto Population Share			0.0279		-0.0231			0.0076		0.0062
			(0.0394)		(0.0312)			(0.0067)		(0.0053)
Geographic and Demog. Controls	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
First-stage F-statistic				[30.8]	[21.9]				[30.8]	[21.9]
Observations	25	25	25	25	25	25	25	25	25	25
Mean of dep. variable	0.107	0.107	0.107	0.107	0.107	0.006	0.006	0.006	0.006	0.006
Implied diff. [coffee]-[food crops] regio	0.113	0.058	0.081			-0.013	-0.002	-0.014		

Notes: Coefficient estimates from OLS and IV regressions are reported. Standard errors in parentheses; significantly different from zero at (*) 90%, (**) 95%, (***) 99% confidence. Demographic controls are the number of children ages 10 and younger in 1899, the number of those 10-19 years old, and the number of adults in each municipality. Geographic controls are mean max. and min. annual temperature, mean altitude, mean land gradient, and distance to nearest port. See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis.

<u>Table A3</u>: Occupational Distribution of Foreign-born Adult Males across Regions, Late 19th Century

	Dependent variables: Prop. of foreign-born adult males employed in							
	Agriculture, fishing, or mining, year 1899				*Commerce or transportation, year 1899*			
Panel A	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Coffee Region Indicator	0.093*	0.171**	0.165*	0.195	-0.104***	-0.146***	-0.140**	-0.123
	(0.051)	(0.079)	(0.087)	(0.127)	(0.032)	(0.050)	(0.055)	(0.090)
Black/Mulatto Population Share			-0.032	-0.012			0.032	0.072
			(0.172)	(0.205)			(0.109)	(0.145)
Demographic Controls	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Department FEs	No	No	No	Yes	No	No	No	Yes
Observations	25	25	25	25	25	25	25	25
R-squared	0.13	0.20	0.20	0.53	0.32	0.36	0.36	0.53
Mean of dep. variable (in food crops region)	0.311	0.311	0.311	0.311	0.343	0.343	0.343	0.343
	Manufacturing, year 1899				*Services (Professional, domestic or personal), year 1899*			
Panel B								
Coffee Region Indicator	-0.052**	-0.082**	-0.083**	-0.116*	0.075*	0.054	0.029	0.077
	(0.022)	(0.034)	(0.038)	(0.065)	(0.038)	(0.061)	(0.066)	(0.103)
Black/Mulatto Population Share			-0.004	0.022			-0.129	-0.261
			(0.074)	(0.104)			(0.130)	(0.166)
Demographic Controls	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Department FEs	No	No	No	Yes	No	No	No	Yes
Observations	25	25	25	25	25	25	25	25
R-squared	0.19	0.30	0.30	0.42	0.14	0.17	0.21	0.46
Mean of dep. variable (in food crops region)	0.101	0.101	0.101	0.101	0.182	0.182	0.182	0.182

<u>Notes</u>: Coefficient estimates from OLS regressions are reported. Standard errors in parentheses; significantly different from zero at (+) 85%, (*) 90%, (**) 95%, (***) 99% confidence. Demographic controls are the number of children ages 10 and younger in 1899, the number of those 10-19 years old, and the number of adults in each municipality. Geographic controls are mean max. and min. annual temperature, mean altitude, mean land gradient, and distance to nearest port.See the data description section and the data appendix for detailed descriptions of the construction of variables used in the analysis.