

The Expansion of Public Education in Puerto Rico after 1900*

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Abstract

During the first half of the 20th century, Puerto Rico saw rapid progress in expanding primary education. However, as elsewhere in Latin America, there were pronounced regional differences in the rates of increased schooling. Due to its varied crop suitability and detailed records from the US colonial government, Puerto Rico is an ideal setting to explore the role of agriculture in explaining regional variation in the growth of education. This chapter presents a newly constructed panel dataset of enrollment and attendance rates by counties between 1907 and 1943. It finds that differing agricultural production technologies, alongside policy decisions and rates of urbanization, help explain why the growth rate of education varied across regions.

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1 Introduction

Latin American countries made a substantial progress in their educational outcomes around the beginning of the 20th century. As with many other indicators of development, there was significant variation in the pace at which the literacy rate progressed across different countries. Argentina and Uruguay led the way. In 1900, around half of their population over 10 years old knew how to read and write. Other large countries like Mexico and Brazil had literacy rates just above 20% in 1900 and only slowly managed to catch up during the first half of the century. Most countries, however, laid somewhere in between (Bulmer-Thomas, 2003; Engerman and Sokoloff, 1997).

Puerto Rico started from a particularly low literacy rate. The 1899 Census reported an overall literacy rate of 16.6%. Approximately 18.3% of the adult population were literate, placing Puerto Rico near the bottom of Latin American countries at the turn of the century (Sanger et al., 1901; Núñez, 2005). However, it also showed some of the fastest progress, with an increase of literate population over 10 years old to 33.7% by 1910. During the next couple of decades that figure doubled. In the 1930 census, 57.6% of people in the same demographic declared they knew how to read and write.

Puerto Rico was also an outlier when it came to political economy. It became a formal colony of the United States in 1898 after the Spanish-American war. It then experienced several decades of American colonial rule until 1947 when the island's inhabitants gained the right to elect the governor (though neither independence nor US statehood; Puerto Rico is in a legal gray area as an organized but unincorporated US territory). During this time Puerto Rico experienced rapid economic growth, measured using national accounts (Devereux, 2019) and anthropometric evidence (Godoy et al., 2007; Marein, 2020). Part of the economic dynamism from the early 20th century was driven by the export of agricultural commodities. The island developed its sugar production, complementing the coffee cultivation which had been a staple during Spanish rule. However, as in other countries in Latin America, improvements in education, growth, and trade hide significant geographic

variation that is key to understanding the patterns of economic development (Maloney and Valencia Caicedo, 2016).

This chapter explores the main local trends in education in Puerto Rico during the first half of the 20th century. Because of the United States colonial administration, the island has better historical information than other countries at similar stages of development. This chapter takes advantage of newly digitized yearly reports from the Governor to the United States government and the decennial Census of Population in 1910, 1920, and 1930. We use them to build a panel database of counties (*municipios*) between 1907 and 1943, which allow us to compare how school enrollment changed over time and to document differential trends by the level of urbanization and by the agricultural specialization of each county.

Overall, Puerto Rico started the 20th century with around 20% of children of school age enrolled in school. By 1945 that figure went up to around 50%, with significant geographic variation. After the imposition of US control, the number of children enrolled in elementary school grew rapidly until 1915, both in urban and rural schools alike. However, around a third of the progress that was made between 1904 and 1915 was reversed by 1920. The subsequent two decades saw very limited growth in capacity but a shift towards more urban schooling, especially in highly populated counties. Such increase in capacity was not entirely followed by increases in the most basic learning measure: literacy rates. We combine data from the reports of the Governor and literacy data from the Census of Population. The growth in rural schooling has a modest positive correlation with literacy rates. However, we show that counties that expanded their schooling capacity the fastest between 1910 and 1930 are not the ones with the fastest growth in literacy.

The expansion of public education also depended on the type of crop produced in each county. Investments in education relied partly on local finances. Since sugar exports brought more revenue to producer counties, sugar counties increased their enrollment rate faster than coffee counties during the first decade of US control (Bobonis and Toro, 2007).

Coffee counties caught up by 1920 but the gap widened again during the 30s and early 40s. This difference in long-run trends between coffee and sugar counties is especially striking for urban schools.

While capacity was driven by fundamentals like local finances, demand for schooling fluctuated quite dramatically in the short run. For instance, between 1915 and 1918, enrollment dropped by about 25% in coffee counties. Using our enrollment panel data and international commodity price data, we compare how school enrollment and attendance responded to increases in crop's export revenues in a county that specializes in sugar production versus one that specializes in coffee production.

Puerto Rico did export other crops besides coffee and sugar. In 1910, for example, Puerto Rico exported sugar worth \$24 million (nominal USD), tobacco products worth \$6.8 million, coffee worth \$5.7 million, and tropical fruit (oranges, pineapples, coconuts, etc.) worth \$1.9 million (Annual Report of the Governor of Puerto Rico, 1901). However, we focus on coffee and sugar for three reasons. First, the areas suitable for tobacco and fruit cultivation were less geographically distinct than coffee and sugar (Wilson, 1899). Second, while coffee and sugar were homogenous commodities with a single price, tobacco was exported as cigars, cigarettes, tobacco leaves, and scraps. Likewise, while fruit was an important category of exports, specific crops had relatively small shares. Third, tobacco processing was an important manufacturing industry on the island. While sugar cane was refined in mills, it lost value quickly if not transported quickly or processed close to the plantation (Bergad, 1978). Therefore, sugar price variation likely had a more localized effect than that of tobacco price variation.

This exercise is useful for two reasons. First, the way coffee and sugar was produced is different. Sugar production was characterized by strong economies of scale, which generated larger farms than those used for coffee cultivation (Bobonis and Morrow, 2014). Second, farmers in the island were price takers in coffee and sugar markets, which allow

us to use changes in the international world price of commodities to proxy for local prices.¹

In sugar counties, increases in the export revenue of sugar led to increases in enrollment and attendance rates. However, when the export revenue for coffee went up, school enrollment in counties that specialize in that crop went down. Why did increases in agricultural income have such different effects on investments in human capital? When export revenues increase, workers involved in sugar production have higher wages so they can afford to send their children to school. While this effect is also present in coffee areas, coffee farms tend to be smaller farms with no economies of scale. Moreover, since picking coffee cherries and cutting sugar cane require very different skill and strength levels, coffee is more amenable for child labor than sugar. Therefore, when coffee revenues increase, the opportunity cost for a family of not sending their children to school also increases. This chapter provides evidence that this substitution effect dominates for coffee areas, while the income effect dominates for sugar areas.

The negative relationship between coffee price shocks and education has been explored historically for the cases of Colombia (Carrillo, 2019; Uribe-Castro, 2021) and Puerto Rico during the Spanish period (Bobonis and Morrow, 2014), as well as contemporaneously for the case of Brazil (Kruger, 2007; Duryea and Arends-Kuenning, 2003). This chapter highlights that such relationship depends on the specific production technology of coffee that easily employs child labor. The comparison between coffee and sugar is useful to understand other mechanisms through which export price changes can affect the accumulation of human capital (Musacchio et al., 2014; Atkin, 2016) and to highlight that the specific production functions of commodities can shape the development path different areas take (Bustos et al., 2016; Droller and Fiszbein, 2019). More generally, understanding differences in education outcomes across and within countries is crucial to understand long term development (Porzio et al., 2020; Valencia Caicedo, 2019; Gennaioli et al., 2013).

¹It should be noted that Puerto Rico was operating within the US tariff system, with sugar receiving a protective tariff and coffee not. However, there is more variation in international prices than in the tariff rate, and local farmers effectively had no control over either.

This chapter also provides context to the rise in public schooling in Latin America. The US was a clear leader since the 19th century in the development of a public school system. This was in part due to “the long-standing commitment of the United States to democratic ideals,” but also due to “decentralized decision-making... greater geographic mobility and technological dynamism” (Goldin and Katz, 1997). The supply of schooling was determined by local elections. Regions with low wealth inequality, fewer opportunities for youth employment, and more homogenous populations saw the earliest rises in schooling during the 20th century (Goldin, 1999).

However, democratic considerations are not the only explanation of why countries expanded their public education systems. Elites can benefit from investing in schooling in multiple ways. For instance, elites can enjoy the benefits from a more educated service industry (Galiani et al., 2008). Moreover, governments have often promoted education to “foster industrialization, forge a national identity, promote loyalty and domestic order or strengthen military power” (Paglayan, 2021). Without decentralized democratic decision-making, an autocratic elite might still impose top-down educational reforms despite high inequality, opportunities for child labor, or heterogenous population.

The American colonial government oversaw a large expansion of schooling despite high inequality and child labor. While some decisions were decentralized, the Commissioner of Education also pushed for top-down reforms. Alongside promoting loyalty and the culture of the United States, these reforms genuinely attempted to improve human capital. Indeed, increasing education was both an ideological goal of many administrators and a frequent justification given for colonial rule.

2 Public Education in Puerto Rico, 1898-1948

2.1 Spanish attempts at reforms

Aside from limited efforts at reform in the early 19th century, the first major attempt at public schooling was the Organic Decree of 1865. This decree attempted to establish a standardized school system, but the “founding, financing, and management of schools remained under the responsibility of municipal governments” (Bobonis and Morrow, 2014).

The new school system had many shortcomings. Due to this decentralization, the development of schooling was very heterogenous across different counties. While schooling was made compulsory for those aged 6 to 12, compliance was extremely low (Bobonis and Toro, 2007). The frequent turnover of governors led to serious uncertainty regarding education policy. For example, the 1865 decree was suspended in the 1870’s but reinstated in 1880. The more conservative governors also saw schools as a tool of political suppression, especially after the Grito de Lares revolt of 1868.

“The mission of an Inspector of primary instruction in these countries distant from the motherland, and influenced by currents of thought, censurable ... [is to] discover the social wound where it exists, more or less hidden, and apply to it with all the energy that the gravity of the circumstances demands an effective cauterization.”

— Don Juan Macho Moreno, School Inspector, late 19th c. (Osuna, 1923)

2.2 The regime change

After the US conquest, Puerto Rico was under military rule for two years and education policy was left to the local school boards. After the Foraker Act of 1900 established a civilian government, the new Department of Education decided educational reform was necessary. It saw its task as remedial, increasing basic literacy in both Spanish and English and instilling pro-American sentiment:

“The crying and current need is a school that can reduce this appalling illiteracy. To teach children to read, to write, to count, and to love home and country.”

— M. G. Brumbaugh, Commissioner of Education (Report of the Commissioner of Education, 1900).

Why was education such a priority to the colonial authorities? The annexation of new colonial territory had sparked a fierce debate amongst American elites (Sparrow, 2006). Up until that point, territorial expansion came with at least an implicit path to statehood.² The territory seized from Spain 1898 was seen as vital to secure maritime trade and secure tropical resources, but the local populations were seen as unlikely to assimilate into American culture. Would Puerto Rico be incorporated into the United States, reducing (at least numerically) the dominance of white Anglo-Saxon Protestants, or would it remain a colony held indefinitely at arms-length, undermining the democratic norms of the US?

The compromise reached was to give some rights to the colonies but to prevent full integration. Puerto Rico hence became classified as an organized yet unincorporated territory. This ruling was justified by an argument that colonial subjects were lacking the training needed to participate in the US democratic system. While to some this may have been merely an excuse to deny full political participation to the new colonies, it implied that civic education might someday open the door to statehood. In promoting public schooling, the Department of Education in Puerto Rico made the implication explicit:

“In my remarks it seemed fitting to say that the free public school was infinitely more potent in lifting the island than all political discussion; that the product of the school, as it is known in the States, will most of all contribute to the speedy placing of a new star in the azure field of the glorious flag of freedom —the star of Porto Rico.”

²There was notable hesitancy in the cases of Utah and New Mexico due to large Mormon and Mexican-American populations.

— M. G. Brumbaugh, Commissioner of Education (Report of the Commissioner of Education, 1900).

Indeed, the imperial conquest was often portrayed in the contemporary press as a benign intervention, with the United States playing the role of school teacher and Puerto Rico as a new student.

2.3 American attempts at reform

The American attempts at reform faced similar issues to the ones that the Spanish encountered decades before. Although the Department of Education centralized the selection of teachers and curricula, schools were still funded locally. This led to greater funding in rich counties, such as those producing sugar (Bobonis and Toro, 2007). Even though school was made compulsory for children age 8 and 14 in 1903, compliance was at first low. Policy, in particular that relating to English instruction, varied wildly as new Commissioners of Education were frequently appointed (Angrist et al., 2008).

The outbreak of World War I had major ramifications for US rule on the island. Under President Woodrow Wilson, the Jones-Safroth Act of 1917 increased the power of the locally elected government in Puerto Rico and granted its inhabitants US Citizenship. However, the unelected governor still appointed the Commissioner of Education. The war also resulted in severe staffing problems for schools (Report of the Governor of Puerto Rico, 1918). The war also saw an increased urgency in the mission to instill loyalty to the United States.

“[M]any of the teachers and not a few of the older pupils have become efficient propagandists, ready and able to take part in the molding of public opinion along patriotic lines.” —Paul G. Miller, Commissioner of Education, 1918 (Report of the Commissioner of Education, 1918).

During the relatively long tenure of Commissioner Miller (1916–1934), a new major focus of the Department of Education was rural school consolidation. By combining several small schools, in theory the school could provide better facilities and more differentiated curriculum. This program attempted to copy similar reforms in the mainland US that were seen as increasing efficiency.

One of the targets of this consolidation was the practice of “double enrollment,” where each teacher has a different morning and afternoon class of half-time students (Report of the Commissioner of Education, 1916). This system allowed limited rural resources to go further when the goal was basic literacy. It also accommodated the needs of rural families: students could make the often-long journey home for lunch and could work part-time during the coffee harvests. The Department of Education noted that this compromise helped increase enrollment and attendance (Report of the Commissioner of Education, 1916). However, it had the obvious drawback that the students only received half as much schooling.

The problem with the rollout of consolidated schools, according to the Department of Education, was the low level of rural development. Consolidated schools required a population willing to enroll and roads that allowed them to attend.

“The advantages of the rural consolidated school are no longer questioned; since these schools require good roads, the problem of roads must naturally be solved first. The only solution to this problem would be the forming of villages which would . . . attract to these places the great majority of our peasant population”

—Report of the Commissioner of Education, 1922.

In other words, economic development of rural areas fell under the mission of the Department of Education, as it was necessary to support modern consolidated schools.

Due to the existing transportation infrastructure, the new consolidated schools were often in coastal regions (Report of the Commissioner of Education, 1918). In particular, the

goal was to consolidate more densely settled rural villages that allowed greater economies of scale for schooling and other public goods. The department sought to promote such villages through what it called “the rural uplift,” a campaign that promoted use of rural schools as community centers (Osuna, 1923). The Department was so confident in this plan that by 1926 “[s]upervisors [had] been instructed to allow one-room rural schools only in exceptional cases” (Report of the Commissioner of Education, 1926).

However, progress in rural areas remained slow. The Great Depression hit the island’s budget hard, combined with the devastating 1928 hurricane and a second, smaller yet still damaging hurricane in 1932. By 1934, blaming budget shortfalls, the new Commissioner of Education claimed to face a stark trade-off:

“the Commissioner has to decide in favor of one of three urgent needs, viz., opening a school where none existed before and admitting pupils to the primary grades; assigning the new position to a school organized on the double-enrollment plan in order to allow pupils in upper grades to attend school for the full day; and assigning the position to a consolidated school in order to add one upper grade to the organization.”

— Report of the Commissioner of Education, 1934.

One thing that had not changed by the 1930’s, despite (or perhaps because of) an increasingly active pro-independence movement, was the Department of Education’s interest in instilling loyalty to the United States. One of the first priorities of education in Puerto Rico, according to the 1939 Commissioner, was to promote “a fundamental faith in the ideal of American democracy” (Report of the Commissioner of Education, 1939).

Overall, while the Department of Education did genuinely seek to improve educational outcomes, it was adverse to neither top-down policy reforms nor propaganda to encourage loyalty to the US.

3 Main Trends in Primary Education

The evolution of primary education in Puerto Rico during the first half of the 20th century was characterized by a rapid increase in capacity followed by a period of slow but steady growth. From the beginning, the US government emphasized the provision of education as an important steppingstone to the modernization of the island and especially the acquisition of “American values” by the native population (Dietz, 1986; Cabán, 2018; Osuna, 1923). As such, the number of schools per children of school age increased until around 1915–1920, when it stagnated at just above 7 schools per 1,000 children between 5 and 17 years old. During those early decades, enrollment in primary education also increased rapidly though actual attendance to classes was more sluggish. Overall, the improvements in capacity led to an overshooting of enrollment rates. At first this did not translate into improvements in attendance, which only caught up between 1915 and 1920. Afterwards, the pace at which the primary education system improved was more gradual and persistent. The initial push to build and operate rural schools was followed by moderate improvements in the literacy rate. However, starting in the 1920’s there was a shift out of rural schools and into graded schools that followed the modernization process of the island.

This section reviews these and other trends of the Puerto Rican primary education system during the period between the Foraker Act of 1900 and 1949, when the first democratic elections for Governor took place. We collected data from several sources, most importantly from a series of reports to the federal US government, written by the Governor of and the Commissioner of Education for Puerto Rico from 1900 until 1948³. In the reports, the Governor accounted for the fiscal situation on the island and provided information on a wide set of issues at the county level. The reports are rich in terms of topics, ranging from crime and order to taxation. In this chapter, we focus on education data. We digitized a yearly panel of enrollment and attendance for different levels of schooling. We also use

³Full citations in the Primary Sources bibliography section.

data from the reports on cultivated land by crops to measure local economic activity. We complement these data sets with information from census of population samples in 1910, 1920, and 1930.

Data

We build a yearly panel at the county level with total enrollment and average attendance in elementary schools for the years 1904–1943. The reports provide information on the number of students in every county that were enrolled in a public school by March 1 as well as the average number of students who attended school each day the school was operating. We refer to these measures as “Enrollment” and “Attendance,” respectively. The reports present information for two types of “Common” (public primary) schools: “Graded” and “Rural” schools.

The panel is unbalanced as there were several changes in county borders over the period. We aggregate the data at the smallest level consistent over time. For new counties created in the 1910s, we include them as they are formed as part of the original set of counties.⁴

The way the reports present information on enrollment and attendance also changed over time. Moreover, during some years the reports do not present information disaggregated at the county level. Towards the end of the sample, information on attendance stops being produced. Despite these limitations, we have information on enrollment for the years 1904, 1907 to 1920, 1922, 1927, 1929, 1931, 1932, 1933, 1934, 1939, 1941, and 1943. For attendance, we managed to compile information for 1907, 1910 to 1913, 1915 to 1920, 1922, 1927, 1929, 1931, 1932, 1933, and 1934.

Finally, there is also information on the number of schools that are operating at each

⁴Barceloneta and Jayuya in 1912; Guainabo and Hormigueros in 1913; Ceiba, Guánica, Las Piedras, and Luquillo in 1915; Villalba in 1917. We omit Cantaño which only formed in 1927. Río Piedras, which was merged with San Juan in 1951, is kept separate in our regressions but not in the maps as we use contemporary county boundaries.

municipality. We digitize information on the number of graded and rural schools in 1900, 1907, 1910, 1922, and 1932. At the beginning of the sample, the vast majority of schools were a classroom operated by one teacher, so the number of teachers correspond nearly one-to-one to the number of schools. While the educational system develops, the reports start measuring both school buildings as well as classrooms and teachers. We focus on the number of classrooms as the definition of school to guarantee consistency over time.

To create per-capita education indicators and control for differences in population over time and across counties, we combine data from the reports with data from Census of Population (Ruggles et al., 2021). We estimate the number of children of school age — that is between 5 and 17 years old — using census samples from 1910, 1920, and 1930. We linearly interpolate between decennial census to estimate the number of kids between 5 and 17 years old for each year. For years before the 1910 Census or after the 1930 Census, we extrapolate using the rate of growth of school age population between 1910 and 1920 and 1920 and 1930, respectively. We follow the same interpolation process for the total population and the urban population.

To explore regional trends in education, we split counties in two ways. First, we define “urban centers” as counties with more than 50% of their population living in urban areas in the 1920 census. Urban centers include San Juan, Ponce, Mayagüez, Bayamón, Fajardo, and Guayama. Their combined population is around 618,700, equivalent to 47.6% of total population. Second, we classify counties according to their main agricultural product. We use data from the reports on the area devoted to sugar, coffee, tobacco, and fruits cultivation in 1901, 1910 and 1920. With a k-means clustering algorithm, we classify counties in 3 groups: coffee counties, sugar counties, and ambiguous counties. That is, for each county we know how much land is devoted to coffee and sugar during the three years for which we have data. We let the algorithm decide which counties are grouped together. The third group are counties with balanced area between coffee and sugar cultivation or with more production of different crops. Figure 5 illustrates why there is persistence in

the crop mixture. Counties located in the central and western parts of the island have a mixture of high elevation (Figure 5a) and high average rainfall (Figure 5b) that make them suitable to grow coffee trees. The lowlands in the east and south-west parts of the island have better suitability for planting sugar cane (Figure 5d).

Finally, we compile geographic information at the county level from two different sources. From the United States Geological Survey we collect information on average altitude (Figure 5a). We also use information on latitude and longitude to calculate distance of each county to San Juan, the capital and largest city, located in the northeast, and Mayagüez, the largest western city and a major port. Finally, we use data from weather stations available from the National Oceanic and Atmospheric Administration on average yearly precipitation between 1981 and 2010. We averaged measures from stations contained on each county. Since 34 counties do not have their own weather station, we averaged measures from stations within 20 km radius, weighting them inversely according to distance to the county's centroid.

Primary Education in Puerto Rico

In the 1903 report to the Secretary of the Interior, M. G. Brumbaugh, then Commissioner of Education of Puerto Rico, asserted: “the people want schools. The pupils will attend schools. This year we shall maintain at least 1,000 schools, an increase of 30 percent” (Report of the Commissioner of Education, 1900). Indeed, after starting the century with 680 schools, the US colonial government had managed to increase access to primary schools by about 34% in only 3 years. According to the 1903 report, Puerto Rico already had 3.1 schools per 1,000 people between 5 and 17 years old. The growth in capacity picked up even more after 1907. By 1922, the island had managed to more than double that figure as there were 7.6 schools per 1,000 children of school age. After the 1920s, the number of schools started to grow just fast enough to keep up with population growth, which was quite high over the first half of the century (Marein, 2021).

The early years of US control were also characterized by a sharp increase in enrollment. In 1907, around 15% of children between the ages of 5 and 17 were enrolled in schooling. In less than 10 years, that figure was over 42% (see Figure 1b). Such sharp increase in enrollment was driven by the initial push from the government to modernize Puerto Rico's school system and it proved to not be sustainable. From 1914 to 1918, enrollment as share of school-age population fell to around 30%. The increase was not sustainable since it did not translate into increased attendance. Average attendance to school was stable from 1910 until 1918, where it started to grow slowly but steadily.

In other words, the first two decades of the primary school system established by the US government in the island was characterized by a rapid increase in supply that was met by more sluggish demand. Even though there was high enrollment, about a fifth of enrolled children did not attend school regularly (see Figure 1d). Only after 1918, attendance started to converge to actual enrollment. By 1930, only about 10% of enrolled children did not actually attend school. The mismatch between both was more striking early on for rural schools, where children had the chance of working in the agricultural sector and where school facilities were more precarious.

During the decades between 1910 and 1940, rural and urban schooling converged in terms of their attendance to enrollment ratio. Part of the reason was a shift into more urban schools and out of rural schools that can be seen in Figure 1a and 1b. Since graded schools had higher quality due to the separation of classes by ages, the government pushed for the consolidation of rural schools into graded schools. The enrollment rate in graded schools increased steadily while it fell for rural schools. This substitution started earlier in counties that were more urbanized, at least by the standards of the time, as can be seen on Figure 2a and 2b. The number of enrolled children in rural schools stayed constant in urban centers and enrollment in graded schools reached almost 80% of total enrollment in elementary school in the 1940s. In the rest of the country, rural schools continued to grow until the early 1920s. Graded schools only managed to represent about 40% of total enrollment in

the 1940s.

The accelerated growth in enrollment and number of schools during the first three decades came together with growth in the literacy rate in the country. According to the 1910 census, 33.7% of people over 10 years old knew how to read and write. In 1930, that share had increased to 57.6%. These figures mask significant geographic variation. Some counties like San Juan had literacy levels comparable to Argentina. In about a quarter of counties the literacy rate was below 50% in 1930. The best results in terms of literacy were clustered in the southwest and northeast corners of the island. The southeast corner was the region that struggled the most. Maps on Figure 3 show that even though there is some correlation between enrollment rates and literacy rates in 1930 across counties, it is not necessarily large. Given that enrollment in primary schooling also doubled between 1910 and 1930, it is natural to ask how much of the improvement on literacy at the local level is correlated with improvements in enrollment.

Figure 4a shows the correlation between the growth rate of attendance and the growth rate of literacy rate between 1910 and 1930. Growth rates of 1 imply that the literacy or attendance rate doubled between those two years. There are two striking findings. First, there is a very small but positive correlation between growth in the primary school capacity, measured with attendance rates and education, measured with literacy rates. The counties where enrollment grew the most are not necessarily the ones where literacy rates improved the most. Second, the correlation is much stronger for rural schools. In other words, counties where rural attendance grew faster are the ones where literacy rates grew relatively fast as well. These correlations between schooling and literacy growth are robust to how we measure schooling (enrollment or attendance). This could be because those counties were relatively more rural and therefore started with low levels of both schooling and literacy. Counties like San Juan or Mayagüez, who already had relatively high levels of literacy in 1910 had high growth in graded schools but not in rural ones.

The preference for increasing capacity in graded rather than rural schools is not only

evident when comparing urban centers with the rest of counties. Counties that specialized in sugar also increased their number of graded schools per 1,000 inhabitants at a faster pace than counties that specialized in coffee production, despite starting the century at similar levels of 1.5 graded schools and 3 rural schools per 1,000 children of school-age. In 1922, sugar counties had 7.2 elementary schools on average, while coffee counties only managed to get to 6 schools. All the difference is due to graded schools, as rural schools per 1,000 children of school-age grew at roughly the same pace. In the 1920s, coffee counties managed to close about 80% of the gap with respect to sugar counties. The latter group followed a similar trajectory than what we call “ambiguous counties,” a mix of counties with a balanced basket of crops (sometimes including both sugar and coffee) and counties with little agricultural production.

These medium-term differences in capacity are also present in enrollment rates, shown on Figures 2c and 2d. Children in sugar counties were enrolled in school at a faster pace during the first decade and continued to lead over coffee counties, though the difference did not grow much before 1940. Moreover, while enrollment in rural schools in sugar counties started to decrease after 1920, replaced by faster growth in enrollment in graded schools, enrollment in rural schools in coffee counties remained constant over time. Coffee counties prioritized rural schools from the start, with graded schools having slow but constant increase in enrollment. Rural and graded schools in sugar counties followed a more balanced trajectory until 1915. Afterwards, they followed a strategy similar to coffee counties where graded schools started to replace rural ones.

4 Agricultural Production and Education

Beside these differences in education supply in the long run, in this section we show that coffee and sugar counties also differed in terms of their short-term demand for schooling. We do so by leveraging changes in export revenue of both crops and cross-county differ-

ences in the degree of agricultural specialization. Intuitively, the main idea behind the empirical exercises in this section is to compare coffee (sugar) counties in years with high and low coffee (sugar) export revenues to the other counties. Given the differences in the incentives coffee and sugar production generate for rural families to invest in their children's schooling, we show that export revenue shocks affect enrollment and attendance very differently in coffee and sugar counties. In coffee counties, high export revenues reduce schooling while the opposite happens in sugar counties; when sugar export revenues are high, enrollment and attendance increase. Moreover, we show this relationship is stronger in rural schools than urban schools for sugar counties. For coffee counties the effect of export revenue shocks on schooling does not seem to vary according to the type of school.

The production processes of coffee and sugar are, even today, very different. While coffee production is mostly undertaken in small, family farms; sugar cane cultivation happens in larger farms. We can corroborate these differences by looking at simple statistics from the 1910 Census of Population and data on land use from the reports of the Governor. 1910 is a relevant year because coffee was starting its slow decline in terms of importance within Puerto Rican exports, while sugar production was only starting to consolidate as the main source of external income (Figueroa, 2006; Ayala and Bergad, 2020).

On average, each Puerto Rican county had 104 coffee farm owners and 44 sugar plantation owners, despite having 761 coffee workers and 896 sugar workers. In other words, there were 10 workers per farm in the coffee sector and 28 workers per farm in the sugar sector. The differences in scale are also evident while looking at farm sizes. Coffee farms had around 23 acres on average while sugar farms had around 102 acres.⁵

Moreover, picking and classifying coffee cherries is more amenable for the use of child labor than cutting and collecting sugar cane, which is an activity performed by workers at least in their teens (Mintz, 1959; Solá, 2011). These two dimensions—economies of scale

⁵Table A.1 in the Appendix has more detailed information about coffee and sugar production in 1910

and child labor—create differences in incentives for families involved in the production of coffee and sugar. When the coffee price increases, the opportunity cost of sending children to school increases, even though the family is potentially richer due to income increases. Moreover, since coffee is produced in small family farms rather than plantations, the opportunity to use household labor for production increases. For families involved in sugar production, only the income effect applies since young children of elementary school age do not participate directly in the production process.⁶ We document these differences using simple regression analysis and panel data.

Here, we estimate the following model for two measures of schooling: total enrollment, and average attendance during the school year. We leverage short term changes in export revenues at the national level and variation in crop intensity at the local level to explain short term changes in schooling outcomes.

$$\Delta y_{ct} = \beta_t + \theta_c + \gamma_s \Delta x_t^s p_t^s \times \text{sugar}_c + \gamma_c \Delta x_t^c p_t^c \times \text{coffee}_c + \alpha X_{ct} + \epsilon_{ct} \quad (1)$$

where Δy_{ct} is the yearly change in each measure of schooling for county c on year t . The coefficients of interest are γ_j . $\Delta x_t^j p_t^j$ is the yearly change in export revenues for crop j . That is the product of multiplying x_t^j —the total exports of crop j —and p_t^j , which is the real price of crop j , deflated using US CPI from Measuring Worth (2022). Those are coefficients on interactions between a dummy equal to one for county specialized in crop j (sugar or coffee) and p_t^j , crop j 's real international price. The specification includes county and year fixed effects (θ_c, β_t), and time-varying population controls (X_{ct}) comprised of logs of total population and school age population. We cluster standard errors at the county level to account for serial correlation.

⁶It is possible high sugar prices might benefit the owners of large plantations or *centrales* (large sugar mills) much more than they increase the income of an average sugar farmer. In this case, we'd still expect to see an increase in schooling due to increased local tax revenue. However, this increase would be due to supply-side factors such as school construction and hiring of new teachers, not increased demand for schooling. Therefore, it would be less pronounced during the period when enrollments overshoot attendance. We plan to test this in future research.

Table 1 illustrates how coffee export revenue increases lead to schooling in coffee counties to decrease while sugar export value increases make schooling in sugar counties to increase. Each column and panel represents a different regression result. Column 1, Panel A shows results for the enrollment in all elementary schools. For instance, when the sugar export revenue increases by 1 million USD, total enrollment in sugar counties increases by 0.173%, which is equivalent to an increase of around 2% with respect to the mean of 8.4%. Similarly, when the coffee export revenue increases, the total enrollment falls by almost 1%. Though these two coefficients are rather large in magnitude, they are not statistically significant. Column 2 shows that average attendance behaves similarly, growing with the crop's revenue in sugar counties and decreasing in coffee counties. However, the results for attendance are stronger: coefficients are larger, even more so with respect to the mean, and they are statistically significant for sugar.

Panels B and C have the same structure as Panel A, but they focus on different types of school, rural and graded, respectively. Comparing both panels, the effect seen on Panel A for sugar counties is being driven by rural schools, which respond much more strongly to commodity price changes than common schools, where we find very small coefficient which is also not significant. However, for coffee counties, even though the coefficients are not statistically different from 0, we cannot rule out that the effect of coffee export revenues on rural schools is larger than in graded schools. The coefficients are around the same magnitude.

5 Conclusion

Puerto Rico in the early 20th century was a microcosm for the complexities of the rise of public schooling in a developing region. Under Spanish rule, the country had made little progress in increasing literacy rates and schooling. By 1900, Puerto Rico was well behind similar Latin American countries. However, the country's educational system benefited

immensely from American control. Motivated by a desire to instill “American values” to the Puerto Rican population, the US colonial regime strongly promoted top-down educational reforms. Moreover, it provided the detailed statistical records that we systematically use in this chapter. Due to its history, the small island can provide large insights into the history of the rise of public education.

Schooling expanded rapidly during the first few years of US control, but there were pronounced regional differences in the rates of growth. Later, during the 20s and 30s, the growth rate of schooling outcomes was more moderated. In other words, there were big inefficiencies and bottlenecks that the US government on the island managed to solve early on, but structural factors made improvements beyond the first decade more difficult to come by. The varied urban and rural settings resulted in separate types of schools with differing effectiveness. Recruiting teachers and school administrators was not an easy task, and managing school funding to run schools was proven to be challenging, specially in rural areas.

Finally, regional specialization in the two main crops implied that educational policies to increase enrollment and attendance had to be very different across regions. The different production techniques for coffee and sugar resulted in opposite impacts of export prices on school attendance and enrollment. While positive booms to export revenues improved attendance to school in sugar counties, it had the opposite effect for coffee regions. Since the channel through which export revenues affected schooling was different, a simple policy at the national level would have been insufficient to reduce regional gaps in education. More sophisticated policies that account for the opportunity cost of schooling, especially when there are positive export booms, would have been more effective to level the playing field in terms of education. In fact, modern programs like conditional cash transfers are designed motivated precisely with that channel in mind. We show the opportunity cost of schooling channel is more prevalent for coffee production than for sugar production.

During the beginning of the 20th century, Puerto Rico started to increase its sugar production, leaving coffee exports behind. Given the results we show in this chapter, we could speculate that the consolidation of sugar exporting helped the consolidation of a public education system under US colonial rule. Sugar provided the government with revenue to fund schools and teachers. Moreover, its production function allowed rural households to send their children to school without having to decide between child labor or schooling.

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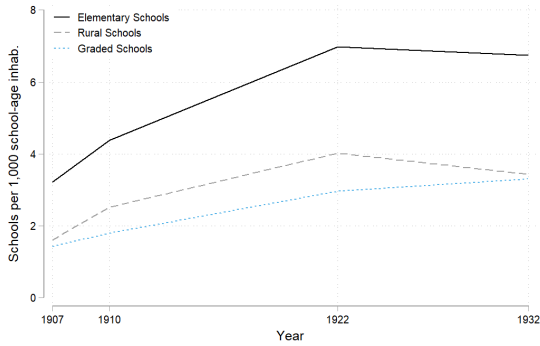
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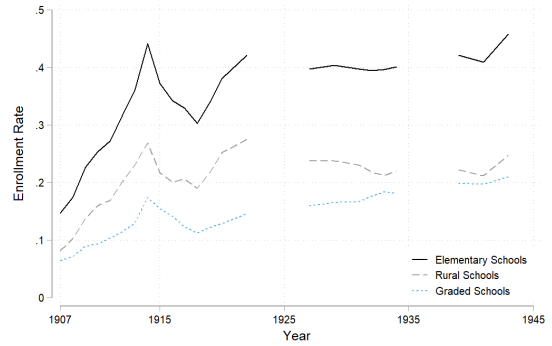
Figures and Tables

Figure 1: Main Trends in Primary Education

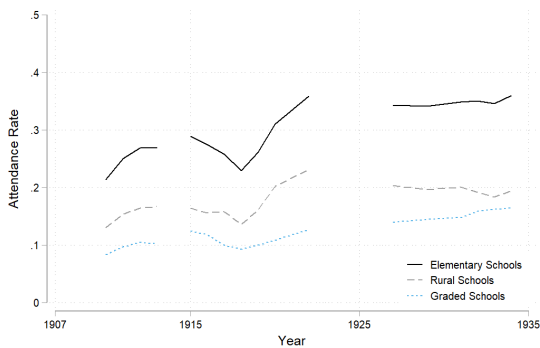
(a) Schools per 1,000 school-age inhabitants



(b) Enrollment Rate



(c) Average Attendance Rate

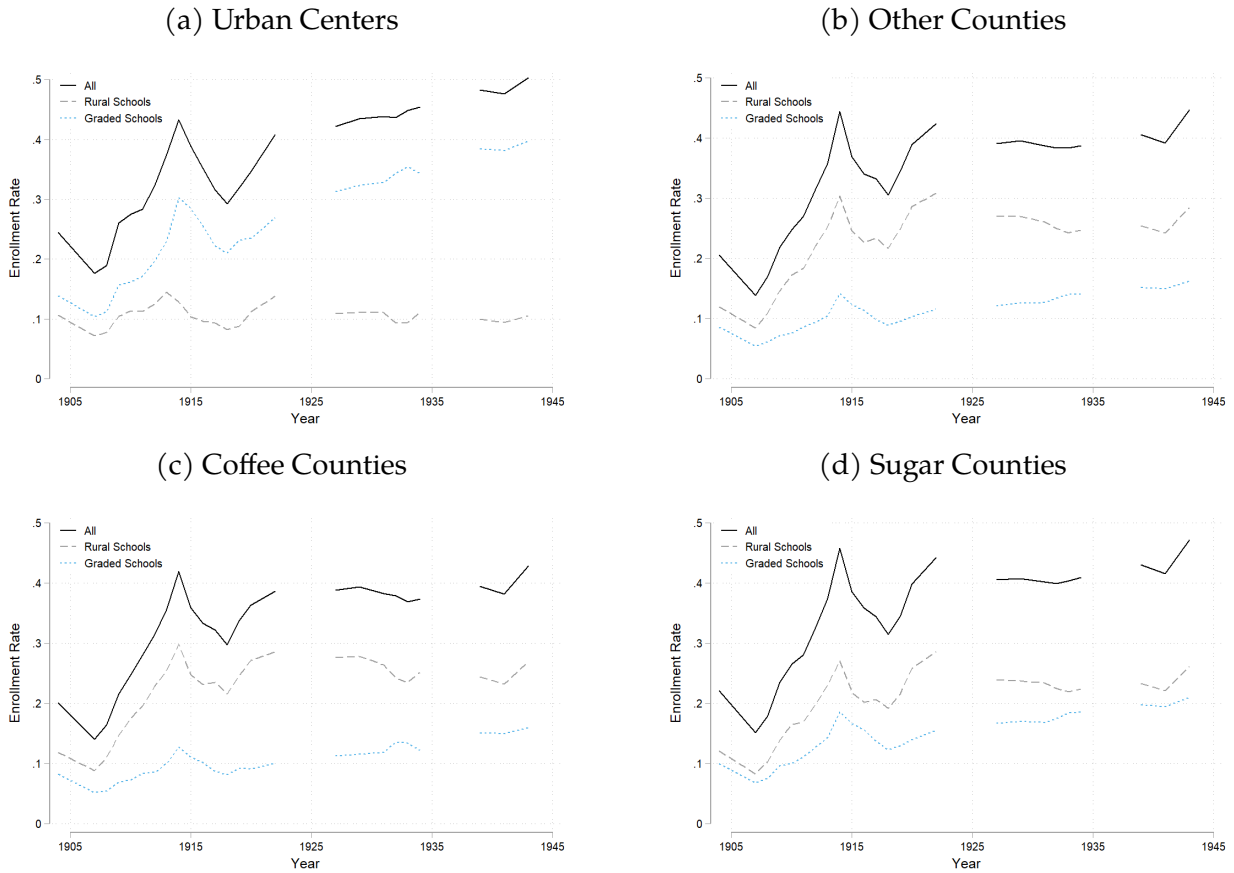


(d) Avg. Attendance as share of Enrollment



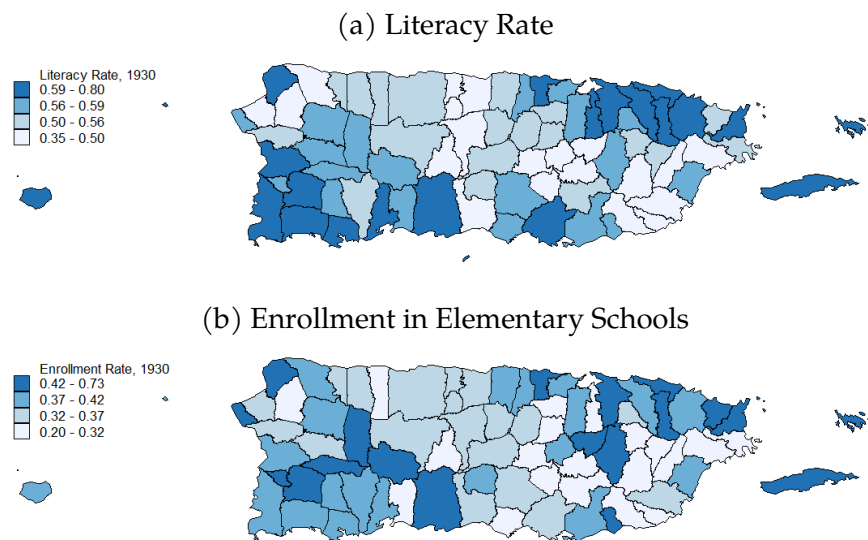
Note: Figure (a) shows the number of schools divided by school age population. Figures (b) and (c) show, respectively, total enrollment and average attendance divided by total school age population. Figure (d) shows average attendance divided by total enrollment. Schools, Enrollment, and Attendance data come from yearly reports from the Governor of Puerto Rico. School age population data comes from Census of Population (1910, 1920, 1930), compiled by IPUMS.

Figure 2: Enrollment Rates in Graded and Rural Schools



Note: Figures show the share of children enrolled in graded, rural, and all schools divided by total school age population. Enrollment data comes from yearly reports from the Governor of Puerto Rico. School age population data comes from Census of Population (1910, 1920, 1930), compiled by IPUMS. Urban counties are those with more than 50% of population classified as urban in the 1920 census most populous urban centers in 1920 (San Juan, Ponce, Fajardo, Bayamón, Guayama, and Mayagüez). Classification of coffee and sugar counties is described on section 3.

Figure 3: Geographic Distribution of Enrollment Rates and Literacy Rates, 1930



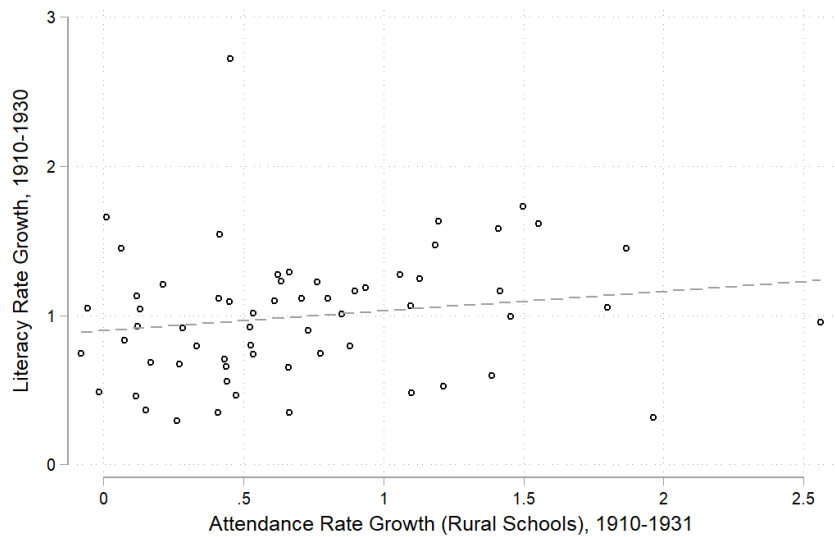
Note: Maps show a) the share of population over 10 years old who knows how to read and write; and b) the share of school-age population enrolled in elementary school. Data from enrollment comes from the reports of the Governor. Literacy data comes from 1930 Census of Population.

Figure 4: Attendance Rates and Literacy Rates, 1910-1930

(a) Attendance to All Schools



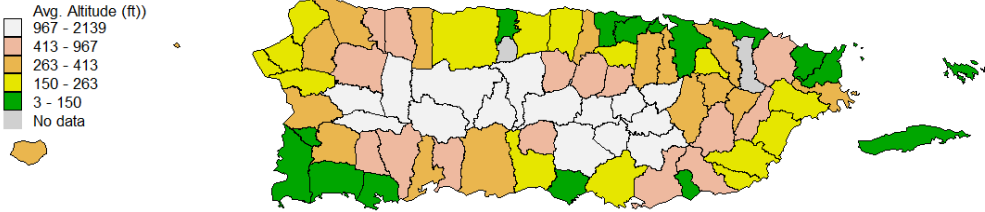
(b) Attendance to Rural Schools



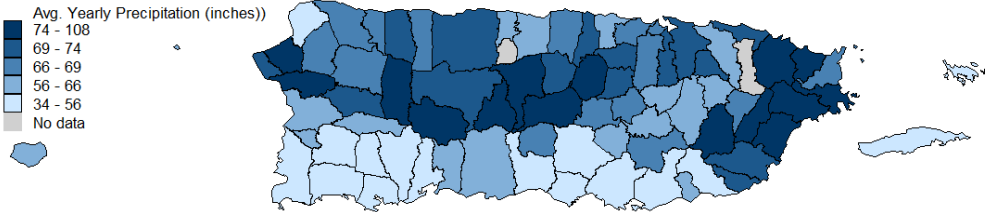
Note: Figures plot the percentage change in Literacy rate between 1930 and 1910 census on the vertical axis and the percentage change in average attendance rates between 1931 and 1910 in the horizontal axis. Panel (a) plots changes in attendance for all schools. Panel (b) plots changes in attendance in rural schools.

Figure 5: Weather, Geography, and Main Crops

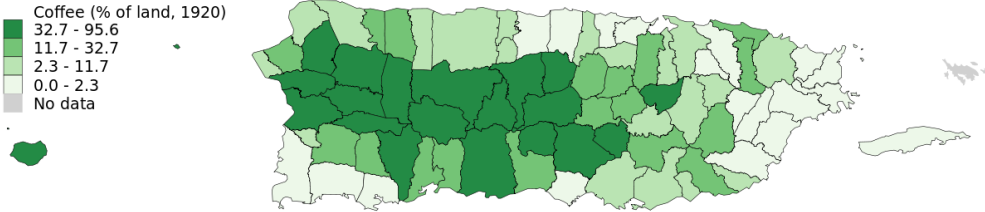
(a) Altitude (feet)



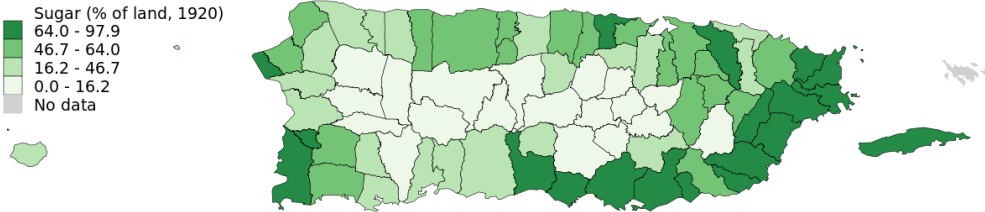
(b) Average Precipitation Level (inches)



(c) Area Planted in Coffee (Share of Cultivated Land)



(d) Area Planted in Sugar (Share of Cultivated Land)



Note: Author's elaboration with data from USGS, NOAA, and Reports from the Governor of Puerto Rico to the US Congress.

Table 1: Effect of Coffee and Sugar Income on Enrollment and Attendance

Dependent Variable:	(1) Δ Enrollment	(2) Δ Attendance
<i>Panel A: All Common Schools</i>		
Δ Sugar Exports Real Value × Sugar Area	0.172 (0.156)	0.238* (0.136)
Δ Coffee Export Real Value × Coffee Area	-0.995 (1.071)	-2.080 (1.344)
Observations	1,024	704
Mean Dep. Var.	8.419	5.169
R2	0.566	0.553
<i>Panel B: Only Rural Schools</i>		
Δ Sugar Exports Real Value × Sugar Area	0.359 (0.227)	0.442** (0.204)
Δ Coffee Export Real Value × Coffee Area	-1.106 (1.532)	-3.126 (1.929)
Observations	1,024	704
Mean Dep. Var.	9.627	6.117
R2	0.433	0.465
<i>Panel C: Only Graded Schools</i>		
Δ Sugar Exports Real Value × Sugar Area	0.170 (0.229)	-0.065 (0.244)
Δ Coffee Export Real Value × Coffee Area	-2.256 (2.039)	-2.816 (2.027)
Observations	1,024	704
Mean Dep. Var.	6.412	3.188
R2	0.377	0.270
Years	1907 - 1943	1907 - 1934
Counties	65	65

Note: Dependent variables are: Column (1): change in log total enrollment times 100; Column (2): change in log average attendance times 100. Panel A uses data for all schools, Panels B and C focus on Rural and Graded schools, respectively. Our sample consists of a set of counties defined consistently over time. Coffee and Sugar total export values are total crop export volume times real crop prices. Coffee and Sugar Areas are average share of cultivated land in 1901 and 1910 used for each crop for each county. All specifications include: year fixed effects, county fixed effects, total population and school age population. Standard errors clustered at the county level in parenthesis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Appendix A Appendix

Table A.1: Average Crops' Characteristics: Coffee and Sugar Production 1920.

Measure	Crop	(1) All Counties	(2) Coffee Counties	(3) Sugar Counties
Land (Acres)	Coffee	2103.4 (3327.0)	6680.8 (4339.1)	708.2 (1360.7)
	Sugar	3159.9 (2832.1)	722.4 (1132.3)	4860.4 (2782.8)
Farm Owners	Coffee	104.8 (170.5)	287.5 (265.0)	50.92 (94.90)
	Sugar	44.41 (55.00)	17.19 (28.11)	63.95 (66.47)
Workers	Coffee	761.1 (886.4)	1640.3 (1145.1)	561.2 (710.0)
	Sugar	896.1 (820.7)	280 (402.1)	1377.6 (813.5)
Workers per Farm	Coffee	10.10 (13.44)	6.592 (3.273)	10.73 (12.50)
	Sugar	28.71 (27.54)	17.37 (10.69)	33.83 (26.67)
Workers per Acre	Coffee	6.422 (37.35)	0.269 (0.111)	3.421 (8.722)
	Sugar	1.996 (13.91)	7.934 (29.89)	0.304 (0.103)
Acres per Farm	Coffee	22.88 (19.91)	30.46 (22.70)	14.98 (12.15)
	Sugar	102.6 (99.93)	50.22 (48.10)	119.7 (97.29)
Counties		76	15	38

Note: The table presents cross-county means and standard deviations (in parenthesis) for different crops' characteristics in 1920. Land acres devoted to each crop's production comes from Governor Reports. Number of Farm owners and number of Workers comes from the census of population. Workers per Farm is equal to the number of workers over the number of farm owners. More details in section 3.

Table A.2: Descriptive Statistics: 1910 Census and Governor Reports

	(1)		(2)		(3)		Source
	Full Sample		Coffee Counties		Sugar Counties		
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
Enrollment rate, Census data	0.39	0.11	0.35	0.08	0.41	0.09	1910 Census
Enrollment rate, Governor reports	0.29	0.07	0.28	0.06	0.30	0.08	Governor Reports
Literacy rate	0.23	0.09	0.20	0.06	0.23	0.06	
Population (thousands)	17.13	12.85	16.20	9.52	15.58	8.49	
Urban share	0.21	0.17	0.14	0.10	0.23	0.14	
Black share	0.36	0.15	0.27	0.13	0.42	0.14	1910 Census
Labor Force Participation	0.61	0.04	0.59	0.03	0.62	0.04	
Women's Labor Force Participation	0.21	0.07	0.19	0.06	0.22	0.06	
Employment in Manufacturing	0.08	0.06	0.05	0.03	0.09	0.06	
Livestock Heads (thousands)	3.23	2.08	2.09	1.39	4.11	2.12	Gov. Reports
<i>Coffee Cultivation</i>							
Coffee (% of cultivated area)	22.22	23.37	45.02	21.03	7.47	8.37	Gov. Reports
Employment (share work age pop.)	0.05	0.10	0.11	0.13	0.01	0.02	
# Coffee Farm Owners	78.53	135.40	155.58	178.42	26.39	52.87	1910 Census
Workers per farm owner	5.28	3.66	5.57	2.78	3.94	3.91	
<i>Sugar Production</i>							
Sugar Cane (% of cultivated area)	34.60	30.95	8.75	12.45	55.97	24.97	Gov. Reports
Employment (share work age pop.)	0.15	0.12	0.04	0.06	0.23	0.10	
# Sugar Cane Farm Owners	72.94	90.39	26.73	47.75	112.08	101.71	1910 Census
Workers per farm owner	33.94	52.76	19.19	21.01	34.94	46.30	
# Refinery Workers	8.09	13.77	3.85	9.09	11.11	16.52	
<i>Geographic Characteristics</i>							
Avg. Elevation (ft)	552.46	549.32	1091.68	570.44	239.23	133.77	USGS
Avg. Yearly Precipitation (inches)	67.39	15.40	68.74	12.87	68.32	16.83	NOAA
Distance to San Juan (km)	59.11	31.88	62.99	29.13	54.00	32.89	USGS
Distance to Mayaguez (km)	81.34	47.00	61.17	34.59	96.36	47.47	USGS
Counties	76		28		41		

Note: The table shows descriptive statistics from 1910 census and other sources. It divides the sample in three groups: Full Sample, only Coffee, and only Sugar counties according to details in section 3.