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Regional differences in Early Human Capital in Latin America. Rethinking the institutional hypothesis

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Regional differences in early human capital in Latin America: Rethinking the institutional hypothesis.

Abstract

The economic disadvantage of Latin America in relation to Europe is one of the main debates in economic history. Recent research focused on the institutions generated in the colonial period to explain this disadvantage. But who created those institutions? In which level did human capital influence the creation of institutions? This paper reviews the debate around institutional determinants of economic growth in Latin America. It argues that the formation of human capital varies widely within countries in Latin America, and the basements of early human capital were given before the early 1750s. However, it was not until 1850 that the formation of human capital started being a determinant for current economic growth.

Keywords: Human Capital, Numeracy, Latin America, Growth, Pre-industrial Economies.

JEL: I25, N30, N36, O40, P40

Resumen

La desventaja económica de América Latina con respecto a Europa forma parte de uno de los debates fundamentales de la Historia Económica. La literatura más reciente se ha focalizado en las instituciones generadas en el período colonial para explicar esta desventaja. Pero, ¿quién ha creado esas instituciones?, ¿en qué nivel el capital humano influyó en la creación de estas instituciones? Este artículo revisa el debate en torno a los determinantes institucionales del crecimiento económico en América Latina. Argumenta que la formación de capital humano varía considerablemente entre los países de América Latina y que las bases del capital humano temprano ya estaban dadas antes de 1750. Sin embargo, fue después de 1850 que la formación de capital humano comenzó a ser determinante para el crecimiento económico actual.

Palabras clave: Capital humano, habilidades matemáticas, América Latina, Crecimiento económico, Economías pre industriales.

JEL: I25, N30, N36, O40, P40

1. Introduction

"Institutions and culture first; money next; but from the beginning and increasingly, the payoff was to knowledge."[1]

One of the more influential debates in the economic history is the economic disadvantage of Latin America in relation to Europe. Among the main theories in which this disadvantage is explained, those linked with the institutional explanation have acquired a predominant role. Especially the institutions promoted by the conquerors who once settled in the region (Acemoglu, Jhonoson and Robinson 2001, 2002). These authors provide evidence that colonial factors can explain differences in economic development. Those explanations argue that, depending on the local conditions, colonizers either set up extractive or inclusive institutions in a given country. This argument is complemented with the idea that the institutions promoted by the conquerors were related to natural resources, hence the main economic activity of the country, and a little further, with the main economic activity of the regions within the countries (Bruhn and Gallego, 2012). These researchers tend to analyse the conditions under which Latin American countries were more affected by colonisation.

Excluding some works, the point of these researchers tends to compare the economic performance of Latin America from a national point of view, taking into account institutional, geographical and economic factors. The contribution of this paper is mainly:

a. The incorporation of regional analysis. The aim is to analyze whether the regional inequalities in education aggravated or smoothed within countries during the period from 1650 to 1850.
b. To include human capital formation as a determinant factor of the performance of Latin America. The aim is to analyze on which level the regional variables influenced human capital formation.

I collected data from parish registers (death and marriages registers) from nine countries of Latin America: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Paraguay and Uruguay from the period 1650 to 1900. The objective is to have a representative panorama of the main geographical regions. From these registers I will approximate to human capital formation in each national province and geographical area. I will use the age heaping technique (numeracy) as a proxy for human capital formation.

The paper is organized into seven sections. Section (2) discusses the theoretical background with a focus on institutional theory and the main debate around it. The main literature related to the topic is presented in this section. Section (3) describes the historical background with special emphasis on the early factor endowments of each region and the literature related to the early human capital in Latin America. Section (4) presents the methods: the age heaping technique and the data set. Section (5) analyses the numeracy trends at the cross-country and regional level, the cartography approach and the inequalities of the regional

[1] Landes, David (1998), The Wealth and Poverty of Nations: Why some are so rich and some so poor, London, Little brown

human capital distribution. Section (6) presents the results of the regressions and analyses the possible determinants of early human capital formation and current economic development. Section (7) concludes. Tables and figures are provided in the Appendix.

2. Institutions, human capital

2.1 Institutions as determinants of economic growth

One of the most emblematic works in which the institutional determinants of economic growth are analyzed is "Reversal of fortune: Geography and institutions in the Making of the Modern World Income Distribution" (Acemoglu, Johnson and Robinson, 2002). The reversal revisits the links between economic development and geographic factors. These authors argue that the reversal of fortune reflects changes in the institutions resulting from European colonialism. The European intervention appears to have created an institutional reversal among the conquerors and the colonies as the Europeans introduced institutions encouraging investment in regions that were relatively poor and sparsely populated in the pre-colonial times (Acemoglu, Johnson and Robinson, 2002). Many authors are devoted to making the idea of institutional determinism stronger. The common factor is that the institutions created in colonial times have formed the basis of the current institutions, which are responsible for economic growth. The reason that the "good" institutions were generated in sparsely populated and relatively poor areas is because this enabled Europeans to settle in large numbers and develop institutions encouraging investment. In contrast, those densely populated and relatively prosperous areas made extractive institutions more profitable for the colonizers (Acemoglu, Johnson and Robinson, 2002). Colonizers established extractive institutions in places where the net benefits of having extractive institutions exceeded the net benefits of setting up inclusive institutions. They argue that three main factors played a key role in determining the net benefits of the institutions: first settler mortality, second pre-colonial population density and third the natural environment for activities with strong economies of scale. The institutional hypothesis of AJR is strongly accepted by other researchers and it is closely related to the work of Coatsworth (1993), Engerman and Sokoloff (1997, 2000), and Easterly and Levine (2002), who emphasize the adverse effects of the plantation complex on the Caribbean and Central America working through political and economic inequality. Another work linked to the institutional hypothesis is "Good, bad and ugly economic activities: do they matter for the economic development?" (Bruhn and Gallego 2012). This paper uses an argument related to AJR to explain within-country variation in economic development across the Americas. The authors argue that colonizers engaged in different economic activities in different regions of a country. Some of these activities were "bad" since they tended to create extractive institutions and encouraged fewer Europeans to settle in the area; other activities were "good" and created inclusive institutions and encouraged more Europeans to settle the region; and the rest of the activities were "ugly" since they used the native population as an exploitable resource (Bruhn and

Gallego 2008). The significant contribution of this paper is that it introduces the analysis at the regional level.

The institutional hypothesis has in common that the period in which the institutions were shaped was during the Colonial era. Some characteristics such as the factor endowments, pre-colonial population density and the early "wealth" of the conquered area were key factors in this institution's shape. With some variances among the research, there is a strong acceptance in the literature of the institutional hypothesis.

2.2 The link between institutions and human capital formation

How could this institutional shape have determined human capital formation? According to AJR (2001) extractive institutions were intended to transfer as much as possible of the resources of the colony to the colonizer. This kind of colonization did not require the introduction of extensive civil rights, protection of property rights, or checks and balances against government power. It also did not require big settlements of Europeans in the colonies. This kind of institution therefore discouraged investment in physical and human capital and had a negative impact on long-run levels of development. With the set up of inclusive institutions, on the other hand, it was possible to put into place constraints on government expropriation, an independent judiciary, property rights enforcement, equal access to education, civil liberties, and unrestrained immigration from Europe. That is why Europeans settled these regions. Inclusive institutions lead to high long-run levels of development.

But who shaped these institutions? Glaeser et al (2004) revisit the institutional hypothesis. They discuss whether political institutions cause economic growth, or whether, alternatively, growth and human capital accumulation lead to institutional improvement. The idea that economic growth and human capital cause institutional improvement is most closely associated with the work of Lipset (1960). Lipset argued that educated people are more likely to resolve their differences through negotiation and voting than through violent disputes. Education is needed for courts to operate and to empower citizens to engage with government institutions. Literacy encourages the spread of knowledge about the government's malfeasance. According to this view, countries differ in their stocks of human and social capital—which can be acquired through policies pursued even by dictators—and institutional outcomes depend to a large extent on these endowments (Djankov et al. 2003).

The hypothesis of Lipset has received considerable support in the work of Przeworski, (Alvarez et al 2000) and Barro (1999). They both emphasize the need for secure property rights to support investment in human and physical capital, and they both see such security as a public policy choice. However, the institutional view sees the pro-investment policies as a consequence of political constraints on government (Glaeser et al 2004).

3. Historical background

3.1 Early factor endowments

Latin America covers an area of 20,541,000 km², approximately 14 percent of the world´s land surface. Although so large, and so long from end to end, Latin America has certain features that provide cultural unity. Most important, perhaps, is its location in a particular part of the world relatively remote from outside influences. In such a large area, virtually every kind of climate is to be expected and almost all types of vegetation are encountered, and crops grown. According to Cole (1965) the inhabitants of pre-Columbian America could be divided into hunters and gatherers on the one hand and cultivators on the other. The cultivators were two main kinds, shifting and sedentary. Shifting cultivation was found mainly in the tropical forest areas, sedentary cultivation in the temperate forest (Southeast USA), drier areas and mountain areas. By about 1600 a different spatial distribution of economic activities in the Americas had emerged and this remained without modification until the early 19th century. It is possible to distinguish the following types of economies: a) almost all the sugar and other tropical crops grown on plantations for export to Europe were produced along the 6,000 km line. Sugar was grown in small quantities elsewhere, but largely for local consumption. b) The mining areas of Mexico, Peru and Minas Gerais in Brazil were not determined by the distance from Europe but by the occurrence of accessible deposits of gold, silver and later precious stones. c) In lands that were neither humid nor densely forested nor excessively dry, the raising of livestock, especially cattle, developed in the colonial period. These areas are relatively thinly populated; the cattle were either loosely organized in large *estancias* or left to roam wild (*ganadería extensiva*). Cattle were mainly used in the colonies for a large number of purposes such as saddler, storing water and carrying liquids, making clothing and so on. The most extensive areas of cattle were in the northern part of Mexico, the northern part of Argentina, the land behind the coast of Brazil, Uruguay, the llanos of Venezuela, and Cuba (Cole 1965).

Some theories of economic development for Latin America have as well put considerable attention on the structural features of the region. For example, the land-tenure system, which was inherited from the Iberian Peninsula, was seen as an obstacle to development; and the legal and administrative apparatus, which was inherited from the colonial powers, was seen as a barrier to private entrepreneurship and efficient decision making in the public sector. However, the institutional and structural landscape inherited from the colonial period was not homogeneous and has changed significantly over time (Bulmer Thomas 2003).

The institutional hypothesis concerning the factor endowments and the “good” and “bad” activities (c.f. 4) goes further with the commodities lottery highlighted by Bulmer-Thomas. This author stresses that the factor endowments differ in terms of their relative demand. Some commodities, such as meat, have enjoyed and still enjoy relatively high income elasticity of demand. Others, such as coffee, have seen income elasticity decline over time, as this product has moved from being a luxury good to being an article of basic consumption. Some commodities such as gold have no close substitute, whereas others like cotton face

competition from synthetic products, so that the price elasticity of demand is high (Bulmer-Thomas 2003). Hence, factor endowments not only had created "good" or "bad" institutions, but they also faced different rivals throughout time. Again, which kind of human capital was required by each commodity? Why is it relevant to analyze the human capital formation?

3.2 Human capital in Latin America: Brief literature review

Human capital is considered one of the most important determinants of economic growth, especially during the transition from Malthusian stagnation to modern growth. This fact was highlighted by the endogenous models of growth (Romer 1990; Lucas 1988) and more recently by the unified growth theory (Galor 2005; Galor and Moav 2002; Galor and Weil 2000). However, this fact was not recognized in a great part of Latin American history. According to the literature some of the colonial settlements were created and their resources shipped back to the Old World for profit. Education was for the colonizers, the only transmission of an ornamental culture (Gomes 1993; Azevedo 1963).

Once the independence was achieved, the Latin American countries kept their export-oriented economies based on mining and agricultural products, such as coffee, sugar, cacao and wheat. Some countries, such as Argentina, Chile, Costa Rica and Uruguay, started the modernization of their educational systems and received corresponding benefits (Furtado 1970; Prebisch 1963). In this context the whole continent and especially those countries with strong mining economies were affected by investment in human capital formation.

Recent research reveals the importance of the set up of human capital indicators to analyze the Regional Differences in Europe (Hippe and Baten 2011). As the researches devoted to the reconstruction of early regional GDP, the construction of human capital indicators in the regional perspective contributed to the analysis of regional inequalities in education in Europe. However, the regional differences in human capital in Latin America is still unexplored. As was said above, this paper is a contribution toward filling this gap in the literature.

Concerning the national level, many efforts have been made to analyze the human capital trajectories of the different countries of Latin America. Taking into account large databases of Latin America and developed countries, studies have found that inequality in education was higher in Latin America before the 20th century. Globalisation in the 20th century seems to have had positive effects by reducing educational inequality (Baten and Mumme 2010). Regarding numeracy (mathematical skills), they argue that Latin America was on a path of convergence with Western Europe during the early 18th century and there was stagnation of numeracy levels in the 19th century. Furthermore, they found that the differences between the countries increased in this period (Manzel, Baten and Stolz 2011).

In this paper I will introduce a regional analysis of the human capital formation in Latin America. The aim is to analyze differences among the regions and possible divergences of human capital formation within the countries.

4. Methods

4.1 Age heaping from marriage and death registers

Even though recent research has introduced indicators on human capital formation for early periods, data availability is still a limiting factor. Unfortunately, evidence on regional inequality of human capital in Latin America before modernization is scarce. As human capital cannot be measured directly, it has to be approximated by related, quantifiable variables. Examples of such proxies employed for modern times include literacy, numeracy, enrollment rates, years of schooling or books per capita (e.g., A´Hearn et al 2009; Baten and van Zanden 2008; Benavot and Riddle 1988).

Most of the methods used to measure human capital formation (literacy and school enrollment) are not able to estimate human capital levels before the second part of the 19th century. For instance, school enrollment data is generally rather scarce in Latin America as compulsory education started after 1870 (Rama and Tedesco 1979). Literacy rates are obtained by signature rates in a large number of studies (Reis 2005; Mitch 1993; Schofield 1991) but unfortunately this indicator is not always available in order to compare the regions of Latin America on a larger scale.

With the age heaping technique it is possible to avoid the limitations of the lack of data as usually age appears in a big part of documents such as census and parish registers. This is the reason why this technique has been used in recent studies (e.g., A´Hearn, Baten et al 2009; Baten and Mumme 2010; Manzel, Baten and Stolz 2011; Juif and Baten 2011; Friesen, Baten and Prayon 2012).

The age heaping method investigates the numeric skills of a population. It uses the declarations made in different documents such as census or parish registers. In this paper it is calculated by using a transformed Whipple index. The quality of age reporting can be measured by means of age-heaping indices to detect the degree of preference for or avoidance of certain ages. Among standard indices (Bachi 1951; Myers 1976; Zelnik 1961),[2] the Whipple index is the most widely applied.[3]

The original Whipple index is obtained by summing the number of people in the age range 23–62 (inclusive) and calculating the ratio of reported ages ending in 0 or 5 to one-fifth of the total sample. As pointed out above (c.f. 3.1), the index assumes a linear distribution of ages in each range of five years, i.e. a continuous and linear decrease in the number of persons of each age within the age range considered. Low ages (0–23

[2] The methods used to calculate these indices are in Shyrock and Siegel (1976: 115–119).

[3] A'Hearn et al (2009) argue that this is the only index that fulfills the desired properties of scale independence (a linear response to the degree of heaping) and that it offers a reliable ranking of samples among which the degree of heaping varies.

years) and high ages (72 years and above), for which the linearity assumption is not plausible, are excluded from the calculation (Spoorenberg and Dutreuilh 2007). Thus:

$$Wh = \left(\frac{\left(Age25 + Age30 + Age35 + ...Age60\right)}{1/5 \times Age23 + Age24 + Age25 + ... + Age62} \right) \times 100$$

A'Hearn et al (2009) suggested another index for an easier interpretation: the ABCC index.[4] This is a simple linear transformation of the Whipple index and yields an estimate of the share of individuals who correctly report their age. The index takes the values between 0 and 1. A value of 0 means total age heaping whereas a value of 1 means no heaping at all.[5]

I calculated the age heaping of marriages registers. Other studies in which the ABCC was calculated with parish registers have demonstrated that that heaping in marriages registers seem to be less pronounced than in death registers or census (Plötz 2013, Bucher 2013). For this reason I corrected the ABCC values by a correction factor (see Bucher 2013).[6]

4.2 Data

The data collected are marriage registers from Argentina, Brazil, Bolivia, Chile, Colombia, Ecuador, Peru, Paraguay and Uruguay in the period 1600 to 1850 from the web site familysearch.org. Although in Latin America there is not an official standardisation of the regions (at the macro level), I used the National and current territorial definitions to classify the different provinces. Depending on the year of the register I collected from 40 to 55 provinces of the whole continent. The main difficulty of this pre-statistical data is that there is not the same number of registers for each period. Furthermore, the regional specification is not well defined for all the countries. That is the reason why I have data for some provinces in 1750 that are not continuous throughout time.

The marriages registers are lists of the people who got married in the parish. The data collected is the names of the grooms, gender, birth and marriage place, and age. The advantage of having the birth, marriage and death place is that it is possible to collect regional data within the countries. The main outcome variables of this analysis are age and birthplace. With the ABCC index calculated from the age, I approximate to human capital formation in the different provinces of Latin America.

[4] The name results from the initials of the authors' last names plus Greg Clark's, who suggested this in a comment on their paper. Whipple indices below 100 are normally caused by random variation of birth rates in the 20th century rich countries. They do not carry important information; hence, they are normally set to 100 in the ABCC index.

[5] To visualize the evolution of the ABCC index by birth decades, I calculated the birth decade of each group by the median age. For example, in the cohort 23–32 years old, I calculated the birth decade of those who are 27 years old. Furthermore, I excluded from the calculation those cases that were less than 30 registers.

[6] I limit the data to the years above 23 and below 72 years old. Under 23 years it is possible that the individuals did not declare the ages themselves. Ages above 72 may be prone to a selection bias because those only who still alive can be counted (see Crayen and Baten 2010)

5. The development of human capital in Latin America

5.1 Numeracy trends: Cross-country and regional levels

To obtain a general idea of the distribution of ABCC values for Latin America, I calculated the ABCCs for nine South American countries between 1650 and 1850. All the trends are presented in half decades, taking into account the birth decade of the person. Figure 1 displays the results of the numeracy trends at cross-country level in the marriages registers. The pattern of the numeracy trend is consistent with the institutional hypothesis given above (Sections 2.c and 2.d). In this figure Argentina, Uruguay and Brazil have the highest numeracy levels, and Bolivia remains with the lowest numeracy values. The high levels of numeracy are linked with the institutional hypothesis in two ways:

1. In the first place are countries of relative late colonization (mainly Argentina and Uruguay), and that were relatively *low populated* until the conquerors established the settlements (with the exception of the Jesuitical missions in the South of Brazil and North Uruguay). These territories are considered by the literature as templates of new settlement economies. This concept was created by economic historiography to describe the characteristic patterns of the extra-European regions of template weather (Nurkse 1961; Armstrong 1978; Fogarty, Gallo and Diéguez 1979; Fogarty 1977; Denoon 1983; Platt and Di Tella, 1985; Schedvin 1990; Cain and Hopkins 1993; Lloyd 1998; McAloon 2002; Bértola and Porcile 2002). These regions, unlike the tropical countries, reached high income levels in the early 20th century. This fact is linked with the institutional hypothesis, which highlights that the low populated territories benefited from "better institutions" as the conquerors settled these areas replicating their own institutions.
2. In the second place these territories are mainly *livestock economies* (mainly the Pampa Argentina, Uruguay and the South of Brazil). That means that the main natural resources of these economies were leather (before the refrigeration of meat) and after modernization meat and other derivatives of the cow. According to the institutional hypothesis economic activities such cattle or agriculture shaped better institutions compared to plantation or mining economies.

At least two of the assumptions of the institutional hypothesis are confirmed in the numeracy trends at the cross-country level. Lower settled regions in the pre-colonial era and cattle economies show high numeracy values throughout time.

Figure 1 shows that Bolivia has the lowest levels but also Peru and Colombia have low numeracy rates. Peru and Bolivia have in common that they were countries of early colonization and were *densely populated* by native civilizations when the conquerors arrived to these territories. The natural resources of these economies were also different from the new settler economies: the main resource was *mining* (the silver and other metals). According to the literature that means that in these economies were established, since the early period, an extractive institution with the objective of exploiting silver mines. Furthermore, the amount

of native population allowed the Spaniards to incorporate a labour force in unstable conditions. One of the most studied examples of this situation occurred in the Potosí mines with the creation of the *mita* system (Tándeter 1992). Hence, the institutional hypothesis that claims that the territories affected by "bad" institutions are confirmed in the lower numeracy trends of Bolivia, Peru and Ecuador. Densely populated regions and mining and plantation economies seem to have been detrimental to the formation of human capital. This assumption is empirically proven in the numeracy trends throughout time.

Other countries under analysis such as Paraguay, Chile and Ecuador have medium numeracy levels and, for example, in the case of Chile converge in the early 1850s with the countries of better performance. Chile is an example of a mixed economy. While a large part of the territory is devoted to cattle—mainly the central Valley—the North of Chile, *Norte Chico* and *Norte Grande*, are devoted to mining. These provinces border Peru, Bolivia and North Argentina and were a strong regional exchange area in the period under analysis. The Norte Chico abounded in high-grade ores, the mining of which required little in the way of capital, and whose processing required only simple technical methods. Some of these were ingenious: the *trapiche,* the ore-grinder for gold and silver, seems to have been a local innovation (Collier and Sater 2004). It is not surprising that in such a diverse economy the requirements for human capital formation were different and linked to the main activity of the region.

In sum, the displayed results show that the human capital requirements for each kind of economy were not the same. Furthermore, the formation of human capital of the old and new settlement economies was different. Was it relevant for the livestock economies to have better levels of human capital? Were these mining extractive economies detrimental for human capital formation?

Figures 2–9 display the regional trends of numeracy in each country based on the marriages registers.[7] The figures have some similar patterns: in all the countries the ABCC values have a positive trend throughout time. However, for some countries the gap in human capital formation remains until the 19th century (especially in Peru and Colombia). In those countries with strong mining economies, those provinces that were centered on this natural resource have extremely lower numeracy levels in comparison with the rest of the country. These are the cases of Minas Gerais in Brazil, Potosí in Bolivia and Loja in Ecuador. Minas Gerais (Figure 5) has almost 30% lower numeracy levels in comparison with Brasilia. This pattern changes at the end since there is a convergence of almost all the provinces. However, Pernambuco remains with the lowest numeracy rates around 1850. Pernambuco was a tropical plantation economy and with Bahia (Northeast area) the most important region in the colonial period (Meade 2004). According to the literature (c.f. 4) this area has a typical factor endowment that was beneficial for the early times but detrimental once technical changes in agricultural production had been developed. Furthermore, in the plantation economies (sugar in the case of Pernambuco), large amount of slaves were exploited (Meade 2004).

[7] Uruguay is not included because there is data for only one province.

Potosí (Figure 3) has between 25 and 30% lower numeracy rates in comparison with the other provinces of Bolivia. However, in the 1900s Potosí converged with Chuquisaca and La Paz, but the ABCC values remained low (64%). Potosí was one of the oldest Spanish foundations in Latin America. The village was founded in 1545 and was the center of the silver miner boom from the 16th to the 18th century. In 1650, at the zenith of silver production, Potosí boasted 160,000 inhabitants (five times its current population). Major silver production occurred during the 16th and first half of the 17th centuries, with the first veins producing unprecedented quantities of pure silver. But by 1560 production began to falter and mining entered into a crisis. One problem was a severe shortage of labourers to work the mines; a second was the depletion of the almost pure surface deposits. With lower-content and less-accessible ore, the process of extraction became more complex and costly in labour and capital. To this end, the Spanish colonial viceroy Francisco de Toledo reintroduced a draft Indian labour system adapted from the Incan *mita* system, thereby ensuring practically free unskilled labour to the mine and mill owners. Other changes included a new mining code, a rationalized taxation structure, royal control of silver production, and a royal mint in Potosí (Morales 2010). According to Klein (2003) and Cole (1985), these developments dramatically reordered the mining economy and the social and economic life of the Indians. Apparently these policies were detrimental as well for human capital formation and for the future development of the region. Both examples—Potosí and Minas Gerais—are related to the human capital formation in a mining economy. Furthermore, they are linked with the institutional hypothesis, which claims that some factor endowments that were beneficial for colonial economies were detrimental for future development. It is possible to add that early human capital formation was a key factor for later economic growth, since these economies are some of the poorest and unequal in the world.[8]

The ABCC levels of the National capitals differ depending on the country under consideration. For example, in Argentina, Buenos Aires features the highest numeracy values after Entre Ríos, and becomes the best numerated in the 1850s, with almost 90% ABCC. Brasilia is the third of the better numerated of Brazil after Paraná and *Rio Grande do Sul*. Asunción is as well the third in ABCC values in Paraguay and converges with Paraguarí and Cordillera in the 1850s with almost 75% ABCC value. Finally, Lima is the second best numerated of Peru in throughout 1700–1750.

However, in Bolivia and Chile the pattern of the national capitals is different. In the early 1800s La Paz had the lowest ABCC values of Bolivia but later converged with the other regions. However, *Región Metropolitana* in Chile begins the 1750s with higher numeracy values but at the end of the period the ABCC decreases to 40%, becoming the least numerated of Chile. These examples suggest that the formation of human capital was not always linked with the central administration.

Several results can be highlighted from the numeracy trends. Empirical evidence confirms some assumptions of the institutional hypothesis:

[8] This fact will be discussed in Section 6. Additional empirical information is in Appendix 4.

1. Higher numeracy trends appear in the lowest populated regions before the conquest and in the cattle economies.
2. Lower numeracy trends appear in the densely populated native regions before the conquest and in the mining and plantation economies.

Furthermore, the evidence shows that the national capital was not the highest numerated in every country. Hence, depending on the country the formation of human capital was not always linked with the central administration. At the very beginning the formation of human capital seemed to be related to the economic activity of the region and not with a central purpose to provide basic skills to the labour force.

5.2 Cartography approach

The analysis of the numeracy trends is complemented by the cartographic analysis. Figures 10–13 display the ABCC index calculated from the marriage registers for three selected years: 1750, 1800 and 1850. Cartographical evidence shows that some geographical characteristics seem to be determinant for human capital formation. In the first place the countries located on the Southern Atlantic Ocean have higher numeracy values than the countries on the Pacific. This factor is related with the colonization period since the oldest colonization settlements (excluding Central America) started in the Pacific Ocean (Quito in 1534, Lima in 1535, Santiago de Chile in 1541, and Potosí 1545).[9] Some of these regions were also densely populated in the pre-Columbian period. The only exception on the Atlantic Ocean is Recife, founded in 1526 (Cole 1965). Provinces such Buenos Aires and Corrientes (Argentina), Soriano (Uruguay) and *Rio Grande do Sul* (Brazil) have high numeracy values throughout time. As well as in the numeracy trends analyzed above (Section 4.a) these two facts are related with the institutional hypothesis that claims that the lower populated territories before the conquest and the economies with activities not related to mining or plantations had higher economic growth. Furthermore, this literature highlights that it was with the introduction of technological change that the gap among the regions became more pronounced (Acemoglu, Johnson and Robinson 2002). However, the analysis of human capital formation in these three benchmarks allows a confirmation that the basements of the numeracy (mathematical skills) were given before the introduction of technological change. The cartography shows that already in 1750 the numeracy of the Southern Atlantic territories was higher than in other regions.

In the second place, the provinces with access to the sea had higher numeracy levels than the countries located in the center of the continent. This fact is especially emphasized in Potosí, Santa Cruz, Chuquisaca, La Paz and Beni throughout time. Apparently these regions were affected for early "bad" institutions and by the geographical location. This fact will be analyzed further in Section 6.

[9] The Portuguese colonisation made some early settlements in the Atlantic as well (Recife 1526, Salvador 1549, and Rio de Janeiro 1567).

5.3 Inequalities of regional human capital distribution

Based on these first cartographic impressions, it is possible to observe statistically the regional differences in the distribution of human capital within countries.

I measured the regional inequality by using the coefficient of variation (CV). Using the CV has the advantages that it is a dimensionless number and that it allows comparisons between the different countries, even though they have different means. It is defined as the standard deviation of regional ABCC values of a country (σ) divided by the average ABCC value of a country (μ), multiplied by 100:

$$CV = \frac{\theta}{\mu} * 100$$

Figure 14 displays the coefficients of variation by countries. In general, regional variation is decreasing throughout time in most countries. Considerable differences in the CV can initially be found in Peru and Bolivia, both one of the lowest numerated since the 1750s. In the case of Peru the CV is notoriously high in the early period; however, it tends to converge in the last years. Furthermore, the coefficients of variation of Ecuador and Brazil are constant throughout time. That means that the inequalities in education in those countries did not change throughout time.

The high CV coincides with the lowest numeracy values, as Peru and Bolivia are two of the countries with lowest levels of human capital formation throughout time. However, the CV shows a low trend in countries with mixed economies (cattle-mining/cattle-plantation) like Chile and Brazil. Only the regions with strong mining economies have high levels of inequality in human capital formation.

According to this approach it is possible to conclude that the inequalities of human capital within the countries are detrimental to national human capital formation as those countries with high variation are as well the least numerate.

6. Determinants of human capital formation and economic growth

The aim of the regression analysis is to illustrate the institutional hypothesis put forward in Sections 2.b and 2.c in two parts. The most illustrative is (1) the analysis of the human capital determinants. Some variables were created in order to explain human capital formation. (2) Furthermore, it is relevant to display the relation of current GDP and human capital formation, specifically, in which way early numeracy affected the current levels of GDP. The sources of the complementary variables are detailed in Appendix 4.

I divided the possible determinants of human capital into three vectors of variables: historical variables, institutional variables and geographical and climate variables. The two main groups of variables are the historical and the institutional since they follow the institutional hypothesis. The geographical and climate variables were displayed as control variables. Both ABCC index (early numeracy) and current GDP are

dependent variables in separated models. Relevant as well is to evaluate the relation between early numeracy and current GDP.

a. Historical variables: The historical variables are those potential determinants of human capital formation that occurred in the pre-colonial and colonial periods. The reason to consider the pre-colonial and colonial periods as key factors is related to the institutional hypothesis (Section 2.a and 2.b). I include in this category the pre-colonial population density and the main colonial activity. Following the analysis of Bruhn and Gallego (2012) I include as dummy variables those activities considered "bad" for institutional formation (plantation and mining). Furthermore, following the work of Cole (1965) I include the areas of early colonization (Cole 1965) and the size of the population in 1800 and 1850 (Mc Arthur and Sachs 2001).
b. Institutional variables. The institutional variables are as well historical variables but are less related to natural endowments (such as pre-colonial activities) or demographic dynamic (such as the size of the population). These variables are directly related to policies of land distribution. Following the work of Cole (1965) I created a typology of land tenure in the pre-colonial period: the hacienda-system, the family-farm system, the plantation system, and the shifting economy. Part of these land tenure systems started in pre-colonial times and continue throughout time, such the examples of the plantation economies and the shifting economies (tribes of the Amazonas). The hacienda system is a typical kind of land ownership that took place after the colonization and remains throughout time.
c. Geographical variables: I include the climate (average degrees), altitude, average rainfall, the distance of the sea and a landlocked dummy as control variables.

6.1 Potential human capital determinants

According to the results of the numeracy trends I expect that high levels of population density and mining and plantation economies are negatively related to the formation of human capital. This hypothesis is linked with the institutional assumption that densely populated areas were more propitious in generating extractive institutions. Furthermore, some activities such as mining or plantations could be detrimental for long-run development. My hypothesis is that these variables are as well detrimental for human capital formation. But who shaped those "bad" institutions? How educated was the population (in terms of mathematical skills) in the conquest and after? Which were the determinants of the human capital formation?

I tested the previous hypothesis by running the following reduced form regression:

$$ABCCrc = Zrc\alpha + Xrc\beta + Wre + Nc + Erc$$

Where c refers to country and r refers to region; Z is the vector of the historical variables; X is the vector of institutional variables; and W the vector of control variables. N is a country fixed effect and E the error term. The historical variables include the pre-colonial population density (by regions), the size of the population in 1800 and 1850 (by countries) and two pre-colonial economic activities as dummy variables: mining and plantation economies. Finally, I include in the historical set of variables a dummy for those regions of early colonization.

The institutional variables are different forms of land tenure. These are directly related to policies of land distribution. They are dummy variables classified in four categories: *hacienda*, family farm, plantation, and gathering economy. The set of control variables are those related with geography and climate.

I ran an unbalanced panel model with country fixed effects to test first the hypothesis of the set of historical variables and the human capital formation. I expected a negative coefficient in the pre-colonial population density and in the size of population in 1800 and 1850. Table 3 displays the results of the fixed effects model panel and the OLS in five different columns. The dependent variable is the ABCC. Columns 1 and 2 display the results of the fixed country effect and OLS including the pre-colonial population density and the pre-colonial activities mining and plantation. The excluded pre-colonial activity is no pre-colonial activity. As expected the pre-colonial population density is negatively related with the ABCC but is statistically insignificant in the fixed effects model. The pre-colonial activity mining is as well negatively related to the ABCC only when I include the fixed effects but has no significance in any of the models. Some of the control variables such as average temperature and altitude are negatively related to the ABCC and have significance in all the models. Being a landlocked country is as well negatively related with the ABCC but has no significance in the model.

In Columns 3 and 4 I included other historical explanatory variables such the size of the population in 1800 and 1850. With this incorporation the pre-colonial population density and mining activity become positive but not significant in the model. Furthermore, the pre-colonial activity plantation becomes negative and significant (Column 5). The size of the population in 1800 is strongly negatively related with the ABCC and significant at the 0.01 level. In Column 5 I included the effect of each country in an OLS regression. The omitted country is Argentina. With the exception of Uruguay all the countries have negative coefficients in relation with the ABCC of Argentina.

In Table 4 are displayed the results of fixed and random effects models. In the random model the pre-colonial population density remains negative but not significant. The pre-colonial activity mining is now positively related with the ABCC but not significant, and the pre-colonial activity plantation is negative and significant in the model. The Hausman test suggests that the random effects model should be preferred.

In Table 5 are displayed the results of the OLS, fixed and random models with the institutional determinants of the human capital formation. As was explained above (Section 6) I created four categories related to the land ownership: plantation system, family farm system, hacienda system and shifting-recollection system. The reference category is the shifting system. Both in fixed and random effects models the hacienda system

is negatively related with the ABCC but has no significance in any of the models. Expected was that the family farm system is positively related to the ABCC but only significant in the OLS. The geographical control variables average temperature and altitude remain negatively related with the ABCC. In this case the Hausman test (p value 0.043) suggests that the fixed effects model is the preferred.

All in all, from all the models it is possible to conclude that the plantation economy was detrimental for human capital formation and those densely populated areas before the conquest generated lower levels of human capital. The family farm ownership of the land seems to have had a positive effect on the formation of human capital.

6.2 Early human capital and development

The aim of the following regressions is to analyze the determinants of the current GDP, especially if the early ABCC could be a determinant of economic development. I collected the data of regional current GDP per capita from the 2000 values from the world development indicators. The gross state product of each region is divided by the current population and converted to per capita values. In order to deal with the problem that some of the values are not comparable across regions, I used the log of the value and I include country fixed effects. Hence, the variables and estimated effects of the regressions can be interpreted as log deviations from country means. The basic form of the regression is:

$$GDPrc = earlyABCCrc + Brc\beta + Crc\delta + Nc + E$$

Where r refers to the region and c to the country; B refers to the set of institutional variables mentioned above; C to the geographical and climate control variables; N to the country fixed effects and E is the error term.

The results of the regressions are displayed in Table 6. As was expected, in the fixed effects models (Columns 1, 3 and 5) the coefficients of the early ABCC are negative but are very low and not significant in the model. That means that a low early low ABCC is negatively related to the current economic development. The low values are due to the logarithmic transformation. As in the previous models related to human capital determinants, the control variables average temperature and altitude are negatively related to the current per capita GDP and have significance in the model. Furthermore, the plantation system is negatively related to the current GDP and has significance in the fixed effects model. In the last column I tested with a random effects model but the Hausman test[10] suggests that the preferred model is the fixed country effects.

Finally, I ran a fixed effect model including the early ABCC of three half decades: 1750, 1800 and 1850. Table 7 displays the results of three models with current GDP as the dependent variable. Although almost none of the coefficients are statistically significant, both ABCC 1750 and 1800 are negatively related with

[10] P value 0,00

the current economic growth, but the ABCC 1850 is positive and significant in the model. The result means that after 1850 the current economic growth is positively related with the formation of human capital. Although from previous results it is possible to confirm that the basis of the formation of human capital was given in the early 1750, it was not until 1850 when it started to be relevant for economic development. This result is in concordance with the literature review.

All in all, although the coefficient of the early ABCC is very low it is possible to estimate that the early formation of human capital seems to be relevant for future economic development. However, it was not until 1850 when the formation of human capital started to be a determinant for current economic growth.

7. Conclusions

This paper explores the differences in the formation of human capital within countries in Latin America. From the empirical evidence it is possible to confirm some hypotheses previously given by the institutional literature: (1) in the first place higher numeracy trends appear in the lowest populated regions before the conquest and in the cattle economies; lower numeracy trends to appear in the densely populated native regions before the conquest and in the mining and plantation economies. These two facts agree with the institutional hypothesis, which claims that depending on natural resources were shaped "good" or "bad" institutions. These "good" or "bad" institutions seem to have promoted as well "better" or "worse" human capital. (2) Some of the determinants that are negatively related with the formation of human capital are the plantation economies and the densely populated areas before the conquest. The family farm ownership system seems to have a positive influence on the formation of human capital.

Furthermore, this paper arrives at some original conclusions that are not explored by the literature: (3) the national capital was not in every country the highest numerated in comparison with other regions. Depending on the country the formation of human capital was not always linked with the central administration. At the very beginning the formation of human capital seems to be related to the economic activity of the region and not with a central purpose to provide basic skills to the labour force. (4) The institutional hypothesis claimed that the gap between the developed and undeveloped countries started in the colonial period. However, the key factor to make the gap deeper was the introduction of technological change into production. Regarding the formation of human capital it is possible to highlight that the basements of numeracy were given before in the early 1750s, hence before the introduction of technological change. The cartography shows that already in 1750 the numeracy of the Southern Atlantic territories was higher than other regions. (5) Through the coefficient of variation by countries it is possible to conclude that the inequalities of human capital within the countries are a detriment to the formation of human capital. Those countries with high levels of inequalities within regions are as well the least numerate. (6) Finally, the regressions results show that the early formation of human capital is relevant for current economic growth, especially after the early 1850s.

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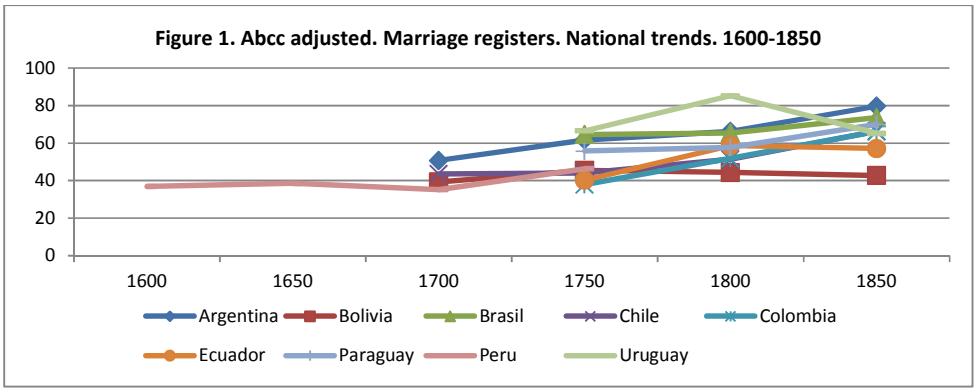
9. Appendix

Appendix 1. Numeracy trends



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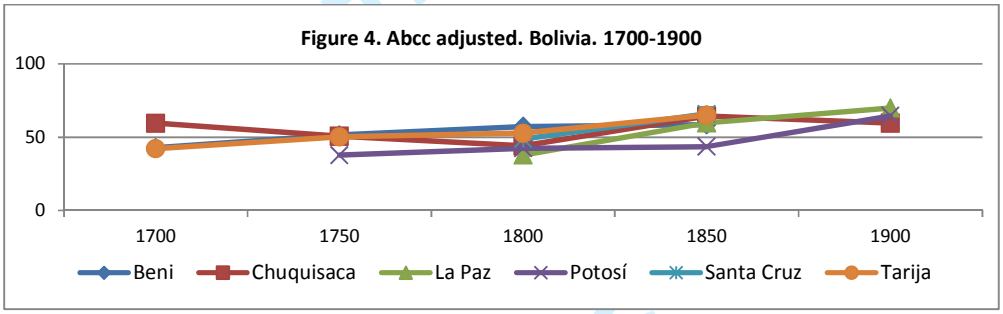

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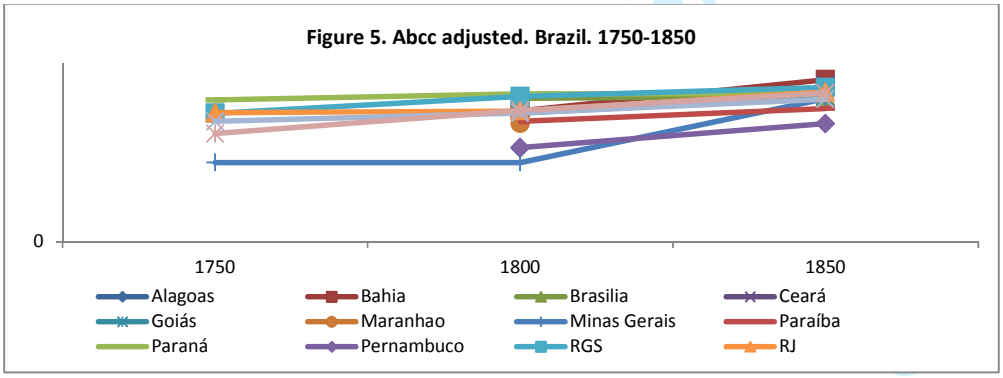

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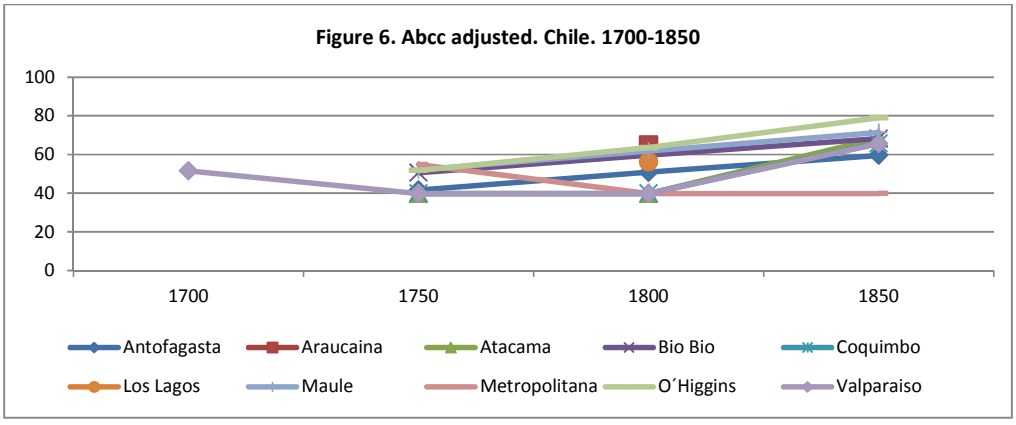

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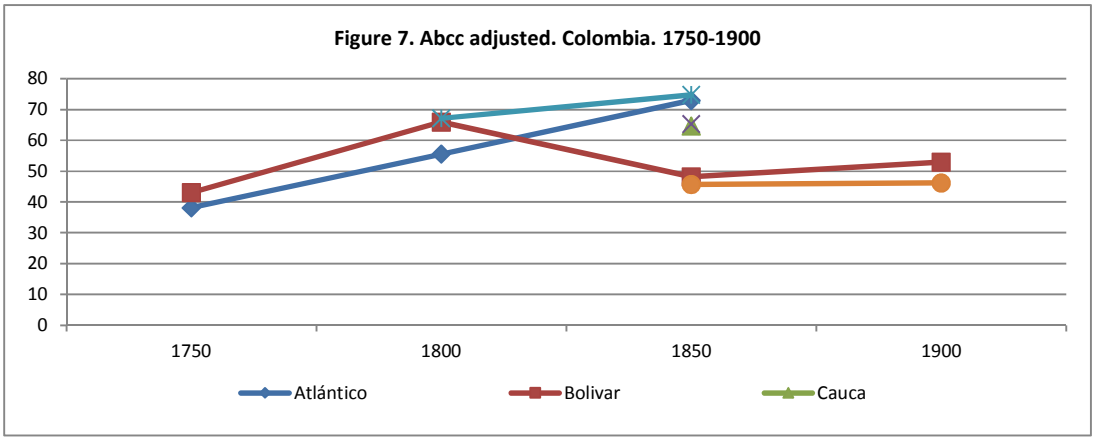

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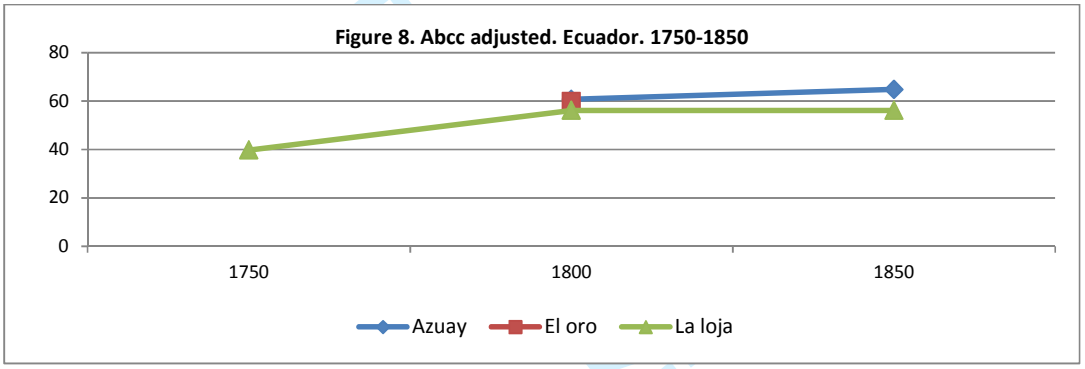

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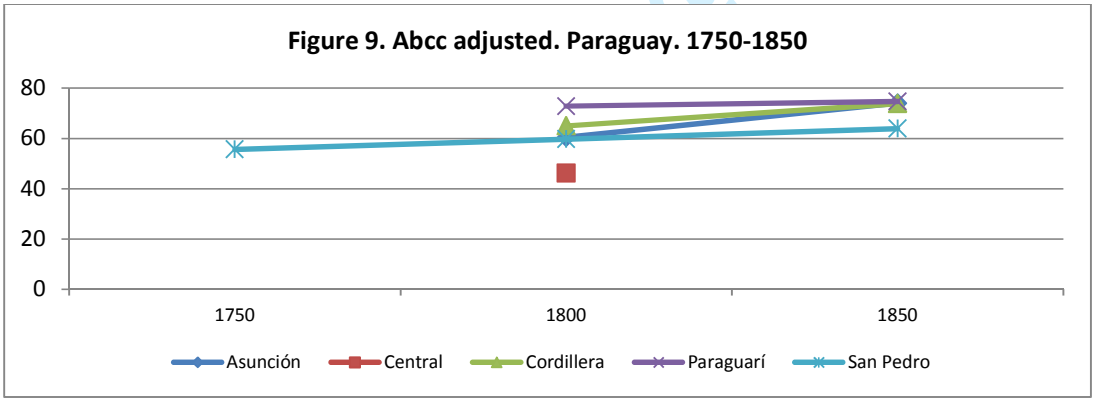

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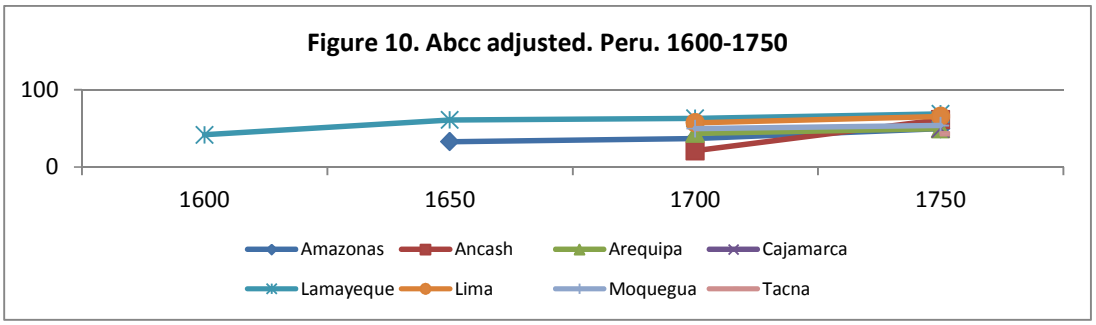

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Appendix 2. Cartography

Figure 11. ABCC per province. 1750

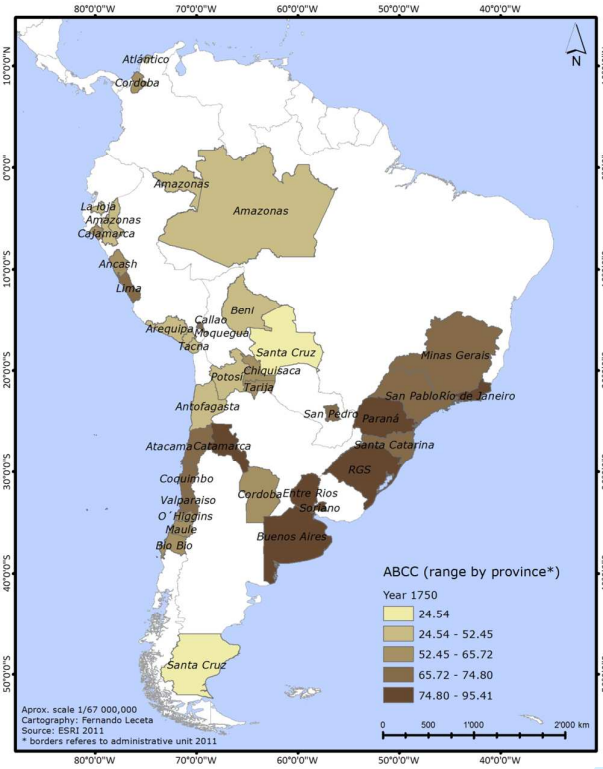

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Figure 12. ABCC per province. 1800

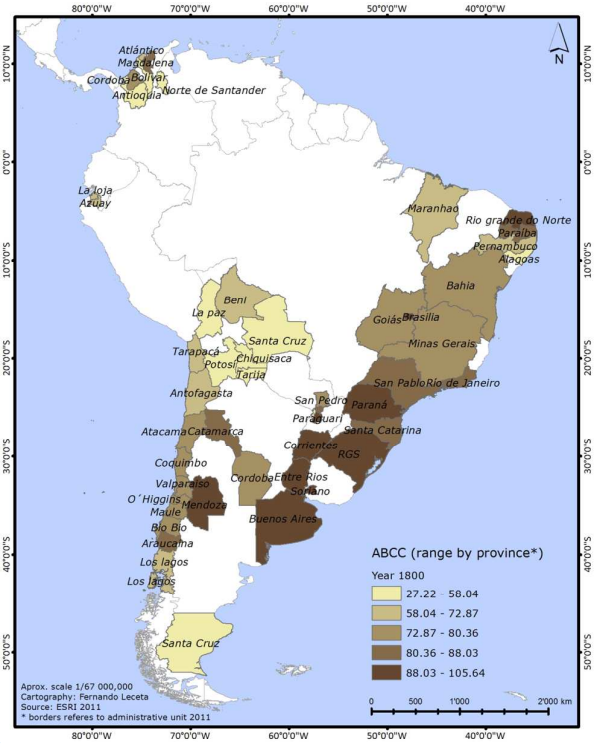

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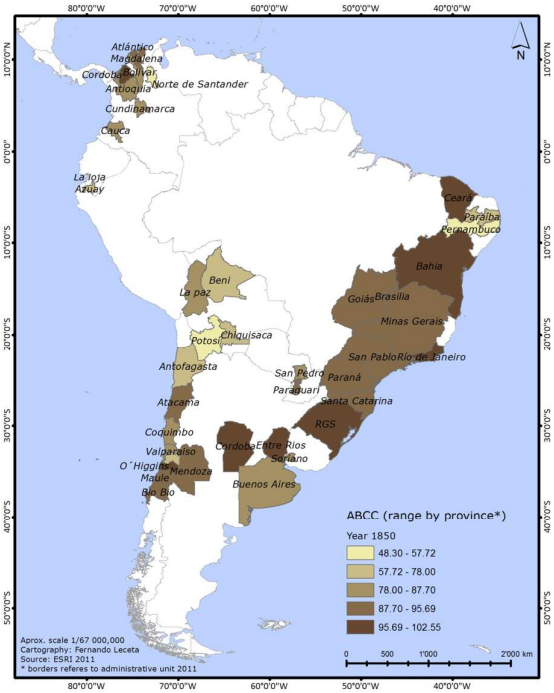
Figure 13. ABCC per province. 1850



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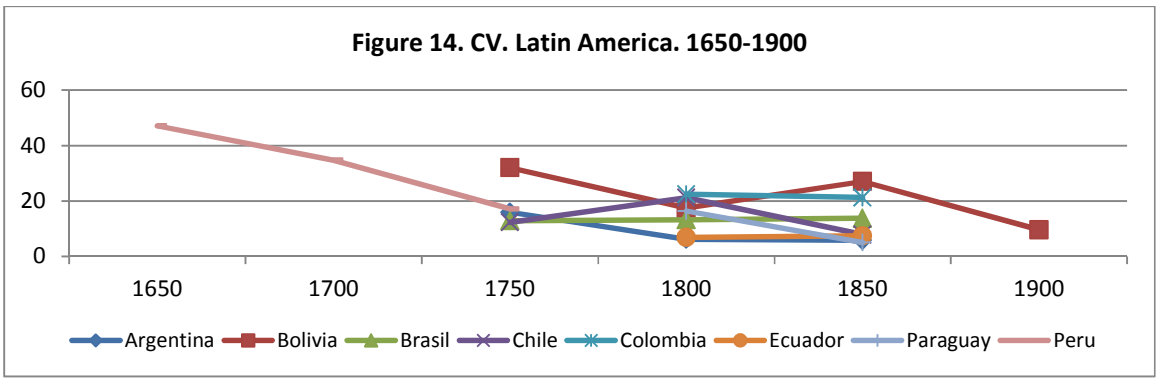
Appendix 3. Inequalities on the human capital distribution



Source: familysearch.org

Appendix 4. Regressions

Table 1. Sources

Variable	Source
Dependent: ABCC	Familysearch.org
Dependent GDP 2000	World Development Indicators
Historical	
Log Pre colonial population density	Brhun and Gallego (2012)
Size of population in 1800	Mc Evedy and Jones (1978)
Size of population in 1850	Mc Evedy and Jones (1978)
Pre colonial activity mining (dummy by provinces)	Brhun and Gallego (2012)
Pre colonial activity plantation (dummy by provinces)	Brhun and Gallego (2012)
Early colonization (Dummy)	Cole (1965)
Institutional	
Land tenure syst. Plantation	Cole (1965)
Land tenure syst. Hacienda	Cole (1965)
Land tenure syst. Family farm	Cole (1965)
Land tenure syst. Shifting cultivation	Cole (1965)
Geographical	
Average temperature (by provinces)	Brhun and Gallego (2012)
Total Rainfall (by provinces)	Brhun and Gallego (2012)
Altitud (by provinces)	Brhun and Gallego (2012)
Absolute altitud (by country)	Mac Arthur and Sanchs (2001)
Landlocked (by provinces)	Brhun and Gallego (2012)
Prop land 100 km sea (by country)	Mac Arthur and Sanchs (2001)

Table 2. Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Dependent variables					
abcc	148	73,48	18,12	21,00	111,00
yppp	151	6.478,82	3.777,48	1.244,53	19.820,19
lyppp	151	8,60	0,62	7,13	9,89
Historical					
log_prepd	151	0,59	1,51	-2,97	4,61
size1800	112	1,45	0,59	0,50	2,50

size1850	111	3,26	2,56	0,80	7,25
early activity mining (dummy)	150	0,19	0,40	0,00	1,00
early activity plantation (dummy)	150	0,11	0,32	0,00	1,00
no early activity (dummy)	150	0,01	0,12	0,00	1,00
early colonization (dummy)	152	0,14	0,35	0,00	1,00
Institutional variables					
l_hacienda (dummy)	149	0,06	0,24	0,00	1,00
l_plantation (dummy)	150	0,16	0,37	0,00	1,00
l_family (dummy)	149	0,23	0,43	0,00	1,00
l_shifting (dummy)	150	0,05	0,21	0,00	1,00
Geographical-Climate (control variables)					
temp_avg	151	18,69	5,11	7,23	28,90
rainfall	151	1,41	2,87	0,00	25,40
landlocked	150	0,44	0,50	0,00	1,00
altitud	151	0,76	1,12	0,00	4,41

Table 3. Historical determinants of human capital

	Model 1	Model 2	Model 3	Model 4	Model 5
Estimation technique	Country fixed effects	OLS	Country fixed effects	OLS	OLS
Dependent variable	abcc	abcc	abcc	abcc	abcc
log_prepd	1.33	-1.80*	2.96*	-0.14	2.96*
	(0.276)	(0.087)	(0.085)	(0.918)	(0.085)
mining	0.43	1.85	4.64	0.66	4.64
	(0.909)	(0.629)	(0.315)	(0.873)	(0.315)
plantation	-3.58	0.27	-10.70*	-4.77	-10.70*
	(0.474)	(0.958)	(0.077)	(0.380)	(0.077)
earlycol			-1.77	2.53	-1.77
			(0.675)	(0.538)	(0.675)
size1800			5.58	-23.61***	5.58
			(0.766)	(0.007)	(0.766)
size1850			-86.08**	8.44***	-86.08**
			(0.020)	(0.000)	(0.020)
temp_avg	-0.56	-0.30	0.90	-0.35	0.90
	(0.187)	(0.362)	(0.230)	(0.288)	(0.230)
rainfall	0.29	0.88*	0.27	0.30	0.27
	(0.524)	(0.090)	(0.581)	(0.546)	(0.581)
landlocked	-2.01	1.81	-6.24	-1.37	-6.24
	(0.569)	(0.585)	(0.164)	(0.737)	(0.164)
altitud	-2.88	-7.52***	2.10	-3.61*	2.10
	(0.143)	(0.000)	(0.530)	(0.075)	(0.530)
Bolivia					-508.96**
					(0.017)
Chile					-492.25**
					(0.018)
Colombia					-470.51**
					(0.018)
Ecuador					-564.66**

					(0.019)
Peru					-480.80**
					(0.013)
Paraguay					-36.73***
					(0.000)
Uruguay					2.02
					(0.830)
Constant	86.36***	83.66***	330.52***	87.04***	676.56***
	(0.000)	(0.000)	(0.003)	(0.000)	(0.008)
Observations	144	144	107	107	107
R-squared	0.04	0.21	0.11	0.40	0.47
Number of land (groups)	9		6		

Note: pval in parentheses *** p<0.01, ** p<0.05, * p<0.1
In Model 5 omitted country Argentina, omitted pre-colonial activity "no pre-colonial activity"

Table 4. Institutional determinants of Human capital

	Model 1	Model 2	Model 3	Model 4	Model 5
Estimation technique	Fixed country effects	OLS	Fixed country effects	OLS	Random effects
Dependent variable	abcc	abcc	abcc	abcc	abcc
l_hacienda	-6.11	5.47	-6.41	1.40	-4.08
	(0.338)	(0.387)	(0.333)	(0.822)	(0.521)
l_plantation	-1.53	11.81***	-0.98	11.84**	1.91
	(0.725)	(0.004)	(0.852)	(0.018)	(0.705)
l_family	4.17	16.27***	3.02	11.25***	5.33
	(0.292)	(0.000)	(0.471)	(0.005)	(0.179)
temp_avg			-0.33	-0.43	-0.47
			(0.536)	(0.294)	(0.335)
rainfall			0.22	0.69	0.31
			(0.613)	(0.155)	(0.477)
landlocked			-2.13	7.51**	-0.10
			(0.579)	(0.025)	(0.979)
altitud			-2.20	-6.79***	-3.62*
			(0.329)	(0.000)	(0.079)
Constant	73.04***	67.41***	81.96***	78.00***	84.82***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	144	144	141	141	141
R-squared	0.03	0.15	0.04	0.27	
Number land (gropus)	9		9		9

Note: pval in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 5. Determinants of current GDP

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Estimation technique	Country fixed effects	OLS	Country fixed effects	OLS	Country fixed effects	Random effects
Dependent variable	Log GDP	Log GDP	Log GDP	Log GDP	Log GDP	Log GDP
abcc	-0.00	0.01***	-0.00	0.00	-0.00	0.00
	(0.997)	(0.004)	(0.717)	(0.774)	(0.689)	(0.904)
l_hacienda					-0.16	0.19
					(0.417)	(0.343)
l_plantation					-0.43***	0.02
					(0.009)	(0.917)
l_family					-0.19	0.03
					(0.148)	(0.819)
temp_avg			-0.02*	-0.04***	-0.01	-0.04***
			(0.099)	(0.000)	(0.748)	(0.001)
rainfall			-0.01	-0.01	-0.01	-0.00
			(0.281)	(0.653)	(0.443)	(0.802)
landlocked			0.18*	-0.10	0.08	-0.09
			(0.098)	(0.272)	(0.487)	(0.399)
altitud			-0.17***	-0.34***	-0.11	-0.34***
			(0.003)	(0.000)	(0.102)	(0.000)
Constant	8.61***	8.03***	9.13***	9.62***	8.98***	9.71***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	147	147	145	145	141	141
R-squared	0.00	0.05	0.09	0.36	0.14	
Number of land	9		9		9	9

Note: pval in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6. Determinants of current GDP. Half decades ABCC

	Model 1	Model 2	Model 3	
Estimation Technique	Country fixed effects	Country fixed effects	Country fixed effects	pval in parentheses
				*** p<0.01, ** p<0.05, *
Dependent variable	Log GDP	Log GDP	Log GDP	p<0.1
abcc1750	-0.01			
	(0.419)			
temp_avg	0.00	0.00	-0.01	
	(0.960)	(0.928)	(0.780)	
rainfall	-0.03	-0.00	-0.02	
	(0.870)	(0.898)	(0.412)	
landlocked	-0.15	0.15	0.11	
	(0.585)	(0.542)	(0.636)	
altitud	-0.15	-0.05	-0.05	
	(0.467)	(0.756)	(0.695)	
l_hacienda	-0.02	-0.30	-0.06	
	(0.978)	(0.457)	(0.859)	
l_plantation	-0.10	-0.59*	-0.49*	
	(0.833)	(0.079)	(0.090)	
l_family	-0.23	-0.09	-0.34	
	(0.400)	(0.729)	(0.152)	
abcc1800		-0.00		
		(0.654)		
abcc1850			0.01*	
			(0.075)	
Constant	9.55***	8.92***	7.97***	
	(0.000)	(0.000)	(0.000)	
Observations	33	48	41	
R-squared	0.24	0.18	0.32	
Number of land1	8	8	8	