European
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EHES Working Paper | No. 181 | April 2020

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Abstract

This work provides data on human capital for the Guarani Jesuit missions during the 18th century. Based on the age heaping methodology, the results of a large sample (over 3,600 observations) suggest that the knowledge of numerical skills in these missions was exceptional. A comparison with other regions and locations with different institutional frameworks, religious or otherwise, or led by other religious orders, confirms the exceptionality of the Guarani Jesuit missions. The model of these missions, based on productive self-sufficiency and egalitarian and cohesive social organization, as well as respect for the pre-existing culture exemplified by their Guaraníization and adaptation to the Guarani world view and language, could explain their successful educational performance and the intergenerational transmission of human capital beyond the disappearance of the Jesuit missions after 1767.

JEL Codes: I21, I25, J24, O4

Keywords: Human Capital, Economic Development, Numeracy, Institutions

* I am grateful for the comments of my supervisors Miquel Gutiérrez-Poch & Julio Martínez-Galarraga; and above all to Julio Djenderedjian for providing me with the lists of the missions that are in the Historical Archives of Porto Alegre. Likewise, to Felipe Valencia Caicedo for his assessment of the previous version "Age-heaping in the Jesuit Mission"; and to Alfonso Díez for his technical assistance. I am also thankful to the working group of Pueblos y números del Río de la Plata 1760-1860, to all the participants of the seminar of the Institute of Economics of the University of the Republic of Montevideo, and to the members of the symposium "Prices, income and living standards: methodological problems in the global agenda, XVI-XX centuries" of CLADHE VI in Santiago de Chile. Financial support from the Spanish Ministry of Science, Innovation and Universities, Project PGC2018-095821-B-I00 (MCIU / AEI / FEDER, UE) is also gratefully acknowledged. Finally, it should be noted that the archival work of this article was made possible thanks to a research scholarship granted by the Barcelona Society of Friends of the Country (SEBAP).
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1. Introduction

The Society of Jesus was created in 1534. This Catholic religious order was born as part of the Counter-Reformation movement that was spreading through Europe at that time and stood out, among other things, for its evangelizing missions[1]. These missions should be studied in the context of European colonial expansion during the Modern Age when the European Crowns, particularly the Iberian Crowns, supported by the Vatican, had the clear objective of extending Christianity to the different areas of the planet under European domination. The Jesuits played an important role in this evangelizing task. In order to spread Christianity, they established missions where, along with their evangelization tasks, they also created schools and provided training. Although the Jesuits founded missions throughout the Americas, their presence was especially noticeable among the Guarani populations in an area close to the borders of today's Argentina, Brazil and Paraguay. This presence began at the beginning of the 17th century and extended for more than a century and a half, until 1767 when the Spanish Crown, under the mandate of Carlos III, expelled the Society of Jesus from America[2].

The Jesuits founded a total of 30 missions, also called *reducciones*, in this area. In the time of their greatest splendour the missions hosted more than 140,000 Guaranis, which belonged to an indigenous traditionally semi-nomadic tribe. The Guarani Jesuit missions were also a unique social experiment within the missionary experiences of the European empires in Africa, America and Asia, and not only because they promoted the education of the Guarani people to encourage their evangelization. Based on self-sufficiency, the reductions were an alternative for incorporating the Indians into the colonial system during the Modern Age. They played a fundamental defensive role in a border area between the two Iberian empires, and also in the internal conflicts of the crown with the *encomenderos* and other native peoples. In addition, the successful economy of the reductions allowed the Jesuits to achieve remarkable solvency in an area of evident poverty and awakened the ambitions of the merchants and *encomenderos* (Fradkin et al. 2009).

To study the impact of the missions as institutions that affect the educational levels of their inhabitants (and their general economic conditions and living standards) it is of particular interest their origin. The reductions created new societies, or at least a new social organization, in this case, of the indigenous population. The Jesuits deliberately founded the missions,

[1] The order, created in 1534 by the Basque knight Ignazio de Loyola at the University of Paris, was approved on 27 September 1540 in Rome by Pope Paul III, who signed the Bull of Confirmation (Regimini militantis ecclesia).

[2] The effective suppression of the Society of Jesus occurred on 21 July, 1773, when Pope Clement XIV approved the brief Dominus ac Redemptor. Although the order would be restored in 1814, the Jesuits would no longer be present in the Guarani reductions.

bringing the people together into a new common space that could accommodate more than 3,000 people. They thus made entire Guarani communities sedentary. The educational and social outcomes obtained in the missions can therefore reasonably be attributed to the organization and functioning of the Jesuits, rather than to the inertia of the past.

Valencia Caicedo (2019a) analyses the effect of missionaries on education and demonstrates that Guarani Jesuit missions had important long-term educational and economic benefits. On the one hand, beyond the religious conversion, which was the main objective of these Catholic missions, this author maintains that they favoured the formation of human capital through the schooling of children and through the training offered to adults in various occupations. On the other hand, this author stresses the persistence of this situation, since in the areas where the missions were established the author found a positive effect on the human capital and income levels in the present (around 10% higher in both cases), also highlighting the importance of occupational, cultural and behavioural changes as the main channels of transmission. In his work, Valencia Caicedo (2019a) analyses the areas of former Jesuit presence using the distance to the nearest mission; however, he does not have direct indicators that allow him to measure human capital.

All this makes it particularly interesting to study the levels of human capital acquired in the Jesuit missions in the years when they were in operation. This is also a field of study that is directly related to various debates currently present in the literature. In general, historiography tends to give a positive role to religious missions of all kinds, not only those of the Jesuits, considering them to be an instrument for transmitting knowledge, skills and technologies. Therefore, the missionary experiences of Europeans in America, Africa and Asia seem to have played a key role in the long-term educational development of these continents (Meier zu Selhausen 2019; Valencia Caicedo 2019b).

The debate on the effects of missions on economic development is also related to other fields of study. This debate falls within the more general area that examines the relationship between religion and economic growth (McCleary & Barro 2006; Glaeser & Sacerdote 2008). Moreover, a number of papers have explored the impact of religion on very long-term formation of human capital (Dittmar 2011; Rubin 2014; Cantoni 2015; Saled 2015; Andersen et al. 2017). Some studies comparatively assess the externalities of human capital of different religious groups over long periods of time (Botticini at al. 2007; Becker and Woessmann 2009). These works usually consider that religious institutions, in charge of providing education during much of the Modern Age, were providers of public goods and non-rival services such as the education of their members (Abramitzky 2011; Colvin 2017). Along these lines, and directly related to this work,

there are studies that show that missions had positive effects in the long term (Woodberry 2004; Gallego et al. 2010), both in Africa (Fourie et al. 2015; Baten & Cappelli 2016), and in the Americas (Waldinger 2017) and Asia (Calvi et al. 2019).

These aspects are also linked to a very frequent debate in economic history, that is, the role that institutions play in economic development in the long term and the persistence of this development over time. This debate focuses especially on the structures implemented by Europeans during the colonial periods (Acemoglu et al. 2001; Nunn 2008). In the specific case of Latin America there are studies on the persistence of the effects of the *mita* system (Dell 2010) and the exploitation of sugar cane plantations and gold mines (Naritomi et al. 2012). This issue has also been studied in terms of the persistence of the effects of pre-colonial institutions in Latin America (Angeles et al. 2016). However, the relationship between human capital, institutions and development is complex (Acemoglu et al. 2014). Some authors argue that the abundance of unskilled human capital due to natural resource extraction institutions would explain the extreme inequality in Latin America (Engerman & Sokoloff 1994). Others argue that more than institutions, the key is in the human capital of the colonisers themselves (Glaeser et al. 2004; Easterly & Levine 2016).

Nevertheless, the mechanism for transferring human capital in colonial institutions and its persistence in the long term is an open debate. This is partly because to assess the role of human capital in economic growth it is necessary to have an indicator of it over time, and this is not easy. It is even more complicated to obtain it for certain historical points in time, that is, in the period in which the colonial institutions were in operation. To fill this gap, this paper proposes constructing human capital indicators for the Jesuit Guarani missions throughout the 18th century.

Measuring human capital, however, is not an easy task. Currently, one of the various human capital indicators available and used by UNESCO to assess human capital focuses on numeracy. This term refers to certain basic skills that are considered relevant to economic development: the ability to calculate for economic and trade purposes (Huizinga et al 2009). Thus, numeracy, using age-heaping as a proxy, is considered a good alternative indicator to literacy for the periods of the Modern Age, for which sources are scarce or non-existent (A'Hearn et al. 2009; Crayen & Baten 2010; Hippe 2013).

In recent years, different works have emerged on the arithmetic capacity levels in some of the regions under the domination of the Hispanic Monarchy throughout the 18th century, such as Castile (Tollnek & Baten 2017; Álvarez & Ramos Palencia 2018), Catalonia (Gómez-i-Aznar,

2019) and the region of Rio de la Plata (Vicario 2014). These are added to the works for the areas that today are Colombia, Mexico and Peru (Manzel et al. 2012) or those carried out for periods even before the Conquest (Juif & Baten 2013). Especially related to this study is the work on the region of Potosi, which shows the differences in the calculation levels between the different native communities in relation to type of institution (Vicario 2017) and that of Central New Spain in the 18th century, which highlights the complexity of the situation within the same region (Calderon et al. 2020). There is also a more recent work on the differences in numeracy between religious minorities, particularly Jews, in the Iberian Peninsula during the years of the Inquisition (Juif et al. 2020).

In this context, the main contribution of this work is to provide numeracy results for the Jesuit Guarani missions of the 18th century. The objective is to be able to provide data on human capital for a particular case within the religious missions, the effects of which persist in the present despite the expulsion of the Jesuits in 1767 (Valencia Caicedo 2019a). It is essential to trace the evolution of human capital in this area over almost a century and compare it to other regions of America under the rule of the Hispanic Monarchy to assess the role of the Jesuits in the economic development of the region.

The arithmetic ability in the Jesuit Guarani missions of the 18th century was obtained from a new source: the censuses of Indians or *padrones*. The *padrones* contain data on the age of the entire male population (in some cases also the female population) of the reductions. These data can be used to calculate the age heaping level, and obtain Whipple and ABCC indices. Unlike other sources used for this period, such as military lists, tax information or hospital records, this source reduces possible sample bias, as it includes the entire population of the Jesuit reductions. Specifically, it overcomes the problem of under-representing the most popular classes or the fiscal concealment that can be found in other Modern Age sources[3].

The sample used in this article obtains information for five Guarani missions and one village founded by the Jesuits, from the thirty reductions that existed, at three different times in the 18th century. Four of these reductions are in what is now Argentina, one in Brazil and one in Paraguay. In total, the population of these five reductions and the town of San Javier amounts to more than 13,000 inhabitants. The results show that the numeracy level of the Guarani population that inhabited the Jesuit missions was extraordinary. This is true both in absolute terms and in comparison with other Latin American, Iberian and Western European regions.

[3] Vicario (2014, 2017) uses a similar source to analyze the characteristics of human capital in the Rio de la Plata region for the period 1744-1858, and for the Andean region of Bolivia between 1683 and 1735. It uses local population censuses for its study.

This confirms the positive role that Jesuit missionaries would have played in the formation of human capital in the region, similar to that found in Valencia Caicedo (2019a).

The availability of censuses for other colonized areas and under the domination of the Hispanic Crown in the 18th century also allows us to compare the results obtained in the Jesuit missions with other colonial experiences. Communities with indigenous populations have been studied in the region of Puno, in southern Peru near the border with Bolivia. A different case is provided for Spanish Louisiana, currently in the United States and information is also available on Franciscan missions, in the colonization of California. This information can be used to make a comparative analysis of the exceptionality of the Guarani Jesuit missions. With this, the paper contributes to the debate on the impact on human capital of the missions organized in Latin America by different religious orders. In this sense, Waldinger (2017) concludes that the effects on the educational outcomes of the Catholic missions in Mexico were very important, and attributes a greater impact to the Franciscan missions than to the Jesuits. However, Waldinger (2014), in analysing the Catholic missions in Venezuela, finds a long-term negative effect for the Franciscan missions and a positive and significant change for those run by the Augustinians. This, then, is a debate that remains open.

This article is organized as follows. Section 2 introduces some of the basic characteristics of the Guarani Jesuit missions. Section 3 explains the methodology used to measure human capital with numeracy levels. It also describes the source (the census of Indians), the content and the way in which the information wa obtained, as well as the details of the missions that make up the sample. Section 4 shows and discusses the main results. Finally, section 5 presents the conclusions.

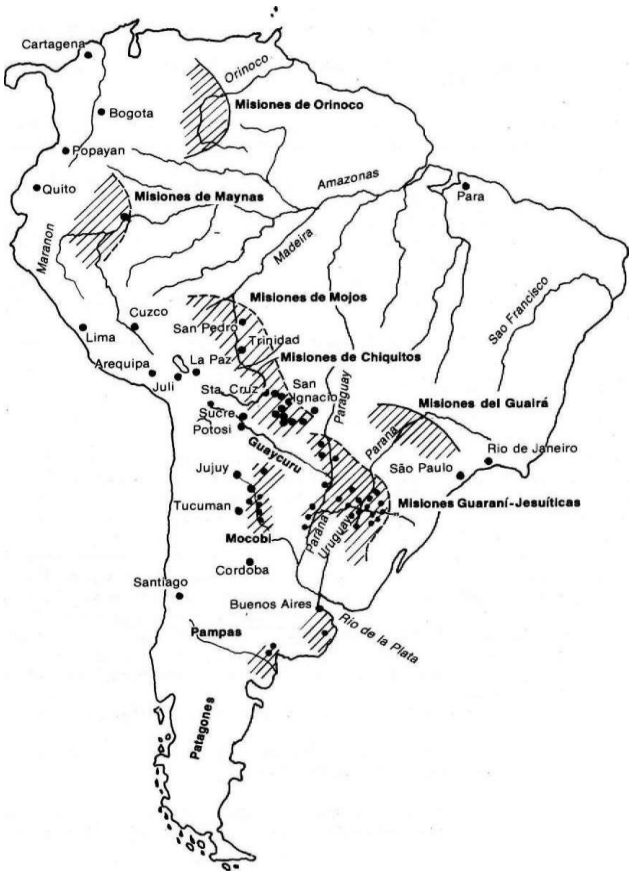
2. The Guarani Jesuit missions: historical background

The Christian missions or reductions were establishments promoted by different religious orders to evangelize the original peoples in different areas of the world. The Jesuit missions in South America were mainly frontier missions, as can be seen in Figure 1 (Bruno 1966, p.254). They also founded missions on the northern border of the Hispanic Monarchy, in what are now Baja California (Mexico) and Alta California (USA). The Jesuits first arrived in South America in 1549, in Salvador de Bahia in Brazil, and later settled throughout the continent. Their missions were modelled on the experience of Juli, in present-day Puno next to Lake Titicaca (Peru), the

first reduction with an indigenous population founded by the Jesuits in 1565[4]. The objective of the mission was to obtain productive self-sufficiency to improve the conditions of daily life, promote the education of the Indians, evade the *encomienda* regime by paying taxes thanks to their agricultural activities (Carbonell 1992, p.39), and in general, "to correct the abuses of indiscriminate exploitation to which they [the native people] were subjected in the early days of the conquest" (Maeder 1995, p.75). In any case, the final objective of all these measures was to accelerate and facilitate evangelization[5].

FIGURE 1

Location of the Jesuit missions in South America



Source: Bruno, p. 254 (1966)

[4] Initially, the Jesuits went to the big cities (Bogotá, Buenos Aires, Lima and Mexico City) where they mainly educated the elite Creole women. After Juli's first experience with indigenous people, others followed in what is now Peru (mainas), Bolivia (chiquitos and moxos), Colombia and Venezuela (Casanare and Orinoco), Mexico (Baja California) and the US (Alta California). Valencia Caicedo (2019b).

[5] "It is hard to overemphasize the value of education for the Jesuit order. Jesuits were at the technological frontier of the time, and their cultural contributions to music and the arts are well known [with] achievements in cartography, ethnography, linguistics, botany, mathematics, and medicine. Jesuits introduced the printing press to Argentina, Brazil, and Paraguay and even established an astronomical observatory in San Cosme and Damián, in modern-day Paraguay" (Valencia Caicedo 2019a, p. 515).

The Jesuits arrived in Asunción (Paraguay) in 1588 and later founded the first Guarani missions at the beginning of the 17th century (1609). These missions were in operation for a long time until the expulsion of the Society of Jesus in 1767 by order of King Carlos III. Throughout this period the Jesuits created new settlements where they located large communities of Guaranis, who had had a semi-nomadic lifestyle until then[6]. The Guarani-Jesuit missions were established in an area between the basins of the Paraná and Uruguay rivers, and offered tens of thousands of Guaranis an education that included reading and writing in Guarani, basic arithmetic and trades[7]. They were exempt from the *encomienda* service, and were further away from the main population centres than, for example, the Guarani Franciscan missions, which gave them a greater degree of independence. The evangelization was carried out exclusively in Guarani, the language of the inhabitants of the reductions, so that the Jesuits created important foundations for the survival of this language, which is an exceptional case of use (and conservation) of the indigenous languages of Latin America (Lustig 1996)[8]. The Guarani language in its different variants seems to have been a fundamental unifying element for the formation of the missions (Wilde 2016).

The territorial organization of the Guarani Jesuit missions was based on a legal system constituted by royal decrees or *cédulas*. There were a total of thirty Jesuit missions or towns distributed in a vast region that at present includes three states: Argentina, Brazil and Paraguay. The missions developed most during the 18th century, which led the Jesuits to organize the thirty missions in two districts. The first included the communities on both sides of the Paraná River[9]. The second district covered those located on the two sides of the Uruguay River (Jackson 2004)[10]. Its location can be seen in Figure 2 and its current territorial distribution would be fifteen missions in Argentina, eight in Paraguay and seven in Brazil.

[6] In the first years up to a total of 14 of the first 20 reductions that existed in 1640 were relocated due to various conflicts (Maeder, 1995).

[7] Except for the initial reductions, most Jesuits were governed by legislation passed by Francisco de Alfaro in 1611.

[8] Its use as a language of evangelization also involved a transformation of the grammatical structures of the original Guarani to Indo-European syntax and the coinage of neologisms.

[9] They were San Ignacio Guazú, La Fe, Santa Rosa, Santiago, Encarnación de Itapúa, Candelaria, San Cosme y Damián, Santa Ana, Loreto, San Ignacio Mini, Corpus Christi, Jesús and Trinidad.

[10] This group included St. Joseph, St. Charles, The Holy Apostles, Conception, St. Mary Major, St. Francis Xavier, The Holy Martyrs of Japan, St. Nicholas, St. Louis Gonzaga, St. Lawrence Martyr, St. Michael, St. John the Baptist, St. Angel Custos, St. Tome, St. Francis Borgia, La Cruz and Yapeyu.

FIGURE 2

Location of the Guarani Jesuit missions

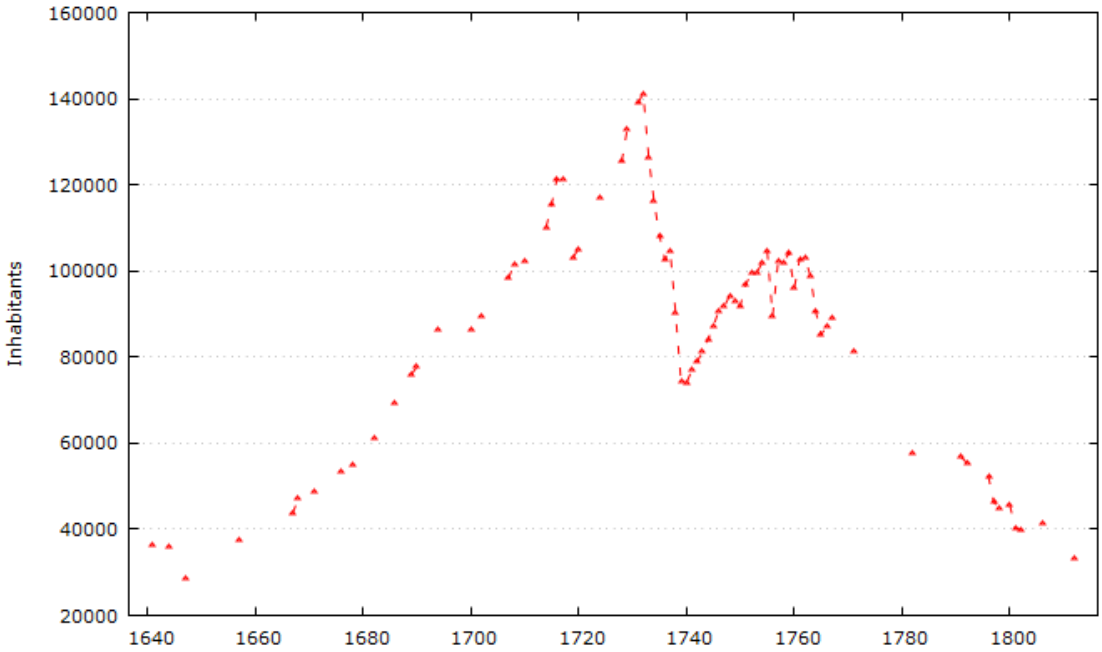
Source: Own elaboration

The evolution of the population of the Guarani missions between 1642 and 1812 is shown in Figure 3. In the middle of the 17th century the combined population was around 40,000 inhabitants. From then on, we can see its spectacular increase during the Jesuit period, which led to a maximum population in the missions in 1732, when 141,182 Guaranies lived there (Carbonell 1992, p.274). This continued increase in population was only limited by two very large demographic crises in 1712, and particularly between 1733 and 1736, caused by smallpox. In the middle of the century, the Guarani wars took place as a consequence of the signing of the Treaty of Madrid in 1750, in which the Spanish and Portuguese empires established new borders that affected the reductions[11]. Finally, the subsequent fall in population shows the decline of the missions after the expulsion of the Jesuits in 1767. Just before the independence processes, the population of the missions had already returned to values similar to those of the beginning of the period.

[11] For the Spanish Crown, the Guarani were legally considered subjects of the king, a fact that prevented them from being enslaved, unlike the Portuguese Crown. In this context, the division of the empires and the layout of the borders agreed upon by the two crowns in the Treaty of Madrid in 1750 meant that seven reductions were transferred to Portuguese territory, which opened the door to possible enslavement of the Guarani. The Guaranis rebelled, giving rise to the Guarani wars that led to the drafting and approval of a new treaty (Pardo 1761) that established that the missions would remain in Spanish hands.

FIGURE 3

Demographic evolution of the Guarani missions 1642-1812



Source: Own elaboration based on Livi-Bacci & Maeder (2004)

The political organization of the Jesuit missions combined two types of authority: the native one, exercised by the cacique (Tuvichá or Mburuvichá); and the one imposed by the Jesuits through the corregidor or indigenous cabildo. The combination of the two figures sought (apparently successfully) to maintain social cohesion and the two Jesuit fathers assigned to each reduction played the role of privileged mediators (Wilde 2001). These were the priest (paí tuyá), responsible for the economy and planning, and the vicar (paí miní), who was usually a young man destined to learn the language and who fulfilled the functions of the catechist, with spiritual responsibilities (Álvarez 2014). The death penalty and torture were prohibited, and any sanction required a previous trial and the penalty had to be appropriate to the crime (Carbonell 1992, p. 203).

Its military organization was fundamentally different from that of the chiefdom (Takeda 2014). Despite their high organizational hierarchy, the Guarani themselves played a crucial role in the functioning of the mission. The presence of only two fathers is insufficient for explaining their successful performance. It was a process of Guaranization of the mission, similar to what happened later in the African missions, emphasizing the role of the local agency. The autonomy of each village, with its particular endowment of natural and human resources, stimulated technical adaptation, creativity and specialization, as well as the disinterested dissemination of knowledge and technical skills (Carbonell 1992, p. 161).

In the economic field, the Jesuits modified the Guarani behaviour and organized productive work in agriculture and cattle raising (Cuervo 2014). The missions had a mixed economic system (Sarreal 2014). On one hand, there was private property (abambaé), and on the other hand, common property (tupambaé), on which everyone worked to support the religious people and the widows and orphans. Each family was assured of their livelihood because all of them were given a plot of land as well as the tools to harvest and do essential craft work[12]. The common property occupied a space similar to the private one and each Guarani had to work on it at least twice a week to pay the tribute to the Crown and to sustain the social and defence structure of the reduction. The Jesuits also encouraged savings and the collection of food. This allowed them to obtain surpluses that were saved for times of shortage. In turn, these surpluses could be distributed to other missions in need (free of charge), or marketed through the Procuratorates or Offices located in the cities, for storage and marketing in the regional circuits (Wilde 2001).

The economic dynamism of the reductions was remarkable. With the arrival of the Jesuits, livestock rearing, mainly cattle became an important part of their activity and the basis of their diet. Along with traditional crops such as cassava or corn, their main crop was yerba mate, of which they had between 20 and 30% of the market in Santa Fe and Buenos Aires. Similarly, in the 18th century, the Jesuit missions provided between 60 and 90% of the cotton canvases sold on the coast of the Río de la Plata. With respect to other products, they were responsible for between 30 and 60% of the production of sugar and between 15 and 30% of the tobacco circulating in the Buenos Aires market, as well as 10% of the total hides exported to Europe (Moraes 2011). In addition, the dynamism of the missions' economies had an important influence on the whole region, such as Uruguay (Moraes 2008). The departments in the northwest of the country, territories that had been under the influence of the Jesuit cattle ranches[13] in what is known as the Missionary North, had a high per capita income even in the mid-nineteenth century (Martinez-Galarraga et al. 2019).

Culturally, all children were taught writing, reading and basic arithmetic between the ages of 6 and 12 (Ganson 2005; Labrador 2006). The Jesuit missions were the first to print books in South America, with the incorporation of the printing press from 1700 (Rizzo 2014). Many of the works were printed in Guarani, which indicates that the vernacular language was used in

[12]The daily dietary contribution per individual of the Guarani people in 1766 in energy expressed in grams was 2,508.8 kilocalories; 84.1 grams of protein and 58.6 grams of fat (Carbonell 2003, p.107).

[13] The cattle ranches (estancias or vaquerías) were unguarded communal cattle reserve spaces, delimited by water currents, at the service of the mission system to supply them with meat.

teaching (Cardiel 1989)[14]. The reductions also had a library,[15] and music and art were taught. The adults were instructed in craftsmanship and construction, and one of the missions was specialize in the manufacture of stringed instruments. In order to improve their training and apprenticeship, the Jesuits also brought in European craftsmen to professionally train the Guarani people in the latest technical developments taking place in Europe (Carbonell 1992, p. 208).

The Jesuits were expelled from the territories of the Spanish Crown, including all of its Latin American colonies, in 1767, as they had previously been expelled from France and Portugal. The execution of the expulsion of the thirty missions was carried out in July under the supervision of the governor of Buenos Aires, and took no more than a month (Wilde 2001). Once it was carried out, the Jesuits were replaced by other religious orders and a lay administrator, and they did not return to the area again. From the point of view of organization, the greatest difficulty after the expulsion lay in finding doctrinaire priests in charge of the religious life, education and teaching of minors at a time when a minimum of seventy religious people were needed with the minimum condition of knowing the Guarani language. The work was entrusted to three religious orders (all of them mendicants) existing in the terms of their jurisdiction: Dominican, Franciscan and Mercedarian. These were distributed in an arbitrary way but arranged so that each order did not have two neighbouring reductions (Martinez Martin 2013).

In addition, general provisions on production, work, pay, possession of goods, trade and residence were established in the missions after the expulsion. Likewise, Spanish dress was made compulsory, the teaching of Spanish was introduced through the schools with lay teachers, and the union of mixed marriages was encouraged with the aim of assimilating the Guarani, a policy that would be intensified over the years (Quarleri 2003). It was in this context, following the expulsion of the Jesuits, that the economic and demographic decline of the missions began[16].

[14] This was common in the African missions, for example, where the intention of Christian conversion prevailed over the imposition of the language of the metropolis (Frankema 2012).

[15] The library of the Candelaria mission, with book loans to the thirty villages, had in its inventory of 1768 a total of 102 books on mathematical subjects (Carbonell 1992, p.160).

[16] In addition to the demographic decline, an example of the decline can be seen, for example, in the supply of meat per Guarani family, which in 1786 had fallen by half compared to 1766 (Carbonell 2003, p. 296).

3. A New Source for Measuring Numeracy: los padrones de indios

3.1. Methodology: age-heaping as a proxy for numeracy

Numeracy is a person's ability to calculate, understood as the ability to process, understand and transmit mathematical and numerical information. The basic arithmetic ability is a good indicator of the informal training that takes place in the periods prior to compulsory schooling. It is common to use age-heaping calculations to obtain historical data on arithmetic ability (Mokyr 1985; A'Hearn et al. 2009). This refers to rounding ages into numbers ending in zero or five when a person does not know his or her exact age. For this reason, there is age heaping in a census (and consequently less arithmetic ability) when there is an inflated frequency of observations with numbers ending in zero and five[17]. This is why age heaping is an indicator of the numeracy level of a population and is considered a good proxy for arithmetic ability (Blum & Krauss 2017).

The degree of age-heaping, and therefore the level of numeracy, is usually calculated using the Whipple Index (WI). This index relates the number of ages ending in zero or five over the total population (normally) between 23 and 62 years old. The WI is calculated using the following formula:

$$WI = \frac{\sum_{i=5}^{14} n_{5i}}{\frac{1}{5}\sum_{i=23}^{62} n_i} \; x\; 100$$

where i represents the years of age and n the number of observations. The range of WI values is between 100 and 500, where 100 means no age heaping (i.e., high level of numeracy), and 500 indicates that all observations end in zero or five (low numeracy). To facilitate interpretation, A'Hearn et al. (2009) propose a linear transformation of the WI, called the ABCC index, which has the following formulation:

$$ABCC = \left(1 - \frac{WI - 100}{400}\right) * 100$$

The ABCC index has the advantage that it is easier to understand than the Whipple index because the values are between 0 and 100, where one hundred is the maximum arithmetic capacity and zero is the minimum. In this article, as usual, the observations of the age cohorts between 23 and 62 are used for calculating the age heaping indicator. In the age cohort between 23 and 32 years old, and due to the possibly greater ability to remember age, we applied the

[17] The reason for using numbers ending in zero and five when a person does not know his own age is biological. In most cultures around the world, people learn to count using their hands and fingers because we use our bodies to communicate with other individuals (Sheets-Johnstone, 2010).

correction factor proposed by Crayen and Baten (2010). Finally, at this point it is worth mentioning that, although the original Guarani numbering system was based on multiples of four, the Jesuits taught them the decimal system by adapting their language to it (Barreiro1986).

Age heaping can be used as an indicator of the arithmetic abilities of a group of individuals, but it also refers to the conditions and factors of the environment where it is located. For this reason, in periods where education is widespread it has a high correlation with literacy (A'Hearn et al. 2009) and other environmental factors such as height (Baten et al. 2014). In contrast, other authors question whether age heaping is a good proxy for numeracy (Spenneman 2017), while others indicate that more than an indicator of cognitive skills, what it could show is institutional and cultural modernization (A'Hearn et al. 2019). In addition, the quality of local censuses for calculating numeracy varies according to the time and place (Szołtysek et al. 2017).

3.2. Los padrones de indios: population counts in the Jesuit missions

To be able to use the age-heaping methodology, it is necessary to have the ages of a set of populations individualized and not grouped. In the case of the regions that were under the dominion of the Spanish empire during the Modern Age, there is a source for obtaining these individualized ages: the registers. Unlike the sources used in works that exploit age heaping, the registers are not a fiscal source, although they could be applied for this purpose, so there are less biases and concealments than in other works of the same period.

In the case of Latin America, municipal registers can be found mainly in urban areas, as in the Iberian Peninsula. However, in Latin America, the methodology for drawing up the registers was also applied to the different communities of native peoples living outside urban environments, including villages, haciendas and missions. Therefore, a singularity of the registers of Indians is that they often differentiate the origin of the neighbours (Spanish, mestizo, black or Indian) in agrarian communities. In any case, the purpose of the registers was to monitor the size of the population, although they were also used for other purposes, such as applying the rules of the *encomienda* system, a socio-economic institution through which one group of individuals were forced to pay another in work, kind, or other means, or to collect the respective fees (Salinas 2018).

The Jesuit missions also prepared these censuses when they were ordered to by the viceroyalty governors, following the monarch's instructions. From 1647 onwards, the viceroy count of Salvatierra declared the Guarani people vassals of the Crown in return for their role in the fight against the Paulist invasions of Brazil. This implied that each Guarani man between the age of 18 and 50, in recognition of the lordship of the monarch, had to pay a peso of eight reals of

silver, in currency and not in fruit. For collection purposes, it was established that the royal officials of Buenos Aires would be in charge of the census (Martínez Martín 2003). Later, the Royal Decree of Felipe V of 1726 regarding the Guarani missions indicated that the census would be ordered by the Governor of Buenos Aires in agreement with the doctrinaire fathers[18]. In addition, they had to be repeated every six years, and a copy sent to the Council of the Indies[19], although the follow-up was very irregular (Muratori 1999, p. 268).

After the expulsion of the Jesuits, standards continued to be drawn up. Governor Bucaleri issued instructions in 1768, entrusting subordinate governors to make the censuses of their villages. These were organized according to the laws of the Indies, paying particular attention to the caciques with the aim of consolidating their social role within the village[20]. The main objective of these censuses was to exercise control over the tax of Indians and to know how many were exercising this position, with respect to bias and how many Indians made up their chiefdom (Martínez Martín 2003). In certain cases and with the appropriate checks, the registers are a reliable source, although sometimes they have limitations (Marino 1998).

One of the crucial aspects to be taken into account in this type of work, since it is key to validating the strategy of calculating age heaping, is the way in which the information related to age is collected, in this case, for the elaboration of the standards. The registers of the Guarani missions have proven to be a high quality demographic source (Livi-Bacci et al. 2004). Moreover, the temporal and methodological continuity of the Jesuit mission registers gives the source a homogeneous character for the whole colonial period, both during and after the presence of the Jesuits.

Each mission was administered, as mentioned above, by two Jesuit fathers, who were responsible for thousands of Guaranis. One of the two priests was responsible for the spiritual government and the other for the organization of life in the mission. The daily power was exercised by the caciques[21], who were part of the cabildo. In turn, the reduction was divided into large communal houses and each communal house was under the orbit of a cacique. These

[18] "Royal Decree, foreseeing what is to be observed in the Missions and Indian villages of the districts of Paraguay and Buenos Aires, which are in the charge of the Fathers of the Society of Jesus".

[19] The Council of the Indies was the body that advised the King on the executive, legislative and judicial function of the Indian administration (Americas and the Philippines). The members of the Council of the Indies were appointed by the king, they were generally enlightened and competent persons with legislative powers over America, appointed viceroys, governors, ombudsmen, judges, among others. They also exercised the right of patronage.

[20] The caciques were exempt from taxation, as were the first-born sons.

[21] The cacique of each house was a kind of representative, similar to the colonial figure of civil character, but in practice this was a formal position without implying, for example, a position of representation or even leadership within the community or the house.

houses accommodated the large Guarani families, in many cases with more than a hundred members, and all those living there were considered relatives (Álvarez Kern 2013).

The residential units were distributed around a large central square (okara) for collective use. In order to draw up the census, those responsible were called to the public square and each inhabitant was registered according to the data declared by that person (Takeda 2016). The distribution of the information from the census used is based on the emptying of all the people living in each house with their main characteristics (age and kinship). In some cases, the names of those responsible for compiling the registers and the date on which the information was collected are known. These were drawn up both by the Jesuits and by the secular authorities after the expulsion following this system. It is recorded that lists were drawn up for the 30 Guarani villages in the years 1656-57, 1676-77, 1715, 1721, 1735, 1759, 1772, 1777, 1784, 1794, 1799 and 1801.

Of these, only some of them are preserved, and some are in a state of difficult transcription. In this work, we consider six lists of Indians referring to Guarani missions with the aim of obtaining a representative geographic and temporal coverage. The reductions included in the work, along with some of the characteristics of the information provided by the census, are shown in Figure 4. Of these six entities, one of them corresponds to the census of the town of San Javier in 1785, located in northern Santa Fe, and founded by the Jesuits in 1743. This was a reduction of the Mocovíes aborigines[22], and had a production and organizational structure similar to that of the missions. The Jesuits, besides providing them with basic education, taught them various occupations, arts and crafts, which meant a significant transformation of the place and the way of life. Moreover, their inclusion for the 1780s, together with the reduction of Santo Angel, makes it possible to analyse the mark left by the Jesuits after the expulsion of the Society of Jesus in 1767, when San Javier passed first to the Mercedarians and then to the Franciscans (Saeger 1985; Moriconi 2012).

The five missions analysed and the town founded by the Jesuits are grouped into three temporal moments. In 1735 we have two censuses: San Javier and San Cosme[23]. It should be noted that this year corresponds to the time immediately following the maximum population of the Guarani missions, but also to a time when thousands of Guarani died from epidemics in 1733,

[22] The Mocovíes are an indigenous people of the Chaco area who have been separated from the guaicurú group. Their language is part of the mataco-guaicuru linguistic family and is still spoken in some of the areas they inhabit in the provinces of Formosa, Santa Fe and Chaco.

[23] The full name of this last reduction was San Cosme and San Damián. In order to simplify, from now on we refer to it simply as San Cosme.

1735 and 1736[24]. By 1759, having overcome the impact of the mortality crises, the census of Santa Ana and Nuestra Señora de Loreto was available. Finally, by 1785, once the Society of Jesus had been expelled, the padrones of Santo Ángel and the town of San Javier were available. These years (1759-1785) coincided with Carlos III's reform agenda to strengthen the administration and military defence of Spanish America, which led to a change in the crown's attitude towards the missions as a frontier institution.

FIGURE 4

List of Indian registers and censuses of the sample with its characteristics

Year	Reduction	Region	Country	N	N(23-62) men	N(23-62) women
1735	San Francisco Javier	Misiones	Argentina	2,497	589	-
1735	San Cosme y San Damián	Misiones	Paraguay	1,143	394	-
1759	Nuestra Señora de Loreto	Misiones	Argentina	3,322	903	-
1759	Santa Ana	Misiones	Argentina	3,191	956	-
1784	Santo Ángel	Misiones	Brazil	2,032	445	343
1785	San Javier (Pueblo)	Chaco	Argentina	1,038	287	231
	Total			**13,223**	**3,661**	**574**

Sources: San Francisco Javier, 1735: padrón de indios AGNBA; San Cosme & San Damián, 1735: padrón de indios AGNBA; Santa Ana, 1759: padrón de indios AGNBA; Nuestra Señora de Loreto, 1759: padrón de indios AGNBA; Santo Ángel, 1784: padrón de indios AHPO; San Javier Pueblo, 1785: padrón de indios AGSF[25].

Together, these six entities had a population of 13,223. The population used for the age-heaping calculations totalled 3,661 men between 23 and 62 years of age, which is therefore the set of observations available for the study of the Guarani missions[26]. Figure A.1 in the Appendix provides a sample of these standards, which also reflect the social organization established in the reductions. As mentioned, the Guaranies were organized in collective houses in which various family units lived and had some kind of personal/family bond. Thus, the censuses present the information house by house, detailing the different families that live in each house. Information is provided on the structure of each family (marital status, sex, number of

[24] An indication of the high mortality is that in the censuses used in 1735, young children and women sometimes appear as substitutes for adult chiefs killed during epidemics.

[25] AGNBA: Archivo General de la Nación Buenos Aires; AHPO: Archivo Histórico de Porto Alegre; AGSF: Archivo General de Santa Fe.

[26] To these should be added 574 women in the reductions of Santo Angel and the village of San Javier in the 1780s, which gives a total of 4,235 observations.

children)[27], and the status of those people who for various reasons had a different situation within the houses (caciques, reserved, fugitives, orphans, widows) is also indicated[28].

A determining factor in applying this methodology is whether the age indicated by each of the filers was compared with the date of birth of each of those registered in the baptismal book. For example, the instructions for preparing the census of Larrazábal in 1772 included a comparison with the baptismal and burial books (Martínez Martín 2003). However, other registers did not make this aspect explicit in their instructions (besides which, it is not possible to ascertain whether this comparison was actually made) and in the registers used for this research everything suggests that the age was not compared. There are several reasons for this statement and two of them are linked to the results.

The first is that the distribution by age cohorts is not homogeneous, and if they had been matched, this difference would not have occurred[29]. The second is that there are differences in the results between the respondents and the fugitives. Of the latter, whose age was declared by a close relative, their name and surname were available and the age could have easily been compared. Two other reasons are linked to the actual completion of the registers. This hypothesis seems to be reinforced by the fact that the results differ due to changes in administrators (change of religious order) and the institution conducting the census (preparation by officials). Moreover, the censuses were made in only a few days, with a small structure and for a very large population. In any case, although the Guarani themselves provided their ages, it must be borne in mind that it is a documentation source that served the interests of the occupying institution (Jesuits or the Crown), and therefore, like all documentation available for the period, does not give the original peoples' point of view.

4. Results

4.1. Age heaping and numeracy in the Guarani Jesuit missions

The general results of arithmetic ability in the Jesuit Guarani missions throughout the eighteenth century are shown in Figure 5. The observations grouped around 1735 and 1759 include four

[27] By the 18th century, the Guarani people of the missions had become monogamous and joined in marriage.

[28] The reserved ones are those who were exempt from paying the tax as they were over 50 years old. Fugitives refer to those who had escaped from the reduction (which often happened).

[29] Figure A.2 in the Appendix shows the results by age cohorts. Each census is divided into four age cohorts (23-32, 33-42, 43-52, 53-62) and the results of each are shown. The same census has decreases in some cohorts, which indicates that the data of a census are not homogeneous and would not have been contrasted. Furthermore, these decreases seem to have similar patterns between the different missions and coincide with the two demographic crises that occurred in the period studied.

reductions (two in each year) that reflect the situation when these were under the supervision of the Society of Jesus. Around 1785, data from two census surveys show the levels after the expulsion of the Jesuits. In all cases, the results show extraordinarily high levels in terms of the ABCC index throughout the 18th century. Both in 1735 and in the middle and end of the 18th century, values close to 100 are observed in all the reductions, i.e. the practical absence of age heaping. This would indicate that, regardless of their location and over time, the Guarani Jesuit missions had reached high levels of numeracy. The only exception would be the Santa Ana reduction, which has lower ABCC values; however, in any case, they are still remarkably high (above 95).

FIGURE 5

Levels of ABCC in the Jesuit missions 1735-1785

Year	Reduction	ABCC
1735	San Cosme & San Damián	100
1735	San Francisco Javier	99
1759	Nuestra Señora de Loreto	99
1759	Santa Ana	95
1784	San Angel	98
1785	San Javier (Pueblo)	99

Sources: San Javier, 1735: padrón de indios AGNBA; San Cosme y San Damián, 1735: padrón de indios AGNBA; Santa Ana, 1759: padrón de indios AGNBA; Nuestra Señora de Loreto, 1759: padrón de indios AGNBA; Santo Ángel, 1784: padrón de indios AHPO; San Javier Pueblo, 1785: padrón de indios AGSF.

Likewise, the census for the 1780s provides separate data for men and women in both the mission of Santo Angel and the town of San Javier. For the town of San Javier, there are hardly any differences between the ABCC of men and women, and in both cases the index is close to 100. This seems to imply, with the necessary caution as these data are only partial, that the Jesuit missions also had a positive effect on education for women. It should be kept in mind that school attendance in the missions, even if segregated by sex, was compulsory for both boys and girls.

These results are in line with the literature that suggests that the Guarani Jesuit missions had a positive effect on forming human capital (Valencia Caicedo 2019a). At a time when formal education in any other region of the world was still very scarce (compulsory primary education would come later), the high ABCC would confirm that the education given by the Jesuits in the missions effectively reached all the inhabitants of the reductions. Likewise, the fact that these values were maintained in the census carried out at the end of the eighteenth century after the expulsion of the Society, would indicate a persistence in the effects of the formation offered by

the Jesuits[30]. The works of Valencia Caicedo (2019a) and Valencia Caicedo and Voth (2018), point out that the Guarani could have transmitted that knowledge between generations beyond the institution through non-cognitive skills and pro-social behaviour.

The evidence gathered in various works that follow the age-heaping methodology shows that the arithmetic capacity levels in various regions of Latin America under the domination of the Hispanic Monarchy between 1700 and 1800 were much lower than those recorded in the Guarani Jesuit missions. For example, by the 1780s, the main cities in Latin America had ABCC index values ranging from 60 to 70. This is the case of Buenos Aires, Cartagena de Indias, Mexico City, Montevideo and Sao Paulo (Figure 6). Decades earlier, at the beginning of the century, around the 1720s, other important capitals such as La Paz and Lima had clearly lower ABCC values, 57 and 45, respectively, as did the city of Buenos Aires itself at that time (ABCC=50). Differences are thus greatly in favour of the Guarani Jesuit Missions.

In turn, Figure 6 also shows that the numerical capacity of the Jesuit reductions far exceeds that obtained in the Iberian Peninsula, where the colonial metropolises were located. The data referring to the north of Castile, Catalonia and Portugal show ABCC index values between 70 and 80 in the first half of the 18th century[31]. These values are clearly below those observed in the Jesuit Guarani missions throughout the 18th century. This evidences once again the exceptionality of these missions within the Hispanic Monarchy in terms of access to education. This also takes into account that the areas with information available for Castile (Palencia, Madrid and Guadalajara) have traditionally had the highest levels of literacy and numeracy within Spain[32]. Finally, the extraordinary levels of numeracy achieved in the Jesuit reductions are clearly evident when they are compared with those of Western Europe, where ABCC values were usually between 80 and 90 at that time (A'Hearn et al. 2009). As shown in Figure 6, even for the areas with greatest numeracy in the 1750s, such as Protestant Germany and Denmark (ABCC=96), the values obtained in the Jesuit missions exceed this.

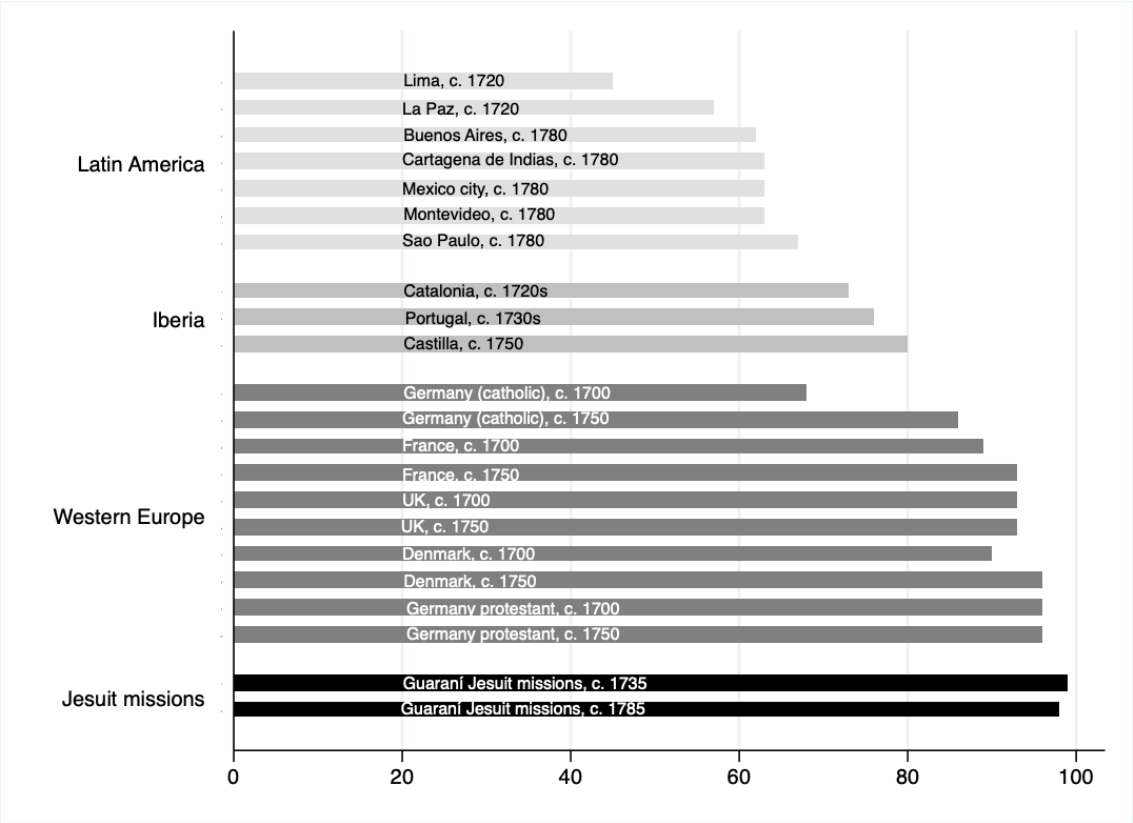
[30] Obviously, in order to contrast the persistence, it would be optimal to have data for the same reduction over time, before and after the expulsion of the Jesuits and for several generations, but this has not been possible and consequently this last result must be considered with caution.

[31] The data for Castile (for the current province of Palencia) come from the Ensenada cadaster of 1749 (Álvarez and Ramos Palencia 2017), while for Catalonia, population registers (padrons) were used, mainly for the 1720s (Gómez-i-Aznar 2019). For Portugal, see Stolz et al. (2013).

[32] This is shown by existing work carried out with census sources for literacy and numeracy in the mid and late 19th century (Beltrán-Tapia et al. 2018, 2019).

FIGURE 6

ABCC index in different world regions, 18th c.



Sources: Castilla: Álvarez and Ramos (2018); Catalonia: Gómez-i-Aznar (2019): Portugal: Stolz et al. (2013); Latin America: Manzel et al. (2012); Western Europe: A'Hearn et at. (2009)

4.2. Beyond the Guaranis and the Jesuits: other territories within the Spanish monarchy

In order to quantify the magnitude of progress in numeracy, and in human capital in general, obtained in the Jesuit missions, we will now study other areas dominated by the Hispanic Crown where there were settlements with indigenous communities as well as initiatives carried out by other religious orders, mainly the Franciscans, in this case in North America.

4.2.1 Indigenous, non-religious settlements: colonial exploitation from south Peru to Louisiana

Among the previous works on age heaping and numeracy during the colonial period in Latin America, those focusing on the Andean regions of La Paz, Potosi and Oruro probably bear the closest resemblance to the present study: they use a similar source, and the census collects only the native population (Vicario 2017). The region of Oruro obtains the value closest to that obtained by the Jesuit missions as it has an ABCC index of 87 for 1735. In the silver mines of Oruro there were only free workers, since the market of forced labour was prohibited, which attracted qualified workers due to the better living conditions. In addition, Indians and mestizos had greater influence in political institutions, which contributed to making it the first place in

the domains of the Hispanic monarchy where an anti-colonial revolution took place, in 1739. However, in the region of Potosi, which had an ABCC level of 60 by 1683, there was forced labour and the silver mines were exploited with slave indigenous populations obtained through the forced migration of the Mita. In La Paz there were many outsiders, who were those who had escaped from the La Mita system and had neither land nor animals, as well as the lowest castes of the Inca system (Urinsaya), and in 1684 this region had a value of 57. In both cases, these areas had much lower levels of numeracy (Vicario 2017).

In order to make a comparison with other regions under the rule of the Hispanic Monarchy, the census of the town of Paucarcolla, near the city of Puno, belonging to the viceroyalty of Peru, is available for 1728 (see Figure A.3 of the appendix). Paucarcolla is a town located on the north-western shore of Lake Titicaca, at an altitude of 3,500 meters, whose main activity was cattle ranching (Hampe 1985). The 1728 census was conducted as part of a general population count in the area of the Collao Plateau, a region that currently includes part of north-western Argentina, western Bolivia, part of northern Chile and part of southern Peru[33]. The 753 inhabitants of Paucarcolla appear in the census divided into four spaces: the *ayllus* aimaras, the *ayllus* urus, the *estancias* and the *ingenios* (Hampe 1985)[34]. The *ayllu* or *ejido* is a form of extensive social community in the Andean region of pre-colonial origin, based on common descent – real or supposed – that works collectively on a territory of archpriest property, and that was under the doctrine of a parish priest. They were self-sustaining units and their function was to educate their own children, trade and serve as a farm for all the food they consumed. On the other hand, the *estancias* were large extensions of land granted in property to a subject, a family or a religious order, mainly for the exploitation of cattle, and where the Indians (Yanaconas) who did not own land lived and worked (Klein 1995). Finally, the *ingenios* were a type of productive agro-manufacturing farm with facilities to process primary products in order to obtain other goods. Both the *estancias* and the *ingenios* therefore represent a typically colonial organization of exploitation where the owner (who does not appear in the census) was a colonist of Spanish origin, although sometimes they could belong to the clergy, and the workers were indigenous.

The results obtained for Paucarcolla as a whole give an ABCC of 91.2, a value which, when put in a comparative perspective, is surprisingly high. However, the results show two clearly

[33] This 1728 recount came shortly after the region was severely affected by the epidemic known as the Great Plague. The demographic decline had suspended the obligation of the Mita in those provinces farthest from the mining center, such as Paucarcolla (Zabala 1978).

[34] The Aymaras are a people originally from South America who have inhabited the Andean plateau of Lake Titicaca since pre-Columbian times, dividing their population between western Bolivia, northern Argentina, southeastern Peru and the Great North of Chile. The Urus are considered the oldest ethnic group of the Collao plateau and would have established themselves in this territory around 1200 B.C.

differentiated realities. While in the *ayllus* the ABCC was close to 100, in the estancias and mills the value was clearly lower: 79.5. Thus, Spanish domination in this area would have resulted in a society with a high degree of exploitation of part of the indigenous population and a social, occupational and ethnic differentiation that would have translated into very unequal ABCC index levels[35]. Even so, two aspects should be noted: The *ayllus*, with their collective organization, had extraordinarily advanced levels of numeracy, similar to those obtained in the Jesuit missions. However, in the case of the *estancias* and sugar mills of Alto Perú, the indigenous population that worked under conditions inherited from the *encomienda*, would also have been allowed to use the land as payment for the work done on the hacienda (Klein 1995), which could explain why the ABCC levels obtained are relatively high. Elsewhere in the empire, as we will see below, colonial exploitation would be more intense.

It was possible to obtain census data referring to other locations of the Spanish Crown where the institutions were also based on the exploitation of indigenous labour, in this case in North America. These settlements would be the antecedent of the plantations that would expand throughout the southern United States. The towns of Attakapas and Opelousas, located in Louisiana, were founded by French colonists between the end of the seventeenth and beginning of the eighteenth centuries. Following the Treaty of Paris in 1763, France ceded the historic territory of Louisiana to Spain, which it ruled until 1803 and which covered much of the U.S. Midwest.[36] These two settlements specialized during the 18th century in producing tobacco in plantations (Frederick 2000). These plantations or estates had a slave model that generated some conflicts during the period of Spanish domination, since unlike the Code Noir, which defined the conditions of slavery in the French empire, or the English or Anglo-American slavery laws, those of the Hispanic Monarchy prohibited the slavery of Indians but not the slavery of the coloured population, and also allowed the manumission of slaves (Webre 1984). Before passing into the hands of the Spanish Crown, the settlements used slave labour of Indian and African origin; however, from the O'Reilly decree of 7 December 1769 only slaves of African origin

[35] However, in this case, the aggregate gender gap would be very large (women ABCC= 58.3 vs. men ABCC=91.2). This gap occurred mainly in the estancias and mills (women ABCC = 46.5 vs. men ABCC = 79.5) but also in the ayllus (women ABCC = 71.2 vs. men ABCC = 100).

[36] The territory of the Spanish Louisiana covered an area of 2,275,940 km ² comprising in whole or in part, more than a dozen states of the current United States.

were available (Ingersoll 1996)[37]. This provoked resistance from plantation owners of French origin (Hall 1986)[38].

Attakapas had a population of 837 in 1777 (see Figure A.3 in the Appendix), which gives a sample of 203 men aged 23-62. Of these, 58.5% were landowners while the remaining 41.5% were slaves. For Opelousas, of the 738 inhabitants, a sample of 183 men between 23-62 years of age is obtained, 70% of whom are owners and 30% slaves. Under these conditions, as expected, the results show that there was a great disparity between the plantation owners and the slaves who worked on the plantations[39]. In Attakapas, the owners' ABCC is 84.2, a high value. The gap with the slaves is enormously significant, since in their case the ABCC is 18.5. A similar situation, although with a smaller gap, is found in the Opelousas settlement: the owners' ABCC is 71 while the slaves' is 25. In typically colonial societies based on exploitation, the numerical capacity is much lower, mainly among the exploited and enslaved population. This once again shows the exceptionality of the Jesuit missions within the colonial sphere. In any case, the differences between ethnic groups in Central New Spain by the end of the 18th century show the diversity of situations that could be found within the same territory (Calderón et al. 2020), as in the case of California.

4.2.2. Other religious settlements: Franciscans in California

In the whole of Latin America in the 18th century the presence of religious orders was dominated, as in the two previous centuries, by the Franciscans, who had more than 2,500 ecclesiastics carrying out tasks of evangelisation on the continent. The Jesuits were second with almost 2,000 ecclesiastics, and in third place was the Capuchins, who barely exceeded 500. The Dominicans, who had come to have a notable presence in the 17th century (1,500) had a testimonial presence in this century (Caicedo Valencia 2019b, p. 65). Together with the Jesuit missions, Franciscan missions were also established in the Guarani area. The Franciscan reductions were founded between 1580 and 1615, mainly in the vicinity of Asunción, and although they reached 11 reductions from 1660-1670 only four remained active: Itá, Caazapá, Yutí and Itatí[40]. The two religious orders both offered resistance to the requirements of

[37] Alejandro O'Reilly was the second Spanish governor of Louisiana. Of Irish origin, he was sent to re-establish control after the expulsion of the first governor by French colonists for restricting trade to only six peninsular ports. He punished the rebels severely, even to the point of publicly executing their six ringleaders. This repression was greatly criticized by the French population, and he is still remembered today as Bloody O'Reilly.

[38] Even so, the different governors adapted the regulations of the metropolis to the reality of the territory in order to avoid uprisings.

[39] The fact that there was a change of Crown would make the results largely attributable to the French colonial organization.

[40] The Jesuit missions were, in any case, more successful than the Franciscan missions in the Guarani area. According to Maeder (1995, p.71): "one can see a demographic stagnation in the Franciscan

indigenous labour, but the geographical proximity of the Franciscans to Asunción and the direct contact with the metropolitan authorities by the Jesuits for their defence before the local powers, caused the Franciscans to be under a regime of *encomienda* and the Jesuits to be exempt (Maeder 1995).

Valencia Caicedo (2019a) shows that the presence of the Jesuit missions in Guarani lands is positively linked to higher education and income levels in the present. This positive effect, however, does not appear in the case of the Guarani Franciscan missions. The reason given by this author for the different outcomes has to do with the differences in the organization of the missions of the different religious orders, and the lower interest in education of the mendicant orders, such as the Franciscans. The results obtained in the same period for Mexico, however, show a different outcome. Waldinger (2017) finds a positive impact of Catholic missions on educational levels, but the effect is stronger in the case of the Franciscan missions than in the Jesuit missions. However, in a previous work, Waldinger (2014) analysed the religious missions that were established in the territory of present-day Venezuela. In this case, however, while she found that the Franciscan missions had a negative impact, which he attributes to the colonial system of the *encomienda*, her work gives evidence that the Augustinian missions had a positive effect[41].

The results of the previous work are at best ambiguous. To delve further into these questions the analysis has been completed with the study of three Franciscan missions established in California for which information is again available thanks to the registers[42]. The California missions were based on the colonizing model of border institutions[43]. In the northwest of New Spain, after failed attempts by the Franciscans, the missionary work was carried out by the Jesuit religious people. As in the Guarani missions, they prevented contact with the settlers and the Indians from working for them[44]. The missionaries taught and encouraged agricultural

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reductions and a greater dynamism in the Jesuit missions: while the former barely maintain a stable number of inhabitants and villages, the latter increase their population and the number of their reductions". Unfortunately, it has not been possible to locate the census of these Franciscan reductions.

[41] Other work has focused on missions in Africa. For example, Fourie & Swanepoel (2015) show the levels of numeracy in various Protestant missions in South Africa in 1849, with ranges from 24.2 to 76.3. Even so, the South African missions are considered to have been key to the high arithmetic levels of slaves born in that country compared to other areas of Africa.

[42] California State Archives (CSA). See appendix A.3.

[43] Along with the missions, the Spanish colonization incorporated prisons and villages. The prison was a military post with a population settlement that protected the missions. The towns were settlements of colonists promoted and financed by the crown to prevent the preponderant role that the missions had in the Jesuit system. In addition, the creation of ranches was promoted as instruments of colonization of the large spaces that remained unpopulated between the Missions, the pueblos and the presidios.

[44] As it happened in the missions of Paraguay, the settlers who followed the Jesuits in their advance, accused them of monopolizing the best lands.

activities such as the cultivation of crops like grape vines, corn, wheat and cotton, and the raising of livestock. The Indians, who carried out all these tasks, received two daily rations of corn and meat and once a year fabrics and clothing. In addition, they promoted construction sites where soap, shoes, fabrics, clothes, etc. were manufactured, products that increased the economic power of the missions (Ortega Soto 1999)[45]. The Jesuits undertook the colonization of Baja California in 1697. The expulsion stopped their plans to extend over Upper California, but the base of the subsequent colonization was the former Jesuit missions in the northwest since the Franciscans not only based their model on productive self-sufficiency and the teaching of the gospel, but the resources to undertake the evangelizing enterprise were obtained from the expropriated Jesuit missions[46].

This makes the study of the California missions particularly interesting as it is, to a large extent, an exceptional case: that is, Franciscans founding and managing missions following the (successful) guidelines carried out by the Jesuits in Baja California[47]. The previous links between the two orders in this region, with a dynamic in which persuasion replaced force (Osante 2010, p.52-55), would explain in this case the similarities of the methods used to found the missions in this area (Ruíz et al 2014). Upper California had a sedentary population despite not practicing agriculture, and they lived from hunting due to the great abundance of environmental resources (Ettinger 2010). The introduction of cattle into the region by the Franciscans generated tensions between indigenous villages and missions, as the indigenous people lost an important source of food as cattle consumed the pastures that served as food for the native population. They moved to the missions because of food shortages, as they found a more reliable food supply there (Jackson et al. 1999), and thus changed their eating habits (Albert et al. 2011)[48]. One of the main differences was that the Franciscans made occasional use of soldiers from nearby prisons in the case of conflict[49]. To overcome the barriers some friars learned the native languages and wrote bilingual catechisms, and although the teaching of

[45] The obrajes in colonial America, and especially in New Spain, were small industries that existed from the mid-sixteenth century until the nineteenth century, where different products were manufactured, especially textiles, by mainly indigenous labour.

[46] The financing of the expeditions was provided by the Royal Treasury, which used the Pious Fund of the Californias, which had passed into its hands following the expulsion of the Jesuits. Indians, cattle, seeds and even working tools and church ornaments for the new missions were obtained from the Baja California establishments.

[47] The group, led by Majorcan Fray Junípero Serra (founder and president of the new missions of Upper California, 1769-1784), had acquired extensive experience in the Sierra Gorda and Baja California for almost 20 years (Rex 2007).

[48] Jackson (1999) establishes a statistical relationship between the number of livestock in a mission and the incorporation of the native population, showing the relationship between livestock development, the destruction of the natural habitat of the indigenous people and the preference for missionary life.

[49] The native Californians who received the Franciscans best were the Juaneños, the Gabrielinos, the Tataviam, the Chumash and the Salinan.

Spanish was promoted, at the end of the 18th century the Franciscans recognized the use of the native languages in the missions (Rex 2007)[50].

In this case we have information regarding three Franciscan missions in the second half of the 1790s: St. Anthony, St. Louis and Soledad. Of these three missions, the one with the largest population was San Antonio (1,137), followed by San Luís (792) and Soledad (344), all of which were inhabited by indigenous communities[51]. The total sample of men between 23-62 years of age in these three missions together amounts to 891 individuals (see Figure A.3 in the appendix). The results show that these Californian Franciscan missions, with similar patterns to the Guarani Jesuit experience, show ABCC index levels of 100 or close to it[52]. These results, i.e. the absence of age heaping, reinforce the view that certain Catholic Christian missions during the colonial era were successful in offering their indigenous mission inhabitants a high level of education, in this case in terms of numeracy, which, moreover, as noted in Waldinger (2014, 2017) and Valencia Caicedo (2019a), has been shown to be persistent over time, making its effects felt even today.

5. Conclusions

The results obtained in this work suggest that the knowledge of numerical skills in the Guarani Jesuit reductions throughout the 18th century was exceptionally high. Although the sample analysed has more than 3,600 observations altogether, the diversity of local situations means that an overall image can only be elaborated with caution; however, the results obtained seem to indicate that the level of calculation capacity in the Jesuit Guarani missions, as well as those in Alta California that replicate the mission model, was close to one hundred percent in the 18th century. These levels are much higher than any region under the rule of the Hispanic Monarchy during that same period, and are only comparable to the more advanced countries in Western Europe. Moreover, they seem to be persistent over time.

These results confirm the positive vision of an institution, as indicated in the literature, which was one of the first in the world to school the whole population. At a time when the rest of the Hispanic Monarchy was teaching in an informal education environment, and learning in the

[50] When the Franciscan friars arrived in 1769, Alta California was populated by twenty indigenous ethnic groups from six different language families with a large number of subgroups, and it is considered that there were probably between 64 and 80 different languages. Despite the ethnic and linguistic diversity, these groups shared a number of cultural traits.

[51] San Antonio de Padua was inhabited by Salinan Indians, San Luis Obispo by the Chumash and Nuestra Señora de la Soledad by Chalon, Yokuts, and Salinan.

[52] In the case of Soledad the ABCC is lower (91.4), but unlike the other two, it had been founded only recently (1791). In any case, obtaining ABCCs of 100 in San Antonio and San Luís, as in the Jesuit missions, reduces the concern that the results obtained, in both these missions (along with the ayllus of Paucarcolla), are a consequence of how the census was prepared and the information collected.

workplace was an important element of the acquisition of this knowledge, in the missions studied, the school was a central element, and all children could access it. This would also be part of a model based on the adaptation to the Guarani worldview with evangelization in their language, a cohesive social structure in which the Indians had a determining role and an egalitarian productive structure that included a support mechanism between the missions in case of shortage. All these factors could explain their successful educational performance and the inter-generational transfer of human capital after the Jesuits were expelled from the missions.

The comparison with other experiences and regions points to the relevance of institutional characteristics. The societies with more resource-extractive colonial institutions were those with lower levels of numeracy in that period. However, within the same territory there could be different types of institutions, which results in more complex realities. Furthermore, this result has to be framed within the literature that studies the role played by the different Catholic religious orders in the formation of human capital. The Jesuits were not the only order that attempted to evangelize the populations that inhabited the areas conquered by the Spanish Crown: Franciscans, Dominicans and Augustinians also formed part of this intense missionary presence in Latin America during colonization.

However, these other religious orders differed from the Jesuits in that they are mendicant orders, so their aim was to expand Christianity from a commitment to reducing poverty. However, the Jesuits are an order of regular clerics who showed greater concern for the organization of economic activity in the communities they governed. In contrast, the Franciscans also founded Guarani missions, but unlike the Jesuits, their effects are not seen today (Valencia Caicedo 2019a). This asymmetry also occurs in the demographic evolution between the Franciscan and Jesuit Guarani reductions (Maeder 1995). A particular case analysed here would be the Missions of Alta California because in these missions the Franciscans followed the enterprise begun by the Jesuits in Baja California and used a similar model. These missions show equally positive results.

Overall, the results point to the role that the type of institution in a territory would have had on numeracy education, which would have been particularly low in non-religious institutions based on models of extreme inequality with less respect for the pre-existing social structure and culture, such as extractive institutions. This has implications for future research on this issue, and this study contributes to the debate on religious institutions, the effects of missions and their dissemination of human capital, and their implications for long-term economic development.

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Appendixes

FIGURE A.1

Image of a *padrón de indios*

Padron del Pueblo de S. Cosme y S. Damian que se hizo este presente año de 1735.

Primera Casa.

Reservado. 1. Dn. Pablo Abarê Cacique de 64. años casado con Isabel Cayru. 2.

Reserv. 2. Pablo Abarê Primogenito del Cacique de 32. años casado con Maria Yraheru. Sus hijos Juan Abarê primogenito de 8. años, Theodoro de 6. años, y su hija Rosalia 5.

3. Franco. Abarê de 24. años casado con Marta Yraheru. Su hijo Eusebio de 5. años y medio 3.

4. Miguel Abarê de 39. años casado con Maria Guabay. Su hijo Miguel de 7. años, y su hija Maria 4.

5. Balthasar Abarê de 35. años casado con Maria Caraicuña. Su hijo Domingo de 13. años, y su hija Margarita 4.

6. Christoval Abarê de 37. años casado con Anastasia Abacuña. Su hijo Ignacio de 13. años, y su hija Maria Rosa 4.

Reserv. 7. Ignacio Arobi de 54. años casado con Ignacia Guapichari. Sus hijos Franco. de 18. años, y Juan de 15. años, y su hija Barthola 5.

8. Felipe Arobi de 24. años casado con Ana Arariyu. Sus hijas Juana, y Clara 4.

9. Andres Tamba de 33. años casado con Damiana Mbaraete. Sus hijos Andres de 13. años, Gaspar de 8. años, y Mathias de 2. años 5.

10. Franco. Xavier Mbariyu de 26. años casado con Josefa Puyi. Sus hijos Antimo de 6. años, Luciano de un año, y Julian de un año 5.

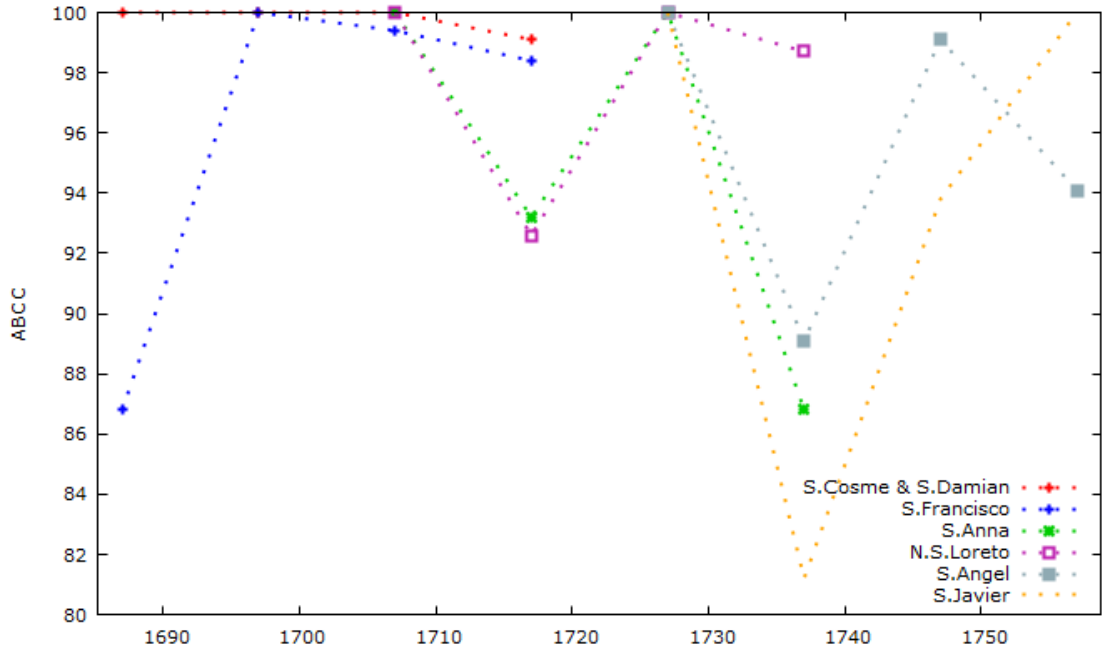
11. Pedro Mbariyu de 34. años casado con Maria Abayeru. Sus hijos Fabian de 15. años, Franco. de 10. años, y Feliz de 6. años. 5.

12. Andres Cayure de 32. años, casado con Ana Guate. Su hijo Manuel de Mes y medio y su hija Ursula 4.

Source: Sheet from the padrón de indiosof San Cosme and San Damián, 1735, AGNBA

FIGURE A.2

ABCC levels by age cohorts in the Jesuit missions 1735-1785



Sources: San Javier 1735 padrón de indios AGNBA; San Cosme 1735 padrón de indios AGNBA; Santa Ana 1759 padrón de indios AGNBA; Nuestra Señora de Loreto 1759 padrón de indios AGNBA San Ángel 1783 padrón de indios AHPO; San Javier Pueblo 1785 padrón de indios AGSF.

FIGURE A.3.

Year	Entity	Repartimiento	Region	Country	N	N(23-62) Men	N(23-62) Women
1728	Paucarcolla	Puno	Collao	Perú	753	133	150
1777	Attakapas	Attakapas	Louisiana	USA	837	203	133
1777	Opelousas	Opelousas	Louisiana	USA	738	183	115
1795	Mission San Antonio	Monterrey	California	USA	1,133	254	213
1798	Mission San Luís	San Luís	California	USA	792	162	154
1798	Mission Soledad	Monterrey	California	USA	344	55	53
	Total				**4,597**	**990**	**818**

Sources: Paucarcolla, 1728: padrón de indios MREP; Attakapas, 1777: censo AGI; Opelousas, 1777: censo AGI; San Antonio, 1795, San Luis, 1797, Soledad, 1797: padrón CSA[53].

[53] MREP: Ministerio de Relaciones Exteriores del Perú, Archivo Especial de Limites ; AGI: Archivo General de Índias; CSA: California State Archive.

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