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Ad maiorem Dei gloriam: Numeracy levels in the Guarani Jesuit missions

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Abstract

This work provides data on human capital for the Guarani Jesuit missions during the eighteenth century. Based on the age heaping methodology, the results of a large sample (over 3600 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 organisation, as well as respect for the pre-existing culture exemplified by their Guaranisation 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.

KEYWORDS
economic development, human capital, institutions, numeracy

JEL CLASSIFICATION
I21, I25, J24, O4n

The Society of Jesus, also known as the Jesuits, 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 evangelising missions.[1] These missions should be studied in the context of European colonial expansion during the early modern period when

[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*).

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 evangelising task. To spread Christianity, they established missions where, along with their evangelical activities, 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 originated at the beginning of the seventeenth 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 reductions (*reducciones*), in this area. In the time of their greatest splendour, the missions hosted more than 140 000 Guarani people who 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 evangelisation. Based on self-sufficiency, the reductions were an alternative means of incorporating the Indians into the colonial system during the early modern period. 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*[3] 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*.[4]

To study the impact of the missions as institutions that affected the educational levels of their inhabitants (and their general economic conditions and living standards), their origin is of particular interest. The reductions created new societies, or at least a new social organisation, in this case, of the indigenous population. The Jesuits deliberately founded the missions, bringing people together into a new common space that could accommodate more than 3000 individuals. They thus made entire Guarani communities sedentary. The educational and social outcomes obtained in the missions can therefore reasonably be attributed to the organisation and functioning of the Jesuits, rather than to the inertia of the past.

Valencia Caicedo analyses the effect of missionaries on education and demonstrates that Guarani Jesuit missions had important long-term educational and economic benefits.[5] On the one hand, beyond 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, Valencia Caicedo 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 per cent 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 analyses the areas of former Jesuit presence using the distance to the

[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.

[3] The *encomendero* was the person in charge of the *encomienda*, a socio-economic institution through which one group of individuals were forced to pay another in work, kind,

[4] Fradkin and Garavaglia, *La Argentina colonial*, p. 54.

[5] Valencia Caicedo, 'The mission'.

nearest mission; however, he does not have direct indicators that allow him to measure human capital.[6]

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, 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.[7]

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.[8] Moreover, a number of papers have explored the impact of religion on very long-term formation of human capital.[9] Some studies comparatively assess the externalities of human capital of different religious groups over long periods of time.[10] These works usually consider that religious institutions, in charge of providing education during much of the early modern period, were providers of public goods and non-rival services such as the education of their members.[11] Along these lines, and directly related to this work, there are studies that show that missions had positive effects in the long term,[12] in Africa,[13] the Americas,[14] and Asia.[15]

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.[16] In the specific case of Latin America there are studies on the persistence of the effects of the *mita*[17] system[18] and the exploitation of sugar cane plantations and gold mines.[19] This issue has also been studied in terms of the persistence of the effects of pre-colonial institutions in Latin America.[20] However, the relationship between human

[6] Valencia Caicedo, 'Missionaries'.

[7] Meier zu Selhausen, 'Missions'; Valencia Caicedo, 'Missionaries'.

[8] McCleary and Barro, 'Religion'; Glaeser and Sacerdote, 'Education'.

[9] Dittmar, 'Information technology'; Rubin, 'Printing'; Cantoni, 'Economic effects'; Saleh, 'Reluctant transformation'; Andersen et al., 'Pre-Reformation roots'.

[10] Botticini, and Eckstein, 'From farmers'; Becker and Woessmann, 'Was Weber wrong?'.

[11] Abramitzky, 'Lessons'; Colvin, 'Banking'.

[12] Woodberry, 'Shadow'; Gallego and Woodberry, 'Christian missionaries'.

[13] Fourie and Swanepoel, 'When selection trumps persistence'; Cappelli and Baten, 'Numeracy development'.

[14] Waldinger, 'Long-run effects'.

[15] Calvi et al., 'Protestant legacy'.

[16] Acemoglu et al., 'Colonial origins'; Nunn 'Long-term effects'.

[17] Mita was mandatory public service in the society of the Inca Empire, and later in the Spanish conquest. Under the Viceroy Francisco de Toledo, communities were required to provide one seventh of their male labor force at any given time for public works, mines and agriculture. The system became an intolerable burden on the Inca communities and abuses were common.

[18] Dell, 'Persistent effects'.

[19] Naritomi et al., 'Institutional development'.

[20] Angeles and Elizalde, 'Pre-colonial institutions'.

capital, institutions, and development is complex.[21] Some authors argue that the abundance of unskilled human capital due to natural resource extraction institutions would explain the extreme inequality in Latin America.[22] Others argue that, more than institutions, the key is in the human capital of the colonisers themselves.[23]

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 to determine. 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 eighteenth 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.[24] Thus, numeracy, using age heaping as a proxy, is considered a good alternative indicator to literacy for the periods of the early modern period, for which sources are scarce or non-existent.[25]

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 eighteenth century, such as Castile,[26] Catalonia,[27] and the region of Rio de la Plata.[28] These are added to the works for the areas that today are Colombia, Mexico, and Peru[29] or those carried out for periods before the Conquest.[30] Especially related to this study is the work on the region of Potosi, which shows the differences in calculation levels between the different native communities in relation to type of institution[31] and that of central New Spain in the eighteenth century, which highlights the complexity of the situation within the same region.[32] There is also more recent work on the differences in numeracy between religious minorities, particularly Jews, in the Iberian Peninsula during the years of the Inquisition.[33]

In this context, the main contribution of this article is to provide numeracy results for the Jesuit Guarani missions of the eighteenth 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.[34] It is essential to trace the evolution of human capital

[21] Acemoglu et al., 'Institutions'.

[22] Engerman and Sokoloff, 'Factor endowments'.

[23] Glaeser et al., 'Do institutions cause growth?'; Easterly and Levine, 'European origins'.

[24] Huizinga et al., 'Literacy, numeracy'.

[25] A'Hearn et al., 'Quantifying quantitative literacy'; Crayen and Baten, 'Global trends'; Hippe, 'Human capital formation'.

[26] Tollnek and Baten, 'Farmers'; Álvarez and Ramos Palencia, 'Human capital'.

[27] Gómez-i-Aznar, 'Human capital'.

[28] Vicario, 'Human capital formation'.

[29] Manzel et al., 'Convergence'.

[30] Juif, and Baten, 'On the human capital'.

[31] Vicario, 'Formation'.

[32] Calderón-Fernández et al., 'Numeracy'.

[33] Juif et al., 'Numeracy'.

[34] Valencia Caicedo, 'The mission'.

in this area over almost a century and compare it with 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.

Data on arithmetic ability in the Jesuit Guarani missions of the eighteenth 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 male 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 early modern sources.[35]

The sample used in this article obtains information for five Guarani missions and one village founded by the Jesuits, from the 30 reductions that existed, at three different times in the eighteenth 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. 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.[36]

The availability of censuses for other colonised areas and under the domination of the Hispanic Crown in the eighteenth 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 colonisation 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 organised in Latin America by different religious orders. In this sense, Waldinger[37] 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, 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.[38] This, then, is a debate that remains open.

This article is organised as follows. Section I introduces some of the basic characteristics of the Guarani Jesuit missions. Section II 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 was obtained, as well as the details of the missions that make up the sample. Section III describes and discusses the main results. Finally, section IV presents the conclusions.

[35] Vicario, 'Human capital formation' and idem, 'Formation', uses a similar source to analyse 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. The studies use local population censuses.

[36] Valencia Caicedo, 'The mission'.

[37] Waldinger, 'Long-run effects'.

[38] Waldinger, 'Missionaries in Venezuela'.

I | THE GUARANI JESUIT MISSIONS: HISTORICAL BACKGROUND

The Christian missions or reductions were establishments promoted by different religious orders to evangelise 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.[39] 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, 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.[40] 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,[41] 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'.[42] In any case, the final objective of all these measures was to accelerate and facilitate evangelisation;[43] but elsewhere in Latin America they focused on the education of elites or created extractive institutions, using different models of evangelisation according to the needs of the context. For example, in the same period analysed, Jesuits used enslaved labour on haciendas in Peru.[44]

The Jesuits arrived in Asunción (Paraguay) in 1588 and later founded the first Guarani missions at the beginning of the seventeenth 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 heretofore had a semi-nomadic lifestyle.[45] 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.[46] 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. Evangelising 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

[39] Bruno, *Historia,* p. 254.

[40] 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 United States (Alta California). Valencia Caicedo, 'Missionaries'.

[41] Carbonell, *Estrategias,* p. 39.

[42] Maeder, 'Asimetría', p. 75.

[43] 'It is hard to overemphasise 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, 'The mission', p. 515).

[44] Indian hacienda labour was salaried and because of this Jesuits preferred slave labour (Cushner, 'Slave mortality').

[45] In the first years, up to a total of 14 of the first 20 reductions that existed in 1640 were relocated owing to various conflicts (Maeder, 'Asimetría').

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

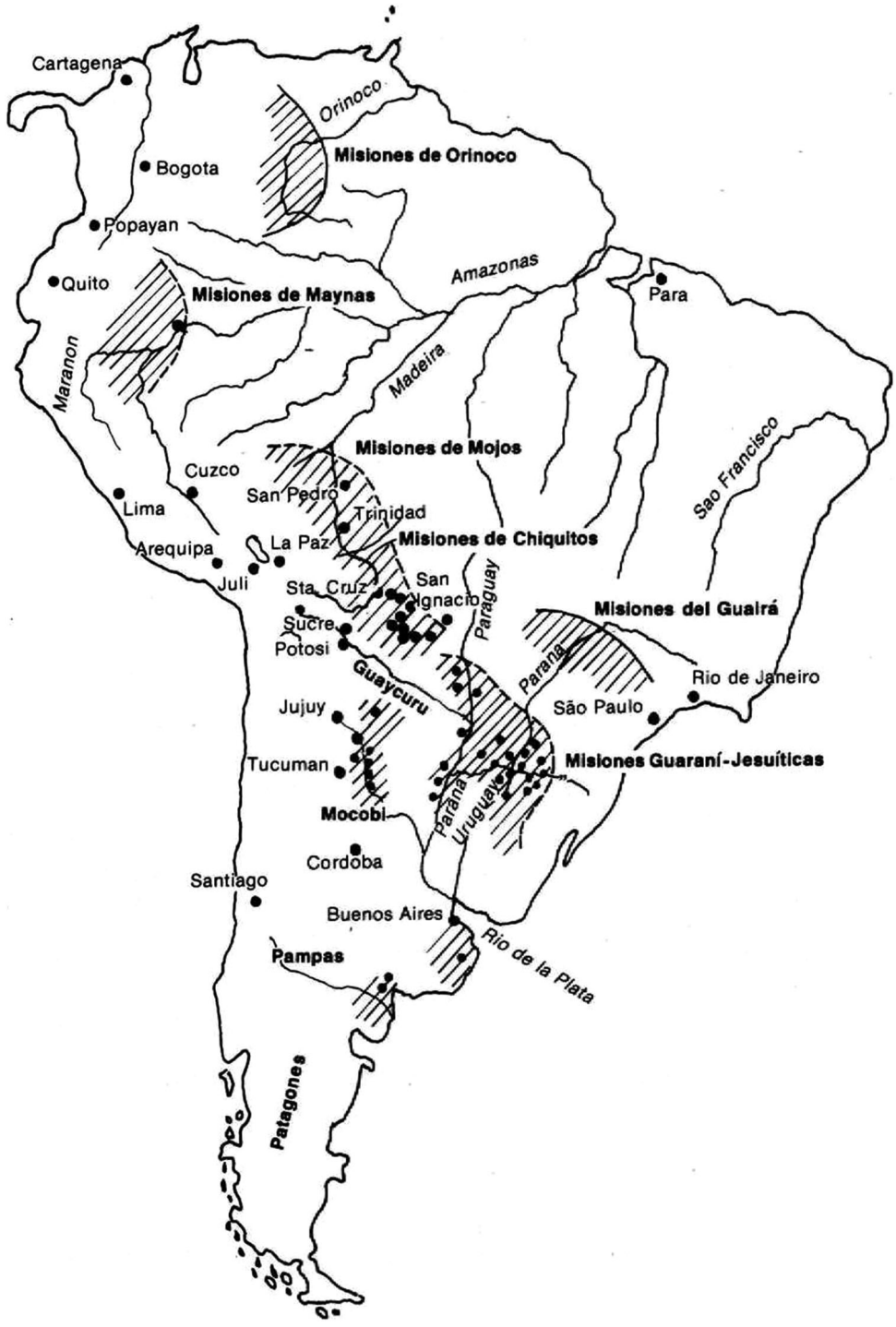

FIGURE 1 Location of the Jesuit missions in South America.

Source: Bruno, *Historia*, p. 254.

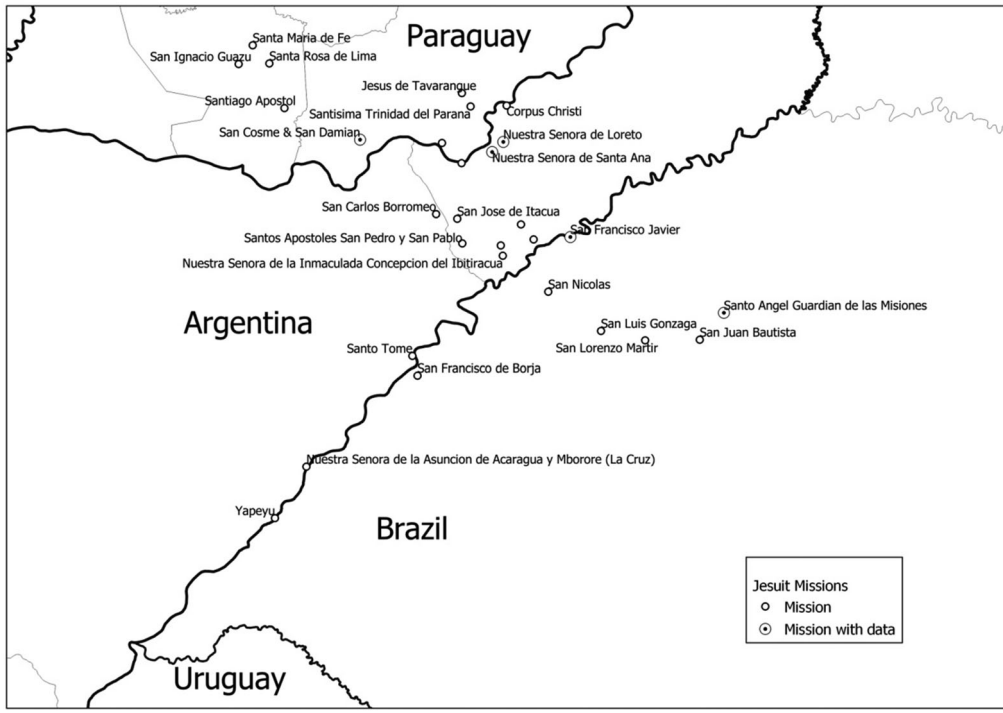

FIGURE 2 Location of the Guarani Jesuit missions.

Source: Author's elaboration.

indigenous languages of Latin America.[47] The Guarani language in its different variants seems to have been a fundamental unifying element for the formation of the missions.[48]

The territorial organisation of the Guarani Jesuit missions was based on a legal system constituted by royal decrees, or *cédulas*. There were a total of 30 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 eighteenth century, which led the Jesuits to organise the missions into two districts. The first included the communities on both sides of the Paraná River.[49] The second district covered those located on the two sides of the Uruguay River.[50] Its location can be seen in figure 2, and its current territorial distribution includes 15 missions in Argentina, 8 in Paraguay, and 7 in Brazil.

The evolution of the population of the Guarani missions between 1642 and 1812 is shown in figure 3. In the middle of the seventeenth century, the combined population was around 40 000 inhabitants. From then on, we can see its spectacular increase during the Jesuit period, which led

[47] Its use as a language of evangelisation also involved a transformation of the grammatical structures of the original Guarani to Indo-European syntax and the coinage of neologisms (Lustig, 'Mba'éichapa oiko la guarani?').

[48] Wilde, *Religión*.

[49] 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.

[50] This group included San José, San Carlos, The Holy Apostles, Conception, St. Maria la Mayor, St. Francisco Javier, Los sagrados martires del Japón, St. Nicolás, St. Luís Gonzaga, St. Lorenzo Martir, St. Miguel, St. Juan Bautista, St. Tome, St. Francisco Borgia, La Cruz, and Yapeyu (Jackson, 'Una mirada').

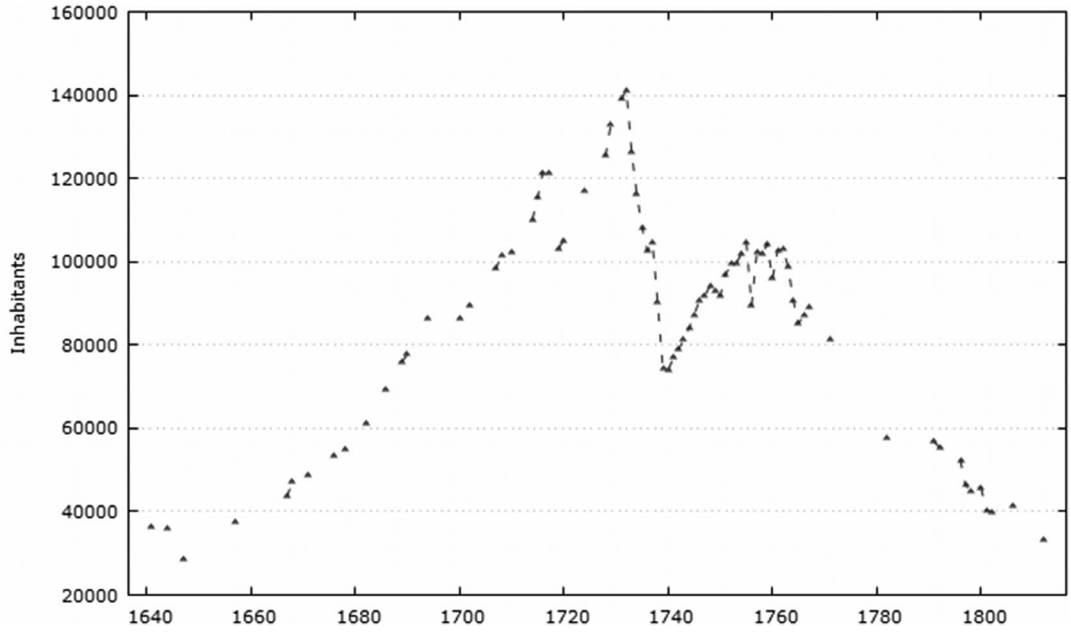

FIGURE 3 Demographic evolution of the Guarani missions 1642–1812.

Source: Author's elaboration based on Livi-Bacci and Maeder, 'The missions of Paraguay'.

to a maximum population in the missions in 1732, when 141 182 Guarani lived there.[51] 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.[52] 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.[53] 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 at the beginning of the 19th century, the population of the missions had already returned to values similar to those at the beginning of the period. The rapid population recovery after the crises indicates unique demographic patterns, showing a viable population after the expulsion of the Jesuits in 1768 and the transfer of the former missions during the first three decades of the nineteenth century.[54]

The political organisation 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

[51] Carbonell, *Estrategias,* p. 274.

[52] Regional conflicts, the mobilisation of missionary militia, and the displacement of armies also played a role. These intensified the effects of epidemics, causing mortality to vary between missions (Jackson, *Regional conflict*, p. 67).

[53] 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.

[54] Jackson, 'Una mirada'.

the *corregidor* or indigenous *cabildo*.[55] The combination of the two figures sought (apparently successfully) to maintain social cohesion, and the two Jesuit fathers assigned to each reduction (there were never more than 100 Jesuits at any one time) played the role of privileged mediators.[56] 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.[57] The death penalty and torture were prohibited, any sanction required a previous trial, and the penalty had to be appropriate to the crime.[58]

The mission's military organisation was fundamentally different from that of the chiefdom.[59] Despite its high level of organisational hierarchy, the Guarani themselves played a crucial role in the functioning of the mission.[60] Only two Jesuit fathers were present, and the mission's successful performance cannot be attributed solely to them. It was a process of Guaranisation of the mission, similar to what happened later in the African missions, emphasising the role of local agency. The autonomy of each village, with its particular endowment of natural and human resources, stimulated technical adaptation, creativity, and specialisation, as well as the disinterested dissemination of knowledge and technical skills.[61]

In the economic field, the Jesuits modified the behaviour of the Guarani people and organised productive work in agriculture and cattle raising.[62] The missions had a mixed economic system.[63] On the 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.[64] 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 financial offices located in the cities, for storage and marketing in the regional circuits.[65] This functioned to produce income to cover the costs of the administration of the mission communities, to procure goods or resources that were not produced in the territory such as iron for bells or wine for mass, and to cover the tribute obligations of the mission residents.[66]

[55] The *corregidor* was a civil authority and the *cabildo* was the municipal corporation of the Spanish colonial administration. In the *reducciones* they were elected annually and did not have privileges such as exemption from work.

[56] Wilde, 'Los guaraníes'.

[57] Álvarez, 'Las misiones'.

[58] Carbonell, *Estrategias*, p. 203.

[59] Takeda, 'Cambio'.

[60] Takeda, 'Los padrones'.

[61] Carbonell, *Estrategias*, p. 161.

[62] Cuervo Álvarez, 'Las misiones de los padres'.

[63] Sarreal, *The Guaraní*.

[64] The daily dietary contribution per individual of the Guarani people in 1766 in energy expressed in grams was 2508.8 kcal, 84.1 g of protein, and 58.6 g of fat (Carbonell, *Estrategias*, p. 107).

[65] Wilde, 'Los guaranies'.

[66] Jackson, *A population histoty*, p. 7.

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 per cent and 30 per cent of the market in Santa Fe and Buenos Aires. Similarly, in the eighteenth century, the Jesuit missions provided between 60 per cent and 90 per cent 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 per cent and 60 per cent of the production of sugar and between 15 per cent and 30 per cent of the tobacco circulating in the Buenos Aires market, as well as 10 per cent of the total hides exported to Europe.[67] In addition, the dynamism of the missions' economies had an important influence on the whole region, such as Uruguay.[68] The departments in the northwest of the country, territories that had been under the influence of the Jesuit cattle ranches[69] in what is known as the Missionary North, had a high per capita income even in the mid-nineteenth century.[70]

Culturally, all children were taught writing, reading, and basic arithmetic between the ages of 6 and 12.[71] The Jesuit missions were the first to print books in South America, with the incorporation of the printing press from 1700.[72] Many of the works were printed in Guarani, which indicates that the vernacular language was used in teaching.[73] The reductions also had a library,[74] and music and art were taught. The adults were instructed in craftsmanship and construction, and one of the missions came to specialise in the manufacture of stringed instruments. 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.[75]

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 30 missions was carried out in July under the supervision of the governor of Buenos Aires, and took no more than a month.[76] 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 organisation, 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 70 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. General provisions on production, work, pay, possession of goods, trade, and

[67] Moraes, 'Las economías agrarias'.

[68] Moraes, *La pradera perdida.*

[69] 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.

[70] Martinez-Galarraga et al., 'Patterns'.

[71] Muratori, *El cristianismo feliz,* pp. 114–15; Ganson, *The Guaraní*; Labrador Herráiz, 'Las reducciones'.

[72] Rizzo, 'La importancia de la imprenta'.

[73] Cardiel, *Las misiones del Paraguay.* 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, 'The origins').

[74] The library of the Candelaria mission, with book loans to the 30 villages, had in its inventory of 1768 a total of 102 books on mathematical subjects (Carbonell, *Estrategias*, p. 160).

[75] Carbonell, *Estrategias,* p. 208.

[76] Wilde, 'Los guaraníes'.

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.[77] It was in this context, following the expulsion of the Jesuits, that the economic and demographic decline of the missions began.[78]

II | A NEW SOURCE FOR MEASURING NUMERACY: LOS PADRONES DE INDIOS

Numeracy is a person's ability to calculate, understood as the ability to process, understand, and transmit mathematical and numerical information. 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.[79] 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.[80] This is why age heaping is an indicator of the numeracy level of a population and is considered a good proxy for arithmetic ability.[81]

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:

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

where i represents the years of age and n is 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.[82] propose a linear transformation of the WI, called the ABCC index, which has the following formulation:

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

The ABCC index has the advantage of being easier to understand than the WI because the values are between 0 and 100, where 100 is the maximum arithmetic capacity and 0 is the

[77] Quarleri, 'Lógicas'.

[78] 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 with 1766 (Carbonell, *Estrategias,* p. 296).

[79] Mokyr, *Why Ireland starved*; A'Hearn et al., 'Quantifying qualitative literacy'.

[80] The reason for using numbers ending in zero and five when a person does not know their 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, *The roots of thinking*).

[81] Blum and Krauss, 'Age heaping'.

[82] A'Hearn et al., 'Quantifying quantitative literacy'.

minimum. In this article, as usual, the observations of the age cohorts between 23 and 62 are used for calculating the age-heaping indicator.[83] In the age cohort between 23 and 32 years old, owing to the possibly greater ability to remember age, we applied the correction factor proposed by Crayen and Baten.[84] 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.[85]

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[86] and other environmental factors such as height.[87] In contrast, other authors question whether age heaping is a good proxy for numeracy,[88] while still others indicate that, more than an indicator of cognitive skills, age heaping may signify institutional and cultural modernisation.[89] In addition, the quality of local censuses for calculating numeracy varies according to time and place.[90]

To be able to use age-heaping methodology, it is necessary to have the ages of a set of populations individualised and not grouped. In the case of the regions that were under the dominion of the Spanish empire during the early modern period, there is a source for obtaining these individualised ages: the registers. Unlike the sources used in studies that exploit age heaping, the registers are not a fiscal source, although they could be applied for this purpose, so there are fewer 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,.[91] These censuses, which were not summaries used for fiscal purposes and which included the entire population, regardless of their age and whether they were taxpayers or not, can be considered a good source for calculating numeracy.[92]

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

[83] This cohort selection is always the same in the age-heaping methodology, regardless of region and period, as the effect is universal in societies based on decimal systems, as in the Guarani Jesuit missions.

[84] In the missions, payment of tribute began at the age of 18, so there was also a greater possibility to remember age in this cohort (Crayen and Baten, 'Global trends').

[85] Bareiro Saguier, 'La numeración'.

[86] A'Hearn et al., 'Quantifying quantitative literacy'.

[87] Baten et al., 'Numeracy and the impact of high food prices'.

[88] Spennemann, 'Age heaping'.

[89] A'Hearn et al., 'Rethinking age heaping'.

[90] Szołtysek et al., 'Age heaping patterns'.

[91] Salinas, 'Población y encomiendas'.

[92] A phenomenon found in other censuses of regions under the Hispanic Monarchy, including the Iberian Peninsula. Although it is used as a fiscal source, in cases where the entire population is collected (numeration of general population), it reduces concealment and serves as a demographic source.

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, not in fruit. For collection purposes, it was established that the royal officials of Buenos Aires would be in charge of the census.[93] 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.[94] In addition, they had to be repeated every six years, and a copy sent to the Council of the Indies,[95] although the follow-up was very irregular.[96]

After the expulsion of the Jesuits, standards continued to be drawn up. Governor Bucaleri issued instructions in 1768, entrusting subordinate governors to conduct censuses of their villages. These were organised according to the laws of the Indies, paying particular attention to the caciques with the aim of consolidating their social role within the village.[97] The main objective of these censuses was to exercise control over the taxation of Indians and to know how many were exercising this position, with respect to bias and how many Indians made up their chiefdom.[98] In certain cases and with the appropriate checks, the registers are a reliable source, although sometimes they have limitations.[99] In this case, because the censuses continued to record the entire male population regardless of age, they can be used as a source for numeracy.

Some researchers have used mission censuses as a source in previous studies,[100] but this is the first time they have been used to calculate numeracy. 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.[101] 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 organisation of life in the mission. The daily power was exercised by the caciques,[102] 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 houses accommodated

[93] Martínez Martín, 'El padrón de Larrazábal'.

[94] '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; https://digibug.ugr.es/handle/10481/8870.

[95] 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, and judges, among others. They also exercised the right of patronage.

[96] Muratori, *El cristianismo feliz,* p. 268.

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

[98] Martínez Martín, 'El padrón de Larrazábal'.

[99] Marino, 'Consideraciones'.

[100] Martínez Martín, 'El padrón de Larrazábal'; Jackson, 'Una mirada'; idem, 'The population'; Sarreal, *The Guaraní;* Takeda, 'Cambio'; idem, 'Los padrones'.

[101] Livi-Bacci and Maeder, 'The missions of Paraguay'.

[102] 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.

large Guarani families, in many cases with more than a hundred members, and all those living there were considered relatives.[103]

The residential units were distributed around a large central square (*okara*) for collective use. 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.[104] Although Takeda points out that the Superior and the priest approved the result of the visit in the prologue to the census, he also indicates that the public scribes and interpreters were the most important members of the visiting group. The scribes wrote down the data reported by the Guaranis themselves; and the need for the interpreters suggests that each individual was asked because they would not have been necessary in the case of direct intermediation by the Jesuits. This self-reporting is reinforced, according to the chronicles, by the active participation of the Indians themselves 'since they wanted His Majesty to know their names'.[105] Sources contemporary to the missions also indicate that the Guarani were able to calculate their own age thanks to their knowledge of arithmetic.[106]

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). There is no evidence that there were any circumstances in the missions that made age recall more accurate than in European cities. Surely the administrative incentives to know one's age accurately were less in the reductions (less bureaucracy), and the celebration of birthdays is a modern invention that did not exist in that period.[107] 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 1656–7, 1676–7, 1715, 1721, 1735, 1759, 1772, 1777, 1784, 1794, 1799, and 1801.

Of these, only some of the censuses are preserved, and some are in a state that makes transcription difficult. In this article, 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 presented in table 1. Of these six entities, one 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,[108] and had a production and organisational structure similar to that of the missions. The Jesuits, besides providing them with basic education, taught the Mocovíes various occupations, arts, and crafts, which meant a significant transformation of the place and

[103] Álvarez Kern, 'Jesuitas'.

[104] Takeda, 'Los padrones'.

[105] Carbonell, *Estrategias*, p. 197.

[106] 'Before they became Christians they counted only up to the number four, not knowing the others. If they wanted to express five they showed one hand, if ten they showed two, if twenty they showed hands and feet, and if more than twenty – whatever the number – they indicated it with a general term which meant a lot. Because of this ignorance, which persists among the unconverted barbarians, those people did not know how to distinguish the number of years of people or so many things useful for human and civil life. Therefore, nowadays, not only are children taught arithmetic in schools, but all the people are made to repeat the tables of numbers in church after the sacred services, so that whoever understands can profit by them.' (Muratori, *El cristianismo feliz*, pp. 114–15).

[107] Schmitt, 'L'invention'.

[108] 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–Guaicurú linguistic family and is still spoken in some of the areas they inhabit in the provinces of Formosa, Santa Fe, and Chaco.

TABLE 1 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	2497	589	–
1735	San Cosme y San Damián	Misiones	Paraguay	1143	394	–
1759	Nuestra Señora de Loreto	Misiones	Argentina	3322	903	–
1759	Santa Ana	Misiones	Argentina	3191	956	–
1784	Santo Ángel	Misiones	Brazil	2032	445	343
1785	San Javier (Pueblo)	Chaco	Argentina	1038	287	231
	Total			13 223	3661	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.
Notes: AGNBA: Archivo General de la Nación Buenos Aires, Argentina; AHPO: Archivo Histórico de Porto Alegre, Brazil; AGSF: Archivo General de Santa Fe, Argentina.

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.[109]

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.[110] 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, 1735, and 1736.[111] 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 (1759–85) 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.

Together, these six entities had a population of 13 223. The population used for the age-heaping calculations totalled 3661 men between 23 and 62 years of age, which is therefore the set of observations available for the study of the Guarani missions.[112] Figure A1 in the Appendix provides a sample of these standards, which also reflect the social organisation established in the reductions. As mentioned, the Guaranis were organised 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 dwelling. Information is provided on the structure of each family (marital status, sex, number of children),[113] 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.[114]

Pandemics such as smallpox, which hit the missions at certain periods, would not alter the census sample. The existence of communal lands and a compensatory system between missions guaranteed equal food sustenance for the entire population. Mortality therefore affected all families without distinguishing between caciques and the rest of the members, leaving a large number of orphans and widows. Moreover, not all missions experienced the same level of population loss or family destruction.[115] One of the effects of the high mortality of these pandemics was the neglect of crops[116] and the loss of productive capacity[117] due to the loss of labour.[118] There was also a certain degree of generational turnover among the caciques. These generational ruptures and the

[109] Saeger, 'Another view'; Moriconi, 'Administración borbónica'.

[110] 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.

[111] 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.

[112] 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 4235 observations.

[113] By the eighteenth century, the Guarani people of the missions had become monogamous and joined in marriage.

[114] 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).

[115] Jackson, 'Una mirada'.

[116] Carbonell, *Estrategias*, p. 54.

[117] Carbonell, *Estrategias*, pp. 269–70.

[118] This loss of production was compensated for by the importation of livestock and the transfer of foodstuffs from the less affected Missions.

disruption of daily activities such as going to school could have hindered knowledge diffusion and knowledge transmission.

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.[119] 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 reason is that the distribution of results by age cohort in the same census is not homogeneous, especially in the cohorts that suffered ecological and mortality crises that disrupted the missionary communal economy,[120] and if they had been matched, this difference would not have occurred in the same registry.[121] 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 do not differ owing 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.

III | RESULTS

The general results of arithmetic ability in the Jesuit Guarani missions throughout the eighteenth century are presented in table 2. The observations grouped around 1735 and 1759 include four 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 eighteenth century. Both in 1735 and in the middle and end of the eighteenth century, values close to 100 are observed in all the reductions, that is, 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).

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

[119] Martínez Martín, 'El padrón de Larrazábal'.

[120] Jackson, *Regional conflict*, p. 20.

[121] Figure A2 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.

TABLE 2 Levels of ABCC in the Jesuit missions 1735–85

Year	Reduction	ABCC
1735	San Cosme and 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.
Notes: Archive details as in table 1.

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 that 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.[122] 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.[123] The works of Valencia Caicedo and Valencia Caicedo and Voth[124] 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 for Buenos Aires, Cartagena de Indias, Mexico City, Montevideo, and Sao Paulo (figure 4). Decades earlier, 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 4 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

[122] Valencia Caicedo, 'The mission'.

[123] Obviously, 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.

[124] Valencia Caicedo, 'The mission'; Valencia Caicedo and Voth, 'Christ's shadow'.

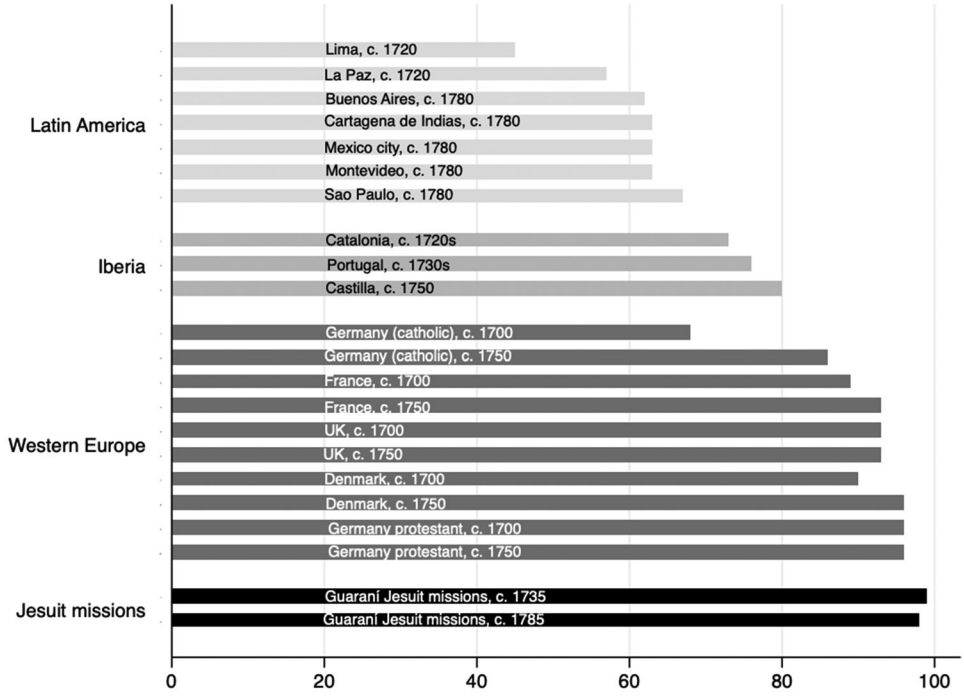

FIGURE 4 ABCC index in different world regions, eighteenth century.
Sources: Castilla: Álvarez and Ramos Palencia, 'Human capital'; Catalonia: Gómez-i-Aznar, 'Human capital'; Portugal: Stolz et al., 'Portuguese living standards'; Latin America: Manzel et al., 'Convergence'; Western Europe: A'Hearn et al., 'Quantifying quantitative literacy'.

referring to the north of Castile, Catalonia, and Portugal show ABCC index values between 70 and 80 in the first half of the eighteenth century.[125] These values are clearly below those observed in the Jesuit Guarani missions throughout the eighteenth 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.[126] 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.[127] As shown in figure 4, 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.

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

[125] The data for Castile (for the current province of Palencia) come from the Ensenada Cadaster of 1749 (Álvarez and Ramos Palencia, 'Human capital'), while for Catalonia, population registers (*padrons*) were used, mainly for the 1720s (Gómez-i-Aznar, 'Human capital'). For Portugal, see Stolz et al., 'Portuguese living standards'.

[126] This is shown by existing work carried out with census sources for literacy and numeracy in the mid and late nineteenth century. (Beltrán Tapia et al, 'Two stories'; Beltrán-Tapia et al., *Capital humano*).

[127] A'Hearn et al., 'Quantifying quantitative literacy'.

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.

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 collected only the native population.[128] 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 forced labour was prohibited, which attracted qualified workers because of the better living conditions. In addition, Indians and Mestizos had greater influence in political institutions, which contributed to making Oruro 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 system. In La Paz, there were many outsiders, who were those who had escaped from the 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.[129]

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 in the viceroyalty of Peru, is available for 1728.[130] (See Appendix table A1.) Paucarcolla is a town located on the north-western shore of Lake Titicaca, at an altitude of 3500 m, whose main activity was cattle ranching.[131] 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.[132] The 753 inhabitants of Paucarcolla appear in the census divided into four spaces: the *ayllus* aimaras, the *ayllus* urus, the *estancias*, and the *ingenious*.[133] 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 children, trade, and grow 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.[134] 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 organisation of exploitation where the owner

[128] Vicario, 'Formation'.

[129] Ibid.

[130] Ministerio de Relaciones Exteriores del Perú, Archivo Especial de Límites (Lima). Documentos de la región del Collao, n93.

[131] Hampe Martínez, 'Visita'.

[132] 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 centre, such as Paucarcolla (Zavala, *El servicio*).

[133] 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, south-eastern 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 BC (Hampe Martínez, 'Visita').

[134] Klein, *Haciendas y ayllus en Bolivia.*

(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 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.[135] Even so, two aspects should be noted: the *ayllus*, with their collective organisation, 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,[136] which could explain why the ABCC levels obtained are relatively high. Elsewhere in the empire, as we will see below, colonial exploitation was 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; Spanish rule continued until 1803 and covered much of the US Midwest.[137] These two settlements specialised during the eighteenth century in producing tobacco in plantations.[138] 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 African population, and also allowed the manumission of slaves.[139] 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 were available.[140] This provoked resistance from plantation owners of French origin.[141]

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

[136] Klein, *Haciendas y ayllus en Bolivia*.

[137] 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.

[138] Frederick, 'Luis de Unganza'.

[139] Webre, 'The problem'.

[140] 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 criticised by the French population, and he is still remembered today as Bloody O'Reilly (Ingersoll, 'The slave trade').

[141] Even so, the different governors adapted the regulations of the metropolis to the reality of the territory in order to avoid uprisings (Hall, 'Raza y libertad').

Attakapas had a population of 837 in 1777 (see Appendix table A1), which gives a sample of 203 men aged 23–62. Of these, 58.5 per cent were landowners while the remaining 41.5 per cent were slaves. For Opelousas, of the 738 inhabitants, a sample of 183 men between 23 and 62 years of age is obtained, 70 per cent of whom are owners and 30 per cent 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.[142] 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 eighteenth century show the diversity of situations that could be found within the same territory,[143] as in the case of California.

In the whole of Latin America in the eighteenth century, the presence of religious orders was dominated, as in the two previous centuries, by the Franciscans, who had more than 2500 ecclesiastics carrying out tasks of evangelisation on the continent. The Jesuits were second with almost 2000 ecclesiastics, and in third place were the Capuchins, who barely exceeded 500. The Dominicans, who had come to have a notable presence in the seventeenth century (1500) had a testimonial presence in this century.[144] 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 to 1670, only four remained active: Itá, Caazapá, Yutí, and Itatí.[145] The two religious orders both offered resistance to the requirements of indigenous labour, but the geographical proximity of the Franciscans to Asunción, as well as 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.[146]

Valencia Caicedo shows that the presence of the Jesuit missions in Guarani lands is positively linked to higher education and income levels in the present.[147] 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 organisation 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 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.[148] However, in

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

[143] Calderón-Fernández et al., 'Numeracy'.

[144] Valencia Caicedo, 'Missionaries', p. 65.

[145] The Jesuit missions were, in any case, more successful than the Franciscan missions in the Guarani area. According to Maeder: 'one can see a demographic stagnation in the Franciscan 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' (Maeder, 'Asimetría', p. 71). Unfortunately, it has not been possible to locate the census of these Franciscan reductions.

[146] Maeder, 'Asimetría'.

[147] Valencia Caicedo, 'The mission'.

[148] Waldinger, 'Long-run effects'.

a previous work, Waldinger analysed the religious missions that were established in the territory of present-day Venezuela.[149] In this case, however, while she found that the Franciscan missions had a negative impact, which she attributes to the colonial system of the *encomienda*, her work gives evidence that the Augustinian missions had a positive effect.[150]

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.[151] The California missions were based on the colonising model of border institutions.[152] In the northwest of New Spain, after failed attempts by the Franciscans, the missionary work was carried out by Jesuit religious people. As in the Guarani missions, they prevented contact with the settlers and forbade the Indians from working for them.[153] The missionaries taught and encouraged agricultural 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.[154] The Jesuits undertook the colonisation of Baja California in 1697. The expulsion stopped their plans to extend over Upper California, but the base of the subsequent colonisation 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 obtained the resources to undertake the evangelising enterprise from the expropriated Jesuit missions.[155]

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.[156] The previous links between the two orders in this region, with a dynamic in which persuasion replaced force,[157] would explain in this case the similarities of the methods used to found the missions in this area.[158] Upper California

[149] Waldinger, 'Missionaries in Venezuela'.

[150] Other work has focused on missions in Africa. For example, Fourie and Swanepoel 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 with other areas of Africa (Fourie and Swanepoel, 'When selection trumps persistence').

[151] California State Archives (CSA). See Appendix table A1.

[152] Along with the missions, the Spanish colonisation 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 colonisation of the large spaces that remained unpopulated between the Missions, the pueblos, and the presidios.

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

[154] Ortega Soto, 'Colonización'.

[155] 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.

[156] The group, led by Majorcan Fray Junípero Serra (founder and president of the new missions of Upper California, 1769–84), had acquired extensive experience in the Sierra Gorda and Baja California for almost 20 years (Rex Galindo, 'Franciscanos').

[157] Osante, *El septentrión novohispano*, pp. 52–5.

[158] Ruíz Gutiérrez and Sorroche Cuerva, 'Jesuitas, Franciscanos y Dominicos'.

had a sedentary population despite not practicing agriculture, and they lived from hunting owing to the great abundance of environmental resources.[159] 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[160] and thus changed their eating habits.[161] One of the main differences was that the Franciscans made occasional use of soldiers from nearby prisons in the case of conflict.[162] To overcome the barriers, some friars learned the native languages and wrote bilingual catechisms, and although the teaching of Spanish was promoted, at the end of the eighteenth century the Franciscans recognised the use of the native languages in the missions.[163]

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 (1137), followed by San Luís (792) and Soledad (344), all of which were inhabited by indigenous communities.[164] The total sample of men between 23 and 62 years of age in these three missions together amounts to 891 individuals (see Appendix table A1). 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.[165] These results, that is, 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 basic education, in this case in terms of numeracy, which, moreover, as noted in Waldinger and Valencia Caicedo, has been shown to be persistent over time, making its effects felt even today.[166]

IV | CONCLUSIONS

The results obtained in this work suggest that the knowledge of numerical skills in the Guarani Jesuit reductions throughout the eighteenth century was exceptionally high. Although the sample analysed has more than 3600 observations altogether, the diversity of local situations means that an overall image can only be elaborated with caution; however, the results obtained

[159] Ettinger, 'Una nueva domesticidad'.

[160] Jackson and Gardzina establish 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 (Jackson and Gardzina, 'Agriculture').

[161] Albert and Soto, 'Indios'.

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

[163] When the Franciscan friars arrived in 1769, Alta California was populated by 20 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 (Rex Galindo, 'Franciscanos').

[164] 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.

[165] 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.

[166] Waldinger, 'Missionaries; eadem, 'Long-run effects'; Valencia Caicedo, 'The mission'.

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 100 per cent in the eighteenth 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 under its care. At a time when the rest of the Hispanic monarchy was teaching in an informal education environment, and learning in the workplace was an important element of the acquisition of this knowledge, in the missions studied here 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 evangelisation 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 intergenerational 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 evangelise 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 colonisation.

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 organisation 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.[167] This asymmetry also occurs in the demographic evolution between the Franciscan and Jesuit Guarani reductions.[168] 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 played in numeracy education, which would have been particularly low in 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 the typology of institutions (whether they were more or less extractive), the effects of missions and their dissemination of human capital, and their implications for long-term economic development.

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[167] Valencia Caicedo, 'The mission'.

[168] Maeder, 'Asimetría'.

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REFERENCES

A'Hearn, B., Baten, J., and Crayen, D., 'Quantifying quantitative literacy: age heaping and the history of human capital', *Journal of Economic History*, 69 (2009), pp. 783–808.

A'Hearn, B., Delfino, A., and Nuvolari, A., 'Rethinking age heaping: a cautionary tale from nineteenth-century Italy', *Economic History Review*, 75 (2022), pp. 111–37.

Abramitzky, R., 'Lessons from the kibbutz on the equality-incentives trade-off', *Journal of Economic Perspectives*, 25 (2011), pp. 185–208.

Acemoglu, D., Johnson, S., and Robinson, J. A., 'The colonial origins of comparative development: an empirical investigation', *American Economic Review*, 91 (2001), pp. 1369–401.

Acemoglu, D., Gallego, F. A., and Robinson, J. A., 'Institutions, human capital, and development', *Annual Reviews of Economics*, 6 (2014), pp. 875–912.

Albert, S. B. and Soto, M. O., 'Indios y franciscanos en la construcción de la Alta California', in E. G. Cruzado, ed., *Actas de las Jornadas de Historia sobre el Descubrimiento de América: Jornadas IV, V y VI (2008, 2009 y 2010)*, vol. 2 (Seville, 2011), pp. 405–34.

Álvarez, B. C., 'Las misiones de los padres jesuitas en Latinoamérica (1606–1767)', *La Razón Histórica: Revista Hispanoamericana de Historia de las Ideas Políticas y Sociales*, 27 (2014), pp. 146–85.

Álvarez, B. and Ramos Palencia, F., 'Human capital and earnings in eighteenth-century Castile', *Explorations in Economic History*, 67 (2018), pp. 105–33.

Álvarez Kern, A., 'Jesuitas, guaranís y sexualidad en las misiones coloniales en el Río de la Plata', *Cuadernos de Antropología*, 10 (2013), pp. 355–73.

Angeles, L. and Elizalde, A., 'Pre-colonial institutions and socioeconomic development: the case of Latin America', *Journal of Development Economics*, 124 (2016), pp. 22–40.

Andersen, T. B., Bentzen, J., Dalgaard, C.-J., and Sharp, P., 'Pre-Reformation roots of the Protestant ethic', *The Economic Journal*, 127 (2017), pp. 1756–93.

Bareiro Saguier, R., 'La numeración en guaraní', *Amerindia*, 11 (1986), pp. 145–54.

Baten, J., Crayen, D., and Voth, H.-J., 'Numeracy and the impact of high food prices in industrializing Britain, 1780–1850', *Review of Economics and Statistics*, 96 (2014), pp. 418–30.

Becker, S. O. and Woessmann, L., 'Was Weber wrong? A human capital theory of Protestant economic history', *The Quarterly Journal of Economics*, 124 (2009), pp. 531–96.

Beltrán Tapia, F. J., Díez-Minguela, A., Martinez-Galarraga, J. and Tirado-Fabregat, D. A., 'Two stories, one fate: age-heaping and literacy in Spain, 1877–1930', *European Historical Economics Society working Paper in economic history* no. 139 (2018).

Beltrán-Tapia, F. J., Díez-Minguela, A., Martinez-Galarraga, J., and Tirado-Fabregat, D. A., *Capital humano y desigualdad territorial. El proceso de alfabetización en los municipios españoles desde la Ley Moyano hasta la Guerra Civil*, Banco de Espana Estudios de Historia Económica, 74 (Madrid, 2019).

Blum, M. and Krauss, K.-P., 'Age heaping and numeracy: looking behind the curtain', *Economic History Review*, 71 (2018), pp. 464–79.

Botticini, M. and Eckstein, Z., 'From farmers to merchants, conversions and diaspora: human capital and Jewish history', *Journal of the European Economic Association*, 5 (2007), pp. 885–926.

Bruno, C., *Historia de la Iglesia en la Argentina I-VI y IX-XI* (Buenos Aires, 1966).

Calderón-Fernández, A., Dobado-González, R., and García-Hiernaux, A., 'Numeracy in central New Spain during the Enlightenment', *Revista de Historia Económica-Journal of Iberian and Latin American Economic History* (2020), 38(2) pp. 369–403 (first view).

Calvi, R., Mantovanelli, F., and Hoehn-Velasco, L., 'The Protestant legacy: missions and human capital in India', *Social Science Research Network working paper* no. 3354891 (2019).

Cantoni, D., 'The economic effects of the Protestant reformation: testing the Weber hypothesis in the German lands', *Journal of the European Economic Association*, 13 (2015), pp. 561–98.

Cappelli, G. and Baten, J., 'Numeracy development in Africa: new evidence from a long-term perspective (1730–1970)', *Journal of Development Economics*, 150 (2021), article 102630.

Carbonell de Masy, R., *Estrategias de desarrollo rural en los pueblos guaraníes (1609–1767)* (Barcelona, 1992).

Cardiel, J., Las misiones del Paraguay*, ed. H. S. Olero* (Madrid, 1989).

Colvin, C. L., 'Banking on a religious divide: accounting for the success of the Netherlands' Raiffeisen cooperatives in the crisis of the 1920s', *The Journal of Economic History*, 77 (2017), pp. 866–919.

Crayen, D. and Baten, J., 'Global trends in numeracy 1820–1949 and its implications for long-term growth', *Explorations in Economic History*, 47 (2010), pp. 82–99.

Cuervo Álvarez, B., 'Las misiones de los padres jesuitas en Latinoamérica (1606–1767)', *La Razón histórica: Revista Hispanoamericana de Historia de las Ideas Politicas y Sociales*, 27 (2014), pp. 146–85.

Cushner, N. P., 'Slave mortality and reproduction on Jesuit haciendas in colonial Peru', *Hispanic American Historical Review*, 55 (1975), pp. 177–99.

Dell, M., 'The persistent effects of Peru's mining *mita*', *Econometrica*, 78 (2010), pp. 1863–903.

Dittmar, J. E., 'Information technology and economic change: the impact of the printing press', *The Quarterly Journal of Economics*, 126 (2011), pp. 1133–72.

Easterly, W. and Levine, R., 'The European origins of economic development', *Journal of Economic Growth*, 21 (2016), pp. 225–57.

Engerman, S. L. and Sokoloff, K. L., 'Factor endowments: institutions, and differential paths of growth among new world economies: a view from economic historians of the United States', *National Bureau of Economic Research h*istorical working paper no. 66 (1994).

Ettinger, C. R., 'Una nueva domesticidad. Los indígenas de la Alta California y la vivienda misional', *Nuevo Mundo, Mundos Nuevos* (2010) http://journals.openedition.org/nuevomundo/58264; https://doi.org/10.4000/nuevomundo.58264.

Fourie, J. and Swanepoel, C., 'When selection trumps persistence: the lasting effect of missionary education in South Africa', *Tijdschrift voor Sociale en Economische Geschiedenis*, 12, 1 (2015), pp. 1–29.

Fradkin, R. and Garavaglia, J. C., *La Argentina colonial. El Río de la Plata entre los siglos XVI y XIX* (Buenos Aires, 2009).

Frankema, E. H. P., 'The origins of formal education in sub-Saharan Africa: was British rule more benign?', *European Review of Economic History*, 16 (2012), pp. 335–55.

Frederick, J. C., 'Luis de Unzaga and Bourbon reform in Spanish Louisiana, 1770–1776', unpub. PhD thesis, Louisiana State University, no. 7355 (2000). Accessed 5 November 2019. https://digitalcommons.lsu.edu/gradschool_disstheses/7355/.

Gallego, F. A. and Woodberry, R., 'Christian missionaries and education in former African colonies: how competition mattered', *Journal of African Economies*, 19 (2010), pp. 294–329.

Ganson, B. A., *The Guaraní under Spanish rule in the Río de la Plata* (Palo Alto, Calif., 2005).

Glaeser, E. L., La Porta, R., Lopez-de-Silanes, F., and Shleifer, A., 'Do institutions cause growth?', *Journal of Economic Growth*, 9 (2004), pp. 271–303.

Glaeser, E. L. and Sacerdote, B. I., 'Education and religion', *Journal of Human Capital*, 2 (2008), pp. 188–215.

Gómez-i-Aznar, È., 'Human capital at the beginnings of the 18th century Catalonia: age-heaping and numeracy in a changing economy', Documentos de trabajo de la Asociación Española de Historia Económica no. 1904 (2019).

Hall, G. M., 'Raza y libertad: la manumisión de los esclavos rurales de la Luisiana bajo la jurisdicción del capitán general de Cuba', *Anuario de Estudios Americanos*, 43 (1986), pp. 365–76.

Hampe Martínez, T., 'Visita de los indios originarios y forasteros de Paucarcolla en 1728', *Revista Española de Antropología Americana*, 15 (1985), pp. 209–40.

Hippe, R., 'Human capital formation in Europe at the regional level – implications for economic growth', unpub. PhD thesis, Universität Tubingen & Université de Strasbourg (2013).

Huizinga, M. M., Carlisle, A. J., Cavanaugh, K. L., Davis, D. L., Gregory, R. P., Schlundt, D. G., and Rothman, R. L., 'Literacy, numeracy, and portion-size estimation skills', *American Journal of Preventive Medicine*, 36 (2009), pp. 324–8.

Ingersoll, T. N., 'The slave trade and the ethnic diversity of Louisiana's slave community', *Louisiana History: The Journal of the Louisiana Historical Association*, 37 (1996), pp. 133–61.

Jackson, R. H., 'Una mirada a los patrones demográficos de las misiones jesuitas de Paraguay', *Fronteras de la Historia*, 9 (2004), pp. 126–78.

Jackson, R. H., 'The population and vital rates of the Jesuit missions of Paraguay, 1700–1767', *Journal of Interdisciplinary History*, 38 (2008), pp. 401–31.

Jackson, R. H., *A population history of the missions of the Jesuit province of Paraquaria* (Cambridge, 2019).

Jackson, R. H., *Regional conflict and demographic patterns on the Jesuit missions among the Guaraní in the seventeenth and eighteenth centuries* (Leiden, 2019).

Jackson, R. H. and Gardzina, A., 'Agriculture, drought, and Chumash congregation in the California missions (1782–1834)', *Estudios de Historia Novohispana*, 19 (1998), pp. 69–90.

Juif, D.-T. and Baten, J., 'On the human capital of Inca Indios before and after the Spanish Conquest. Was there a "Pre-Colonial Legacy"?', *Explorations in Economic History*, 50 (2013), pp. 227–41.

Juif, D-T., Baten, J., and Pérez-Artés, M. C., 'Numeracy of religious minorities in Spain and Portugal during the Inquisition era', *Revista de Historia Económica-Journal of Iberian and Latin American Economic History*, 38 (2020), pp. 147–84.

Klein, H. S., *Haciendas y ayllus en Bolivia: ss. XVIII y XIX*, Estudios históricos, 18 (Lima, 1995).

Labrador Herráiz, M. D. C., 'Las reducciones del Paraguay, una experiencia educativa singular', *Eduga: Revista Galega do Ensino*, 48 (2006), pp. 325–50.

Livi-Bacci, M. and Maeder, E. J., 'The missions of Paraguay: the demography of an experiment', *Journal of Interdisciplinary History*, 35 (2004), pp. 185–224.

Lustig, W., 'Mba'éichapa oiko la guarani? Guaraní y jopara en el Paraguay', *PAPIA-Revista Brasileira de Estudos do Contato Linguístico*, 4, 2 (1996), pp. 19–43.

Maeder, E. J. A., 'Asimetría demográfica entre las reducciones franciscanas y jesuíticas de guaraníes', *Revista Complutense de Historia de América*, 21 (1995), pp. 71–84.

Manzel, K., Baten, J., and Stolz, Y., 'Convergence and divergence of numeracy: the development of age heaping in Latin America from the seventeenth to the twentieth century', *Economic History Review*, 65 (2012), pp. 932–60.

Marino, C. D., 'Consideraciones sobre la utilización de fuentes fiscales coloniales para un estudio sociodemográfico, Alto Perú 1750–1810', *Papeles de Población*, 4, 17 (1998), pp. 209–24.

Martinez-Galarraga, J., Miranda, A. R., and Willebald, H., 'Patterns of regional income distribution in Uruguay (1872–2012): a story of agglomeration, natural resources and public policies', in D. A. Tirado-Fabregat, M. Badia-Miró, and H. Willebald, eds., *Time and Space: Latin American regional development in historical perspective* (Cham, 2020), pp. 271–307.

Martínez Martín, C., 'El padrón de Larrazábal en las misiones del Paraguay (1772)', *Revista Complutense de Historia de América*, 29 (2003), pp. 25–50.

McCleary, R. M. and Barro, R. J., 'Religion and economy', *Journal of Economic Perspectives*, 20, 2 (2006), pp. 49–72.

Meier zu Selhausen, F., 'Missions, education and conversion in colonial Africa', in D. Mitch and G. Cappelli, eds., *Globalization and the rise of mass education* (Cham, 2019), pp. 25–59.

Mokyr, J., *Why Ireland starved: an analytical and quantitative history of the Irish economy, 1800–1850* (London, 1985).

Moraes, M. I., *La pradera perdida: Historia y economía del agro uruguayo. Una visión de largo plazo, 1760–1970* (Montevideo, 2008).

Moraes, M. I., 'Las economías agrarias del litoral rioplatense en la segunda mitad del siglo XVIII', unpub. PhD esis, Universidad Complutense de Madrid (2011).

Moriconi, M. S., 'Administración borbónica de pueblos de indios en el Río de la Plata: matriculas de pueblos de Santa Fe (1785)', *Prohistoria*, 18 (2012), pp. 144–97.
Muratori, L. A., El cristianismo feliz en las misiones de los padres de la Compañía de Jesús en Paraguay*, F. Borghesi, trans.* (Santiago, Chile, 1743/1999).
Naritomi, J., Soares, R. R. and Assunção, J. J., 'Institutional development and colonial heritage with in Brazil', *The Journal of Economic History*, 72 (2012), pp. 393–422.
Nunn, N., 'The long-term effects of Africa's slave trades', *The Quarterly Journal of Economics*, 123 (2008), pp. 139–76.
Ortega Soto, M., 'Colonización de Alta California: primeros asentamientos españoles', *Signos Históricos*, 1, 1 (1999), pp. 1–19.
Osante, P., 'El septentrión novohispano: una secular colonización hispana', in S. B. Albert, ed., *Poblar la inmensidad: Sociedades, conflictividad y representación en los márgenes del Imperio Hispánico (siglos XV-XIX)* (Málaga, 2010).
Quarleri, L. R., 'Lógicas y concepciones sobre trabajo, acumulación y bienestar en los pueblos guaraníes (Siglos XVII-XVIII)', *Anos 90*, 20, 37 (2013), pp. 177–212.
Rex Galindo, D., 'Franciscanos e indios en la Alta California española: 1769–1822', *Espacio Tiempo y Forma. Serie IV, Historia Moderna*, 20 (2007), pp. 157–70.
Rizzo, A., 'La importancia de la imprenta en las misiones de guaraníes (Siglos XVII y XVII)', *Signos Universitarios*, 25, 2 (2006), pp. 127–40.
Rubin, J., 'Printing and Protestants: an empirical test of the role of printing in the reformation', *Review of Economics and Statistics*, 96 (2014), pp. 270–86.
Ruíz Gutiérrez, A. and Sorroche Cuerva, M. Á., 'Jesuitas, Franciscanos y Dominicos: la frontera litoral de Las Californias en el siglo XVIII', in M. I. Montoya Ramírez and M. Á. Sorroche Cuerva, eds., *Espacios de tránsito. Procesos culturales entre el Atlántico y el Pacífico* (Granada, 2014), pp. 133–54.
Saeger, J. S., 'Another view of the mission as a frontier institution: the Guaycuruan reductions of Santa Fe, 1743–1810', *The Hispanic American Historical Review*, 65 (1985), pp. 493–517.
Saleh, M., 'The reluctant transformation: state industrialization, religion, and human capital in nineteenth-century Egypt', *The Journal of Economic History*, 75 (2015), pp. 65–94.
Salinas, M. L., 'Población y encomiendas en el nordeste argentino. El caso de Corrientes en el Siglo XVII y principios del XVIII según las visitas de indios', *Folia Histórica del Nordeste*, 17 (2008), pp. 111–36.
Sarreal, J. J. S., *The Guaraní and their missions: a socioeconomic history* (Palo Alto, Calif., 2014).
Schmitt, J.-C., 'L'invention de l'anniversaire', *Annales. Histoire, Sciences Sociales*, 62 (2007), pp. 793–835.
Sheets-Johnstone, M., *The roots of thinking* (Philadelphia, 2010).
Spennemann, D. H. R., 'Age heaping among Indian hawkers in South-eastern Australia and their source communities in the Punjab', *Journal of Sikh and Punjab Studies*, 24 (2017), pp. 149–202.
Stolz, Y., Baten, J., and Reis, J., 'Portuguese living standards, 1720–1980, in European comparison: heights, income, and human capital', *Economic History Review*, 66 (2013), pp. 545–78.
Szołtysek, M., Poniat, R., and Gruber, S., 'Age heaping patterns in Mosaic data', *Historical Methods: A Journal of Quantitative and Interdisciplinary History*, 51 (2018), pp. 13–38.
Takeda, K., 'Cambio y continuidad del liderazgo indígena en el cacicazgo y en la milicia de las misiones jesuíticas: análisis cualitativo de las listas de indios guaraníes', *Tellus 12*, 23 (2012), pp. 59–79.
Takeda, K., 'Los padrones de indios guaraníes de las misiones jesuíticas (1656–1801): análisis dinámico y comparativo desde la óptica de los cacicazgos', *Surandino Monográfico*, 1 (2016), pp. 66–105.
Tollnek, F. and Baten, J., 'Farmers at the heart of the "human capital revolution"? Decomposing the numeracy increase in early modern Europe', *Economic History Review*, 70 (2017), pp. 779–809.
Valencia Caicedo, F., 'The mission: human capital transmission, economic persistence, and culture in South America', *The Quarterly Journal of Economics*, 134 (2019), pp. 507–56.
Valencia Caicedo, F., 'Missionaries in Latin America and Asia: a first global mass education wave', in D. Mitch and G. Cappelli, eds., *Globalization and the rise of mass education* (Cham, 2019), pp. 61–97.
Valencia Caicedo, F. and Voth, H. J., 'Christ's shadow: non-cognitive skills and prosocial behavior amongst the Guarani' (Bonn University, mimeograph, 2018) https://cepr.org/sites/default/files/Valencia_CEPR_EXP.pdf.
Vicario, C., 'Human capital formation in South Latin America: the Río de la Plata region between 1744 and 1860', *Revista Uruguaya de Historia Económica*, 4, 5 (2014), pp. 11–33.

Vicario, C., 'The formation of human capital in pre-modern Latin America', unpub. PhD thesis, Eberhard Karls Universität Tübingen (2017).
Waldinger, M., 'Missionaries in Venezuela' (London School of Economics, manuscript, 2014).
Waldinger, M., 'The long-run effects of missionary orders in Mexico', *Journal of Development Economics*, 127 (2017), pp. 355–78.
Webre, S., 'The problem of Indian slavery in Spanish Louisiana, 1769–1803', *Louisiana History: The Journal of the Louisiana Historical Association*, 25 (1984), pp. 117–35.
Wilde, G., 'Los guaraníes después de la expulsión de los jesuitas: dinámicas políticas y transacciones simbólicas', *Revista Complutense de Historia de América*, 27 (2001), pp. 69–106.
Wilde, G., *Religión y poder en las misiones de guaraníes* (Buenos Aires, 2016).
Woodberry, R. D., 'The shadow of empire: Christian missions, colonial policy, and democracy in postcolonial societies', unpub. PhD thesis, University of North Carolina at Chapel Hill (2004).
Zavala, S., *El servicio personal de los indios en el Perú (extractos del siglo XVI)* (Mexico City, 1978).

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Additional supporting information can be found online in the Supporting Information section at the end of this article.

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