Universidad de Chile
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“NUMERACY AND EDUCATION IN CHILE: 1860-1940 COHORTS”

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Abstract

The study of human capital development is an important although complex task as it has a multidimensional nature but also because data is not as systematically available as researchers would hope so. Literacy is the most used historic variable to proxy for human capital, nevertheless, in the last decade or so the study of numeracy has gained strength trough the development of the Age heaping Technique. In this thesis we link the upwards trend in numeracy experienced by the 1860-1950 Chilean cohorts to the expansion of public primary education triggered by the primary instruction law of 1860. We find a strong and significant correlation between educational coverage and numeracy. Also, the effect is stronger for females, coherent with the fast expansion of schooling in this sub group.

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1. Introduction

The study of the development of human capital throughout the world has been an important subject for historians and anthropologist but also to economist and public policy makers insofar as it can leave valuable lessons regarding social processes that have and will take place in the future.

Even though the significance of this matter, the data's limited availability and the multi-dimensional nature of human capital -which comprise cognitive and social abilities, health, interpersonal relations, knowledge, etc.- have forced researchers to rely on poor and partial measures as school enrollment rates and self-reported literacy. This is an even bigger problem when it comes to developing countries as they lack at a greater extent systematic and reliable data.

Historic literacy rates can be found in self-reported data or, on earlier periods, inferred from signature rates in marriage registers or legal documents[1]. But when we talk about numeracy, obtaining historical aggregates becomes a more complex task because almost none statistics were collected on this issue in the past. However, this ability plays a major role in labor market outcomes, often being more important that literacy[2], and deserves further examination.

[1] For a more detailed approximation on literacy see Núñez (2005) for Latin America and Mayorga (2010) and Serrano and Jaksic (2000) for the specific Chilean case.

[2] See Murnane, Willet and Levy (1995), Charette and Meng (1998), Bynner and Parsons (2005).

An underexploited way to assess historical numerical abilities is the relatively new Age Heaping Strategy (A'Hearn, Crayen and Baten, 2009). This method infers the individual's lack of arithmetical skills by measuring the "heaping" in self-reported age data. Individuals that do not know their exact age or are unable to calculate it using their year of birth do not state this openly but rather approximate their age preferring ages ending in 0 or 5, so, more or less individuals approximating their age is used as a proxy for the ability to count and as so, as a proxy for human capital[3]. Although the concentration of the distribution of ages in certain "attractive" numbers is a well-known phenomenon among demographers and statisticians, only since the last decade or so it has been closely interpreted as a measure of human capital. The crucial advantage of the age heaping method is that data is relatively widely available for the early modern period, because many people were asked for their age in a more or less standardized way. For the Chilean XIX century there is no individualized data available but through censuses records the aggregate number of people declaring certain ages can be obtained.

This thesis is an attempt to measure numeracy in Chile in the late XIX and early XX century trough the Age Heaping strategy and interpret the results in the light of the educational public policies held throughout the period, more specifically the primary instruction law of 1860, which initiates the consolidation of the Chilean public education and which explicitly incorporates, the before forgotten, females.

[3] Nowadays we can assume that most people living in industrialized countries know their exact age or can check this information in documents, passports etc. but on earlier time periods this was not the case and age awareness was not so common as it is today.

Schooling is a variable strongly related with age heaping as previous studies have shown (as we will see in the next section of literature review), but never before this exercise has been done for Chile and at the same time giving it coherence thought the creation of the public educational system and its expansion.

The spread of public education in the XIX century is an extremely important event in Chilean history because before 1840 practically nothing was done regarding this matter. The minor incursions of the state seen in the 1840' and 1850' were finally formalized in the Primary Instruction Law of 1860, which vindicated the state's responsibility towards its citizens, made primary education universal and free and integrated the female population to the schooling system.

Using censuses from 1930 to 1970, all separated by a 10 year length interval, we are able to track down cohorts born as early as 1860 (people who were approximately 70 years old in the 1930 census) and as late as 1940 (people who were approximately 30 years old in the 1970 census) giving us a panoramic view of the development of numeracy in Chile.

Our main hypothesis is that primary educational coverage strongly and significantly affected the numeracy levels of the population, and that the high growth seen on the female enrollment rates produced that this effect was even stronger for the female subgroup.

This thesis is organized as follows: first, we review the literature on age heaping and its main findings in an attempt to convince the reader of why age heaping can be effectively used as a proxy for numeracy. Then, we analyze the Chilean

educational context and educational public policies of the period in terms of organization, curriculum, coverage and segregation, paying special attention in sex differences and rural-urban differences. In a fourth section we explain in detail the construction of the ABCC index, which is the index that formally measures age heaping, and the data used for the study. In a fifth section we discus the stylized facts and address the age, period and cohort effects, trying to solve the inherent co-linearity problem presented in data of this nature. In the sixth section we look more deeply in the cohort effect and its correlation with educational coverage and other dependent variables. Finally, the last section concludes.

2. Literature Review

More than a half century ago Bachi (1951) already investigated age heaping and its correlation with education levels within and across countries. With data from 1950 Israel and 1946 Palestine he found that the increasing spread of education resulted in a more educated population according to lower age heaping. Another early example was Herlihy and Klapisch-Zuber (1978), who used tax records and found that the distinct heaping on multiples of five declined substantially in the period from 1371 to 1470 and that this measure was worst among women from small communities and among the poor. But it was Mokyr (1983) the pioneer to establish the age-heaping measure as an explicit numeracy indicator in economic history assessing the effect of this measure on the labor quality on 1800' Ireland.

The correlation between numeracy and literacy is also well document, providing evidence that the age heaping method can effectively complement existent human capital studies (Hippe, 2012 and Manzel, Baten and Stolz , 2012). Using the Integrated Public Use Micro Samples (IPUMS) of XIX century United States censuses A"Hearn, Crayen, and Baten (2009) concluded that the probability to report a rounded age increases significantly with regional and personal illiteracy and that with age itself, phenomenon that will be examined in greater depth in the following chapters of the thesis.

The main premise is that if age heaping is a proxy for numeracy, it can also be used as a proxy for a more broad human capital measure because of the

implications that numeracy has on social and economic development. In A"Hearn, Crayen, and Baten (2009) the authors compared the level of age heaping to numerical skills as measured in the Programme for International Student Assessment (PISA)[4] survey yielding a considerable correlation coefficient of 0.80. Later in Crayen and Baten (2010a), the first exploration of long-run trends of numeracy and its contribution to growth, the authors found that for 165 countries evenly distributed throughout the word for the period from 1820 to 1949, numeracy, measured as the degree of heaping, proved to be crucial for growth patterns. The same intent to make robust the correlation between age heaping and numeracy can be seen en Baten, Crayen and Voth (2008), using the 1993 Assets and Health Dynamics Among the Oldest Old (AHEAD) dataset from the Health and Retirement Survey, which asked individuals to count backwards from 100 in steps of 7 as an overall indicator of numerical ability, they showed that in fact basic numeracy and age heaping are heavily correlated.

As for differences by gender, in Manzel and Baten (2009) the authors outlined the development of gender disparities in education for 28 Latin American and Caribbean countries for the period from 1880 to 1949, using age heaping techniques. By separating by regions, Latin American and the Caribbean, they could show that the first set of countries had typically lower gender equality indices than Caribbean countries during the whole period under consideration and that in

[4] PISA is a worldwide study conducted by the Organisation for Economic Co-operation and Development (OECD) to measure 15-year-old school students' performance on mathematics, science, and reading.

both sub regions the overall trend is characterized by increasing gender equality in numeracy, process going hand in hand with economic development.

Another creative example is Földvári, van Leeuwen and van Leeuwen-Li (2012). They use census from US, Britain, Norwich and Tuscany and find that while women heap more than men, married women heap significantly less than unmarried ones. They give three possible explanations for this phenomenon. The first one is selection, that is, a possible tendency that only the better educated succeeded in the task of getting married. The second one is learning within marriage, namely, that wives learned basic arithmetic skills from their spouses, making it possible for them to improve numeracy in time. A third and last explanation is that wives adjusted their reported ages to that of their spouses independent of their arithmetic skills, causing an underestimation of age heaping for married women. The later hypothesis is supported by the fact that the age difference between both spouses age is not statistically different from zero, and that widows return to their high heaping levels after their husband's deaths.

While the relatively recent age heaping literature grows, academics have expanded the possible explanatory variable for this measure beyond schooling and literacy. Age heaping can be related to a variety of factors; for example in Crayen and Baten (2010a) the authors explore the correlation between age heaping and schooling, state development, and protein malnutrition. The relationship with schooling is pretty straightforward as it is a measure of mathematical skills. They justified the inclusion of state development to the extent that the degree to which

an individual interacts with the state or religious and other administrative authorities can affect its own necessity of age awareness. To approximate state development, they used data on state antiquity as a proxy for the strength of the state and the quality of its institutions. As an alternative to this variable, they also computed the number of censuses taken in each country since 1600 up to the individual's birth decade. The justification for including protein malnutrition in the analysis is that biologists and psychologists suggest that Infant Protein Malnutrion Syndrom (IPMS) limits an adult's cognitive abilities by lowering neurodevelopment during the first two years of life; children who had received less nutrient-rich diets showed significantly lower IQ scores, which can affect numerical abilities regarding schooling and other factors. As an IPMS measure is not available for the period, they use height as a proxy[5]. In summary, after considering all of these possible alternative explanations, the majority of specifications yield that schooling is by far the strongest determinant of age heaping patterns.

[5] Another example of height being used a proxy for nutritional status can bee seen in Crayen and Baten (2010b) were the taller half of the height distribution displayed a much lower age heaping tendency than their shorter peers in France during the XVII century.

3. Chilean Educational Policies in the XIX century

3.1. The Primary Instruction Law and its background

As soon as the fight for independence from Spanish colonial rule began to take its course in the early XIX century, mass education was seen as a way to train citizens to sustain popular sovereignty. In the project of a new political community, virtue of citizenship stood as a critical milestone in the legitimatization of the nascent nation.

Although the ideas were there, before 1840 practically nothing was done in the field of public education mainly because the starting point was a non-existing system. The lack of resources and political consensus, the disorganization, the scattered population and the primitive way of living of the vast majority of people were all obstacles to the first initiatives regarding this matter.

The first proposal for a public school system, born within the dominant elites as all other mayor issues in the period, was not so much oriented towards social integration and the development of a productive task force as it was to preserve stability and civilize and homogenize the population, teaching lower class offspring's basic notions of morale and good manners, behaviors that were thought people should internalize[6].

[6] This is why humanities prevailed over natural sciences, not only because teachers were lacking but also because they were seen as way to develop morale and virtue.

The educational proposal for the masses was not very successful if we look at the coverage achieved, the attendance, the infrastructural context or the learning outcome level, but it succeeded in generating consensus on the importance of this matter, and to produce professionalized teachers and standardized norms and controls.

In the beginning, government tried to promote public education trough old institutions as councils and convents, and direct it trough norms and supervision. Local and religious initiatives mostly took form in schooling for the children who could afford it and accepted few pupils from the lower half of the income distribution in return of domestic tasks such as cleaning and cooking. Private initiatives from locals who committed to provide the basic resources in exchange of government support and additional finance was a formula that allowed the system to expand more rapidly and to reach isolated locations, nonetheless, it also condemned the rural and small communities to a very precarious infrastructure, as contributing families were, in most cases, extremely poor. Till 1860, the involvement of the state in this matter depended heavily on the motivation of the local communities and its ability to effectively organize; education was not provided by the state but directed by it.

Although the system was not really formalized till 1860, in the previous decades several initiatives were held in order to pave the way. The Ministry of Justice, Cult and Public Instruction was created in 1837 and the Normal School of Preceptors was created in 1842. Also, the figure of “visitors” (1947) -public employees who

traveled around the provinces recording the needs of the existing schools, being the link between the demands of the local communities and the state apparatus- was created in order to proceed with a cadaster of what was already there in terms of education. In sum, the necessity of having educated and standardized teachers to organize the nascent system, which was developing in a rather inorganic and messy way, and to have hard data and panoramic for what the current education was lacking, was a priority. So, the 1860 law came to formalize a lot of was already going on regarding public education.

Deputy José Victorino Lastarria presented the draft law that gives origin to the Primary Instruction Law to the chamber of deputies in 1843, one year after the foundation of the Normal School of Preceptors. This version of the law addressed the issues of divisions by educational level and administration, detailed the teacher's duties, functions and work conditions and proposed that primary education should be free, being the municipalities and convents the ones in charge of financing schools at their own cost. The project was send to the University of Chile's Philosophy Faculty for its review, but was subject to various modifications, reason that lead to Lastarria´s later sponsorship withdrawal. This draft law was later resumed by Antonio Garcia Reyes who formalized the function of visitors and proposed that schools also accepted paid interns as an alternative source of funds. This new version of the law was send to the chamber in July of 1848 but its discussion will only began a year later. Parliamentarians were still dissatisfied so it was send to a new commission chaired by deputy Manuel Montt, who will later become President of the Republic. The version redacted by Montt shed light on the

fact that none of the previous versions had explicitly recognized education as right; he put forward the idea that it was the state`s duty to give its people proper instruction and also criticized that as to that point, the discussion only contemplated male education, leaving females abandoned to their own fate. Also a sociological discussion arouse regarding promotion and expansion of popular education. Intellectuals like Lastarria, Salvador Sanfuentes and García Reyes argued that a thousands public school could be funded but they would remain empty due to the lack of recognition of the importance of formal education among poor families, the scatter population and the overall poverty. But Montt's line of thought was the inverse: by establishing education as a positive right they were going to fight this lack of demand with perseverance.

Nevertheless, the most controversial item and the primary reason for the delay in its approval was referring to the financing of the system. Montt proposed a direct money contribution from all citizens, raised and administrated by the municipalities. An opposite and more liberal view[7] relied on the premised that the state should have a predominant roll in the education system, and therefore the economic resources should come from the national treasury. A third view, hold by the ultra conservative party, exposed the potential difficulty that could arise by taxing the rich and wealthy, whose children would not benefit from the public educational system. To all of these alternative arguments Montt's reply was "They are afraid to put another financial burden on our country's citizens but they are not afraid to leave them ignorant and demoralized"[8]

[7] José Victorino Lastarria's view.
[8] Serrano, Ponce de León and Rengifo (2012), Vol. I, Pp. 90.

The paperwork of the law became stagnated, but Montt insisted on it in 1857, year in which he was reelected for a second term as president. The first article in his law, that was the essence of it all, stated that the citizens of the republic had a right to being educated and was the state's duty to provide it; if it was a right, the following reasoning was that it would have to be free and universal. The parliament's majority was against it arguing that "it tasted like socialism" and "now we give them schooling but tomorrow they will ask for food, and after that clothing and housing, until we fall in all the consequences that the principle has". This first article was reject by 28 votes against and 2 in favor and was replaced by "primary instruction will be given under the rule of the state" to which José Manuel Infante, Montt's closest collaborator replied "they have killed the most beautiful part of the law"[9].

Although the original article failed to be approved, it's important in Republican Chilean History because it was the first proposal of a positive right and it was the first to explicitly incorporate women.

The long time that it took for the law to be approved was a reflection of the fact that the discussion on primary instruction was a lot more polemic than it could have appeared at first glance. Finally in the year 1860 the Primary Instruction Law was approved and established two measures of great importance: that a school for girls

[9] Serrano et al. (2012), Vol. I, Pp. 91.

and another one for boys would exists for every 2.000 inhabitants and that they would be free of charge[10].

The law of 1860 was liberal in the way that institutionalized, extended and projected primary education to the mass, giving the state a protagonist roll in its direction and implementation, but it also had conservative elements in the way that safeguarded the independence of private institutions against government control and it did not alter the social status quo. The quality of the consensus in which this law was conceived – the union between liberals and anti-Montt conservatives- gave the law its strength to remain valid for 60 years, until the 1920 Mandatory Primary Education Law. For 60 years primary instruction policies escaped political conflicts protagonized by conservative tendencies also because it was directed towards popular sectors whom did not related intimately with the elite`s agenda.

3.2. Educational coverage

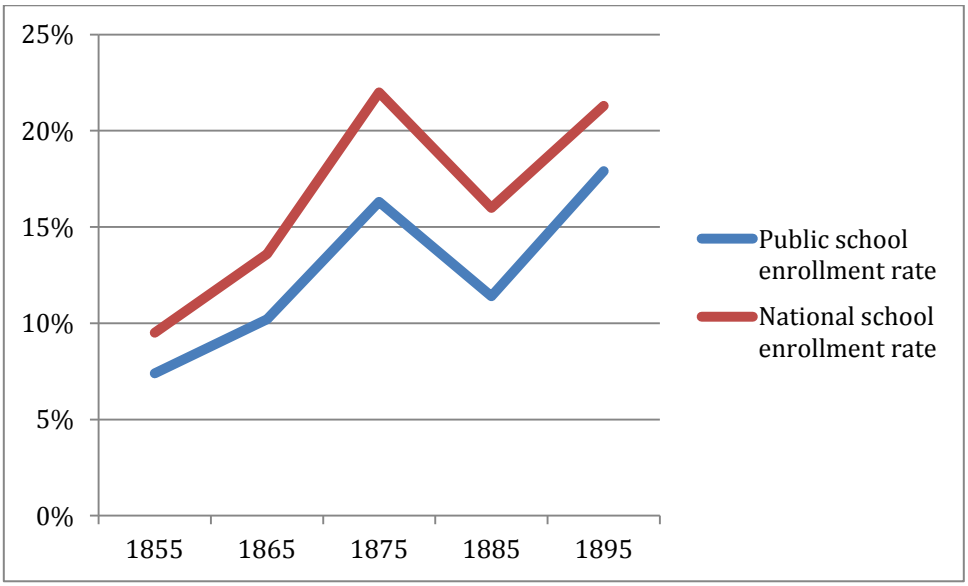
During the decade of 1840 the system was born into a mix of copayment and state contributions, until the state met with property its duty of take care of people`s education by the law of 1860.

Although enrollment rates do not truly reflect the real attendance to school, it is a helpful indicator of the growing value that families were giving to education. As Graph Nº1 tells us, the 1860 law had a high and positive impact on educational

[10] A detailed description of the law in Spanish can be found in Annex Nº1.

coverage. The 1870-decade presented the highest growing rates, mainly because the mandate of funding two public schools every 2.000 inhabitants (one for each sex) allowed the rural sectors to amplify their educational supply[11]. In the 80s there is a small set back in coverage that can be explained in part by the pacific war's need for male enrollment in the army.

Graph Nº1: Percentage of children between the ages of 7 and 15 enrolled in primary schools, 1855-1895.



Source: Serrano, Ponce de León and Rengifo (2012), Vol. II. Pp. 69.

[11] Still and all, important differences remained between the urbanized cities and the rural agricultural zones. By 1873, there was a school for every 352 children in urban zones and there was one for every 604 children in rural zones. Serrano, Ponce de León and Rengifo (2012), Vol. II. Pp. 184.

Regarding differences by sex, the willingness to expand proper instruction for girls was set back not so much by the lack of schools or their resources but primarily by the lack of female teachers. In 1854, under Montt's presidency, the first Female Preceptors Normal School was founded but only 11 years later of the male's normal school. The Female Preceptors Normal school was organized trough a 4 year curriculum which taught reading, writing, morale, catechism, grammar, geography, drawing and history, besides sewing and embroidery, task that were thought every woman should master. However, instead of rapidly producing qualified teachers for female schools, the female normal preceptor school functioned as a sort of welfare establishment for poor family girls who were more attracted by the 100 pesos a year grant than by the profession itself. Of the 40 female students that were enrolled in the first generation of this institution, only 9 graduated in 1857. By 1864, the annual average of graduated female teachers was only 6.

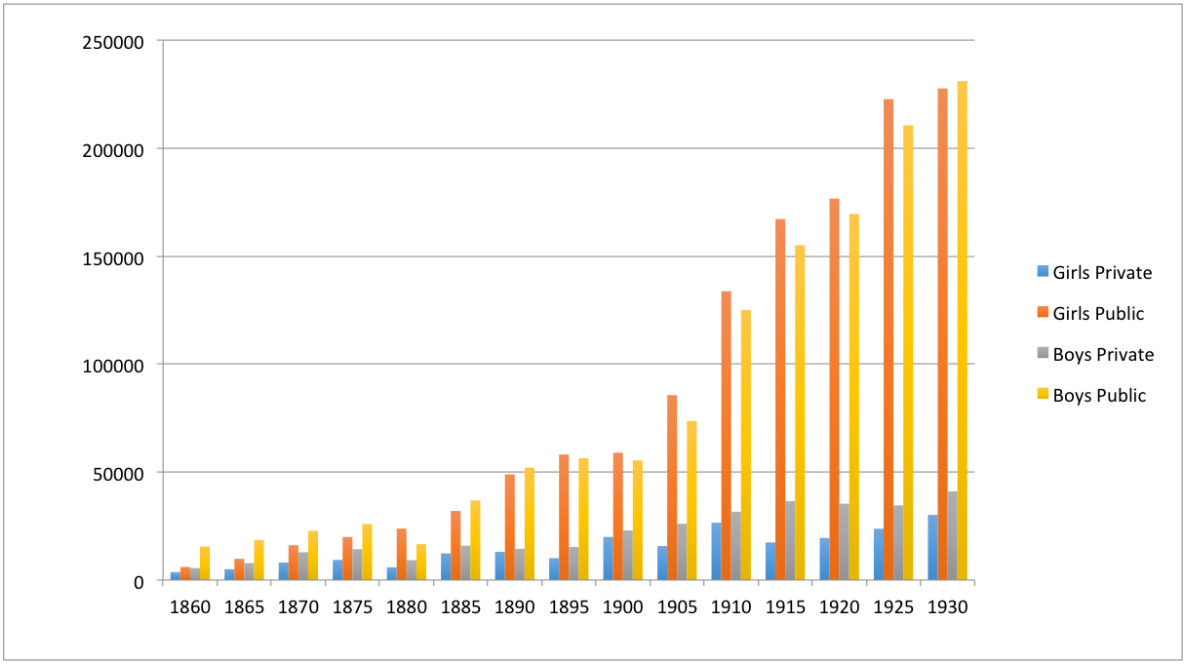
Despite these difficulties, president Montt gave a major impetus to female education in his mandate, even before the 1860 law was operating. If we look at the popular sector enrollment in primary school as a whole, the progress made was a at a very low pace; in 1865 10.9% of Primary-school age population was enrolled in it, two decades later the number was 20.4% and by 1907 the percentage reached 35.5%, being evenly distributed between sexes.[12]

More efficient was the female enrollment as a subgroup, as we can see in Graph Nº 2. In all early XX century primary public enrollment was higher for girls than for

[12] Egaña, Nuñez and Salinas (2003), Pp. 68.

boys, phenomenon that is explained by Egaña, Nuñez and Salinas (2003) as boys were more likely to be taken out of school to help their parents with agricultural labors. This was a bigger issue in rural sectors, were if boys did not attend school at an early age, probably were not going to be able to attend later because of their entry in the labor force. Also, as supply of mixed gender school grew, schools that only accepted children till the age of 12, girls were the most beneficiated as their household duties were the most compatible with school attendence.

Graph Nº 2: Public and Private School Enrollment (Nº of students) by sex



Source: Egaña et al. (2003) Pp. 73.

The intra-regional coverage index (Table Nº1) that will be revised with more detail in a later chapter of this thesis also reflects this pattern; school coverage grew more rapidly for girls in the vast majority of the territory.

Nevertheless, it is important to stress that education for boys and for girls had considerable differences. Although the academic curriculum set by the 1860 law stipulated a common base of subjects for primary education, in practice the teaching of this subjects had substantial differences between sexes. Female education was more oriented towards domestic life and not so much towards a public life, as it was the case for men.

Table Nº1: Primary education coverage (% of 7 to 15 year old children) by sex, year and region

	Year					
	1870		1892		1910	
Region	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**
Tarapacá	-	-	23.59%	27.73%	40.49%	26.48%
Antofagasta	-	-	51.00%	38.58%	42.69%	34.54%
Atacama	19.56%	19.67%	45.40%	34.82%	50.10%	39.51%
Coquimbo	6.82%	9.64%	24.77%	23.13%	37.07%	29.80%
Aconcagua	9.53%	11.62%	23.79%	19.34%	58.92%	40.85%
Valparaíso	14.12%	17.38%	29.48%	29.15%	48.94%	33.50%
Santiago	12.53%	12.52%	27.10%	22.88%	46.70%	36.23%
O´Higgins	-	-	19.84%	20.31%	42.27%	32.25%
Colchagua	8.24%	13.29%	18.84%	22.27%	38.39%	27.15%
Curicó	5.35%	11.85%	17.16%	18.49%	30.70%	31.39%
Talca	5.43%	10.16%	14.47%	11.47%	39.02%	32.63%
Maule	4.62%	6.96%	17.24%	18.92%	41.75%	40.77%
Linares	-	-	20.00%	23.07%	33.96%	35.37%
Ñuble	6.43%	7.20%	19.47%	20.39%	45.37%	42.29%
Concepción	8.66%	11.46%	25.28%	24.10%	37.37%	34.14%
Arauco	5.58%	6.46%	14.04%	14.19%	28.64%	26.24%
Bio-bio	-	-	16.25%	16.72%	30.74%	28.85%
Malleco	-	-	19.06%	17.22%	30.17%	29.69%
Cautín	-	-	12.50%	8.90%	24.11%	25.60%
Valdivia	8.01%	19.56%	13.62%	18.85%	24.38%	23.43%
Llanquihue	4.45%	13.64%	14.18%	27.33%	27.81%	35.07%
Chiloé	4.84%	12.43%	17.71%	29.69%	43.11%	58.39%
Magallanes	-	-	-	-	52.90%	54.51%

Notes and source: Own elaboration from Egaña et al. (2003) and censuses (1865, 1875, 1885, 1895 and 1907). A detailed description of the construction of these rates can be found in Annex Nº6.

Chilean educational expansion process was slightly uneven due to the sex bias, but also if we look at the coverage by zones. In a predominant rural country, local communities made possible the expansion of schools but because they had a small amount of children, coverage didn't grow as much. The new set of schools was concentrated in small villages but they only housed 13% of the country's total population[13]. Between 1865 and 1895 the number of schools grew by 229.4% but general schooling grew by 123.6%. In conclusion, schools were not being created were the vast majority of people resided. Despite de good intentions of focusing in the relegated rural zones, another factor that did not hinder these efforts was the high rotation and drop out rates of the children`s communities. The annual harvesting seasons and the field's work usually enabled pupils to attend school a few months of the year, giving education an intermittent and insufficient nature.

The fact that schools were being founded in places that had extremely low levels of attendance did not scape the policy maker's eye. For this regard, the 1863 General Regulation of Public Instruction stipulated that every school with less than 25 pupils would have to be closed. Although this was a well-intentioned policy to ensure the

[13] Serrano et al (2012), Vol I, Pp. 357.

efficiency of the resources, it left the deep field's population at its own fate once again. A measure to counter the low attendance and the school's shut down was the creation of "temporal schools" or "alternate schools" which taught boys in the morning and girls in the afternoon, or girls the first three days of the week and boys the remaining three days. The problem with this system was that formal schooling was cut to a half of its regular duration, being a specially detrimental issue in the rural context where children would only attend school for a few years of their life, leaving too little time to learn the basic abilities as reading, writing and counting.

This is why despite the strong conservative resistance in 1881 mixed schools were created, giving a renewed impetus to rural education. Between 1880 y 1899 47,9% of all school foundations took place in new districts, were of a mixed nature and were located outside the cities, concentrated in the rural center of the country[14].

This was a deeply beneficial measure because besides helping schools to get enough alumni in order not to close it also helped boost coverage significantly and homogenized the curriculum, slowly eliminating the differences between what was taught for boys and what was taught for girls.

3.3. In sum

In the beginning school coverage grew slower than territorial extension, but overall, in the decade of 1880 the popular elementary education system was pretty much consolidated. The institution that represented the state had significantly moved towards its own legitimization. The growing demand of schools and its attendance

[14] Serrano et al. (2012) Vol. I, Pp. 178.

were an indication of the growing value that families were giving to education and the identification of the state's responsibility.

Notwithstanding the obvious educational progress made in this century, the real gains in terms of learning left much to be desired. This was due in part to the scarce resources and the fact that the academic content and methodology were very distant to the student's realities and social context. To this regard, it is important to consider the wide and permanent influence that foreign models of education had in this early education system and the strong Europeanization of the elites looking to built a cultural identity that would separate them from the Spanish past and the aboriginal and mestizo (crossbreed) present.

Unlike the European alphabetization process, which began with popular literature, the first printed text of mass circulation in Chile was the school textbook; so alphabetization developed hand in hand with schooling and more often than not the benefits of formal education were not clear for the people receiving it. Being able to read, write and count were not necessary attributes for the full individual development in society and the low schooling rates are a reflection of this reality.

4.Index construction and data

Because the majority of age heaping studies are still rather recent (e. g., A‟Hearn et al. 2009, Manzel and Baten 2009), it is very necessary to explain the underlying methodology.

The basic premise is that the self-reported age of the population in historic data presents frequency accumulations in attractive ages, such as the ones ended in 0 or 5, because individuals did often not know their exact age. This can be caused by the lack of basic arithmetical skills of the individual or the uncertainty of the year of birth, and although the two possible explanations in one way or another gives us substantial information on human capital accumulation, we will use the first explanation for our analysis because of the close correlation between age heaping and numeracy stated earlier on this thesis.

There are inherent characteristics of this method that make it especially advantageous for the historic quantification of numeracy. The main one is that age statements are available for very early periods of time, giving the possibility of going centuries back and tracing the long-term development of human capital.

Nonetheless, it is quite clear that this method only captures very basic numerical abilities. The quantification of these rudimentary skills, however, makes sense when studying the past and it makes even more sense when studying developing countries.

In this thesis we will use the ABCC index but the most intuitive way is to begin with the definition of the Whipple Index, which is the ratio of the observed frequency of ages ending in 0 or 5 to the frequency predicted by assuming a uniform distribution of terminal digits (one tenth for each terminal digit). The later index is defined as:

$$Whipple\ Index = \frac{\sum(n_{25} + n_{30} + \cdots + n_{65} + n_{70})}{\frac{1}{5}\sum_{1=23}^{72} n_i} x100$$

Where an index value of 500 would indicate perfect heaping, i.e. all declared ages end on multiples of 5. If everybody reports the correct age the ages ending in 5 and 0 should account for 20 per cent of all age statements and the Whipple index would yield a value of 100. All values between these two extremes would represent different levels of numeracy; for example, a Whipple index of 300 means that 60 per cent of respondents claim that their age ends in a 0 or 5, implying that probably 40 per cent misreport their age.

The summation notation in the denominator is meant to emphasize that the Whipple Index must be defined over an interval in which each terminal digit of age occurs an equal number of times, as in an age range of 10 successive single years. Since more people are alive at 50 that at age 59 the total share of people whose age ends in 0 should be naturally larger than the total share of people reporting an age ending in 9. In order to spread the final digits of 0 and 5 more evenly across the age ranges and to avoid overestimating the heaping, literature systematically uses age ranges starting with the final digit 3 and ending with the final digit 2, such as 23-32, 33-42 and so on till the 62-73 interval. We exclude

people over the age of 74 primary because of the low life expectancy and thus the little observations available.

But because the interpretation of the Whipple index is not so intuitive, in this thesis we employ a simple transformation of the Whipple Index that can be interpreted as the share of individuals that correctly report their age. This index is known as the ABCC index and it was first developed by A'Hearn et al. (2009):

$$ABCC\ Index = \left(1 - \frac{Whipple - 100}{400}\right) x100$$

Here values range from 0 to 100, where 0 is the lowest numeracy level and 100 the maximum. This ABCC index has the advantage of having a more intuitive interpretation; just like literacy rates show what percentage of the population are able to read and write[15], the ABCC index can be seen as its equivalent but for numeracy skills.

The data used in the stylized facts section corresponds to Chilean republic censuses from 1930 to 1970[16] for the sex differences analysis and from 1950 to 1970 for the rural-urban differences analysis.

Although Chile has censuses from as early as 1813, annualized reported age can only be found after 1930[17], and annualized reported age that also separates by rurality can only be found after 1950, hence the different starting points between the two mayor study groups.

[15] Or just able to read, depending on the definition of literacy used.
[16] 5 censuses: 1930, 1940, 1952, 1960 and 1970
[17] Prior to that date age is reported in groups, i.e. between the ages of 10 and 15, 15 and 20, etc., so an ABCC index cannot be calculated.

Working with different censuses, all which are separated by a decade, allows us to track down cohorts as early as those born in 1860 (individuals that had approximately 70 years in the 1930 census) and as late as 1940 (Individuals that had approximately 30 year in the 1970 census), so we are left with a substantial period of time, and most important, cohorts that were directly affected by the XIX century's public educational policies.

The same cohort mentality is used in our "schooling and numeracy" section although we only use the 1930 and 1940 censuses because they are the only ones that have annualized age on a provincial level. This characteristic allows us to exploit intra-national differences both in schooling and in numeracy. The data for school coverage is constructed with the numerator as public primary school enrolment from Egaña, Nuñez and Salinas (2003) dated 1870, 1892 and 1910 and the denominator as number of children in age to attend school i.e. between 7 and 15 years from census data[18].

[18] Because there is no 1870 census but an 1865 and 1875 census and no 1890 census but an 1885 and 18895, the number of children in age to attend school was calculated using a geometrical interpolation.

5. Stylized Facts

5.1. Analysis technique

There are three main effects that must be detangled when proceeding in analyzing long-term changes among the members of a society: age, period, and cohort effects.

In our particular age heaping context, ABCC index is determined by Age itself; younger people can have more age awareness because they are in a stage in their life were they are more frequently asked about it in, for example military and marriage records, and older people are more likely to have a weaker memory. There are also period effects that can make ABCC index vary from one census to another because of inherent census's methodological variations or institutional development[19]. The third effect, cohort effect, reflects the particular socioeconomic context in which the individual was born and raised, including for example the educational public policies being held throughout the particular period.

Although this as an important methodological issue in assessing evolution on age heaping[20], previous work has consistently ignored it[21]. A reason for this can be that

[19] For example, a Chilean Civil Registry office was not created until 1884. A legal obligation to register births, marriages and deaths can have a significant influence on the knowledge of one's age.
[20] And cohort analysis as a whole. See Ryder (1965), Oppenheim, Mason, Winsborough and Poole (1973), Glenn, N. D. (1976), and Fienberg and Mason (1985).
[21] Although there are some studies that address the age effect (A"Hearn, Crayen and Baten (2009), Crayen and Baten (2010), Földvári, van Leeuwen and van Leeuwen-Li

assessing these effects, jointly and independently, is a substantial problem due to the linear dependence between them (i.e., period + age = cohort). There exists no all-purpose method for cohort analysis that can be routinely applied to produce reliable and valid estimates of the different kinds of effects but rather a wide range of literature to choose from[22].

We begin by describing the age heaping's trends and patters by sex and urbanization highlighting stylized facts in a visual analysis. Then, following the example of Robinson and Jackson (2001) and Clark and Eisenstein (2013) we combine descriptive analyses of the dependent variable[23] that include only two of the Age Period Cohort (APC) variables, leaving the third uncontrolled, followed by estimates for the full APC accounting models using the Coefficients Constraints Approach, also referred to as the Constrained Generalized Linear Models Estimator (CGLIM).

This is the most common method used to estimate each of the age, period, and cohort coefficients independently in APC models and it consists on imposing one or more equality constraints on the coefficients in order to just-identify (one equality constraint) or over-identify (two or more constraints) the model. Its first developer Mason (1973) recommend using the over identified model whereby two age groups, two periods, or two cohort groups are assumed to have similar influences

(2012)) and the cohort effect (Manzel, Baten and Stolz(2012) and Baten, Ma, Morgan, and Wang (2010)), there are no studies that address the three simultaneous effects properly.

[22] For example Generalized Linear Mixed Models (GLMMs), Intrinsic Estimator (Yang, Fu and Land, 2004), Bayesian statistics approach (Saski and Suzuki, 1987) and Proxy Variables/Age-Period-Cohort Characteristic (APCC) Approach (O'Brien, 2000)

[23] For our case is the ABCC index but for the other two authors cited above is a trust index.

on the dependent variable, constraining their coefficients to be equal. The main criticisms of this approach and its variants is that the analyst needs to rely on prior or external information to find constraints that hardly exists or can be well verified and that different choices of identifying constraints can produce widely different estimates of patterns of change across the A, P, and C categories and at the same time identical goodness-of-fit to the data, but we will address this problems later on.

5.2. Visual analysis

For a first approximation on the subject in Table Nº 1 we can see how ABCC index has evolved through age, year of survey and cohort. Since both age and period are of 10-year interval lengths, the diagonal elements of the matrices roughly [24] correspond to cohorts. For example, the 1898-1907 birth cohort is represented in the 23-32 years olds interviewed in 1930; ten years later, this cohort is 33-42 years old and it appears in the second row of the 1940 survey.

Each column in Table Nº2 shows that Numeracy levels are systematically higher for younger individuals as previous literature has evidenced in the past. A comparison through rows, evidence that for each age group, numeracy levels have a tendency to grow across time periods, but all of this visual examination ignores the previously discussed isolation of age, period and cohort effects.

[24] There is no 1950 census but a 1952 census and individuals surveyed are not the exact same individuals due to potential migrations.

Table Nº2: ABCC Chilean index by age and year of survey.

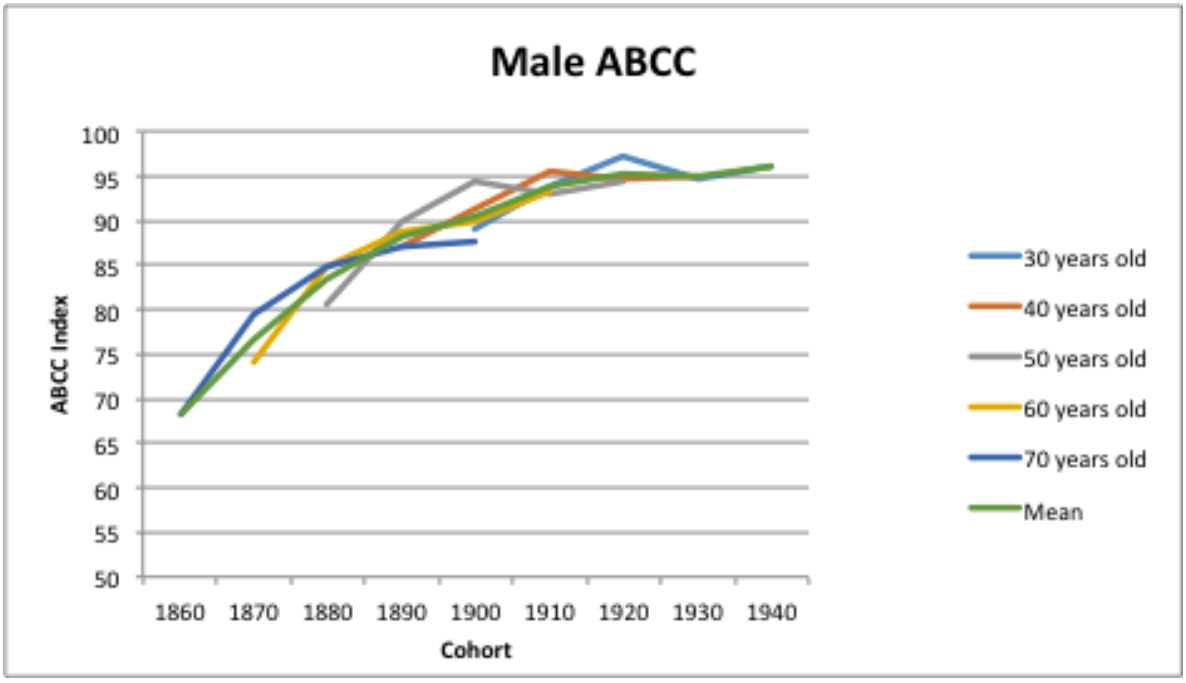
Age	Year of survey					
	1930	1940	1952	1960	1970	Age totals
23-32	87.58	92.86	96.07	94.24	95.92	95.34
33-42	83.52	89.70	93.91	93.64	94.45	94.01
43-52	75.18	86.20	91.28	91.37	93.30	91.54
53-62	67.91	80.20	84.47	87.91	91.30	88.48
63-72	62.28	74.44	79.85	84.33	86.32	85.22
Year totals	80.57	88.18	92.00	91.91	93.58	90.92

Source: own elaboration from the 1930, 1940, 1952, 1960 and 1970 Chilean censuses.

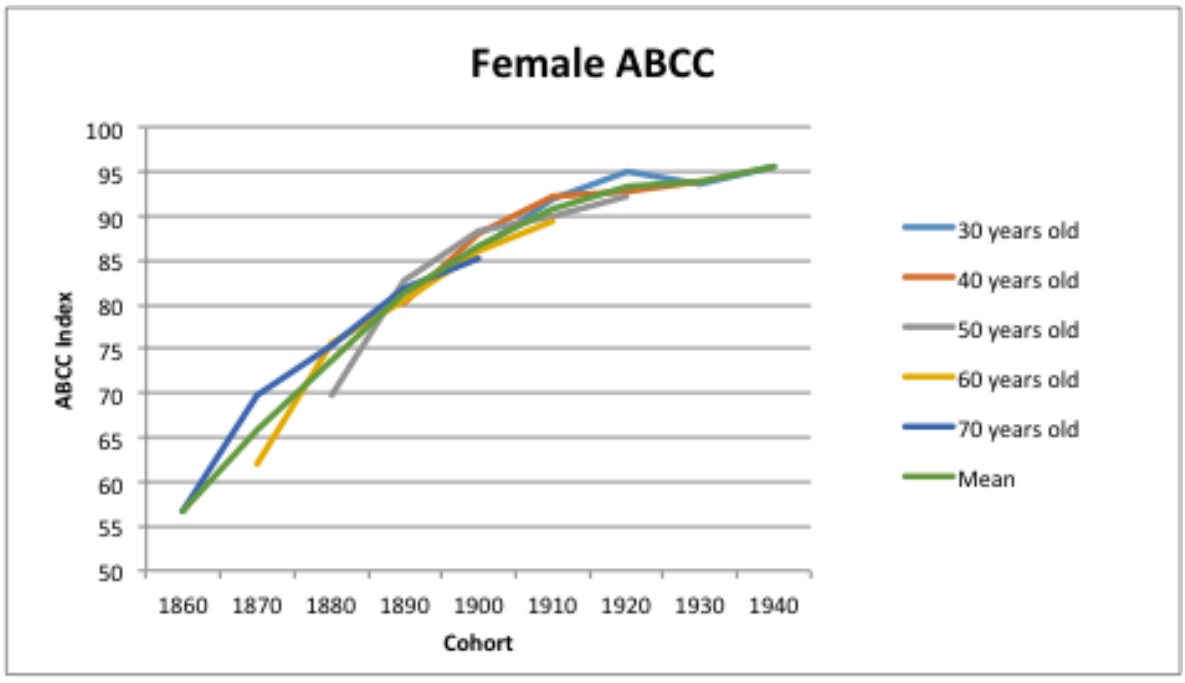
As for gender and urbanization differences and a more explicit analysis for cohort effect we refer to graphs Nº3 to Nº6. Graphs Nº3 and Nº4 illustrates ABCC indexes for each cohort, each age group[25] and gender. Here we can see more clearly that although there is some variation across the life cycle, the vast majority of the increase in ABCC index comes from the individual's cohort, presenting a concave pattern i.e. the increase in numeracy is more rapid for earlier cohorts becoming smoother towards the ends. Although women start with significantly lower levels, there is a fast catching-up to men and by the 1920's cohort these differences in numeracy practically disappear. This evidence is consistent with the grand female schooling efforts made in the late XIX century.

[25] The 23-32 years old group is abbreviated as 30 years old, the 33-42 years old group is abbreviated as 40 years old, and so on.

Graph Nº3: Male ABCC index by age and cohort of birth in Chile 1860-1940.



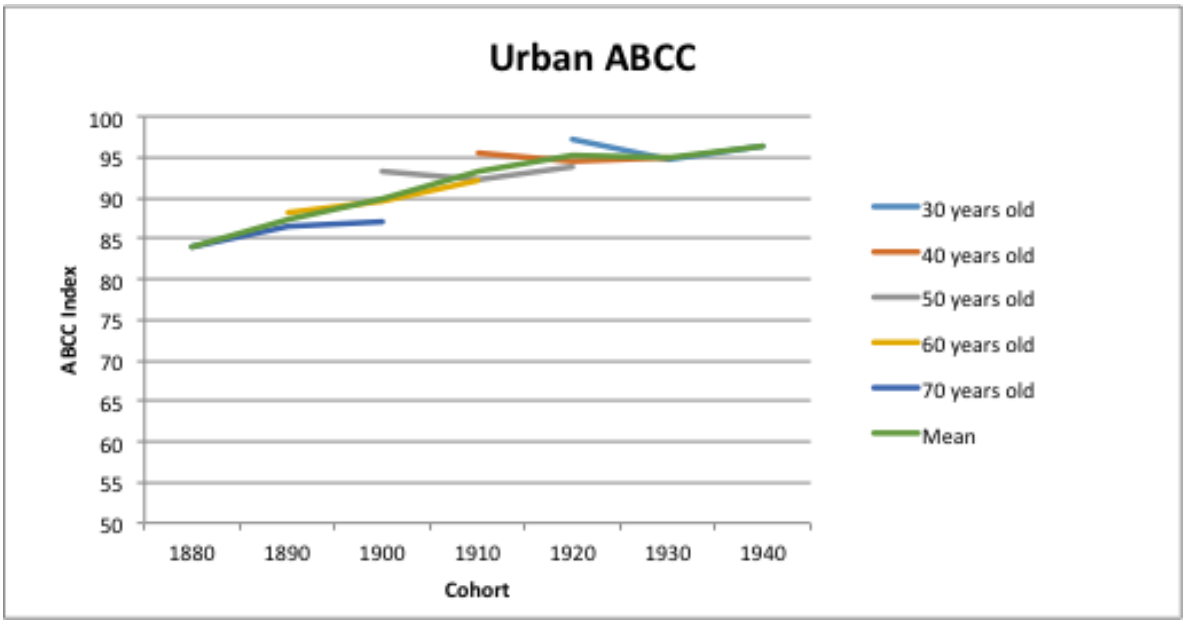
Graph Nº4: Female ABCC index by age and cohort of birth in Chile 1860-1940.



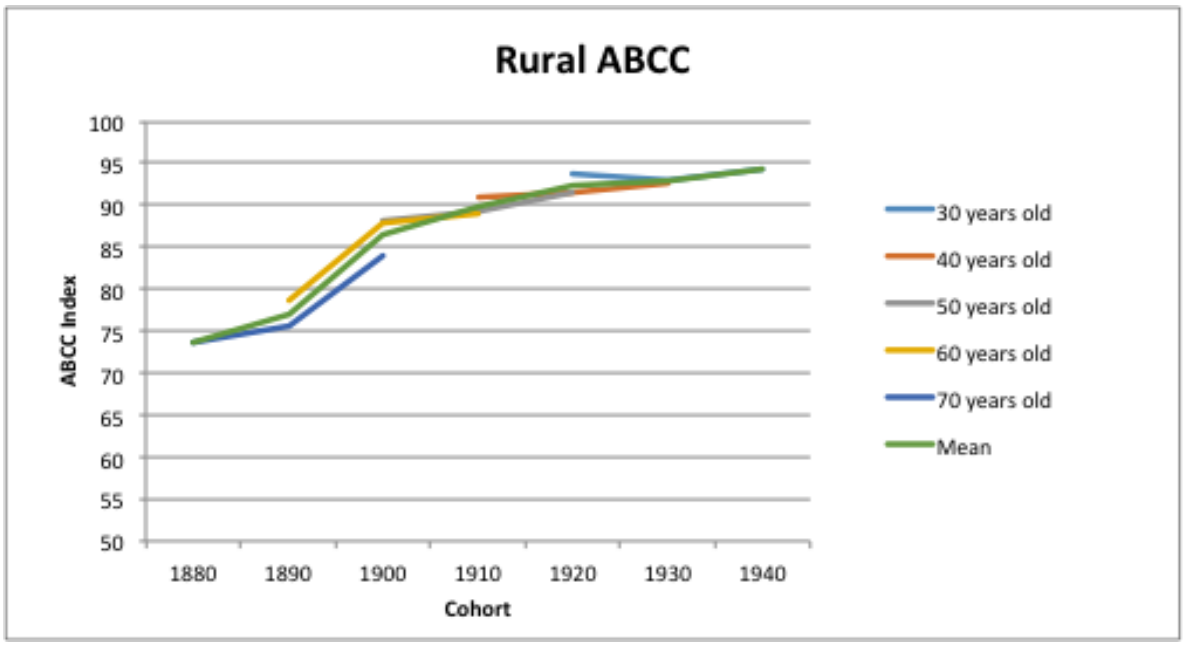
A valid hypothesis is that all this catching-up process can be attributed to

improvements in urban numeracy due to all of the rural schooling obstacles presented in the previous chapter. But this is not the case. As Graph Nº5 and Nº6 show us, there is also a marked catching-up between rural and urban zones, practically eliminating the differences to the 1900's cohort. After that cohort, urban and rural numeracy behaves almost the same way, presenting only modest numeracy improvements.

Graph Nº5: Urban ABCC index by age and cohort of birth in Chile 1880-1940.



Graph Nº6: Rural ABCC index by age and cohort of birth in Chile 1880-1940.



5.3. GLIM with identifying constrains.

But as we already stated, the previous analysis is incomplete. It help us to get an overall picture but the magnitude of each of the three effects can not be detangled because of their close correlation. In the sake of pursuing the truthful independent and joint effect of age, cohort and period we now apply the CGLIM methodology.

One mayor critique of this approach is that the analyst needs to rely on prior or external information to find constraints that hardly exists or can be well verified and that different choices of identifying constraints can produce widely different estimates of patterns of change across all of the categories of the analysis. Because of this, we refrained from invoking side information for the basis of selecting the equality restraints and we appeal to the data based approach,

assessing which constrains are the most empirically justified by looking at consistencies across the various regressions in which they are not constrained to be equal[26]. We therefore end up with equality restrictions that would result in little loss of information.

First we analyze aggregate data. In table Nº3 we begging by estimating 3 reduced models where we only control for one of the three dimensions leaving the other two uncontrolled for. This gives us the Gross effect of each dimension. In models 4-6 we control for only two of the three effects, one for each of the three possible pairings. Looking at models 1-6 serves as a guide for correctly choosing where our constrains should be place on, and that is how we choose ages 30 and 40, periods 1960 and 1970, and cohorts 1920 and 1930 to force their coefficients to be equal[27].

Models 7 trough 9 place equality constraints on two adjacent ages, two adjacent periods, and then two adjacent cohorts, respectively. These constrains appear to be justified by their coefficient's consistencies throughout the regressions,. The 10th model presents a summary regression where all the previous constrains are active at the same time.

Goodness-of-fit statistics- i.e. BIC, AIC, R-squared and Adjusted R-squared- are presented for each of the models at the end of Table Nº3 and are used to select the best-fitting especification. The results show that the model including only cohort and period is the best specification mainly because the age effect is rather small. It

[26] Following the recommendation of a substantial part of the literature. See Clark and Eisenstein (2013), Robinson and Jackson (2001), Oppenheim et al. (1973) and Glenn (1981).
[27] Because they're already quite similar.

is also important to emphasize that the inclusion of cohort as an explanatory variable always improves the information criterions, and it is the biggest and more stable affect of them all.

Table Nº3: Coefficients from constrained generalized linear models of ABCC index for our aggregated data.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
	Age (A)	Period (P)	Cohort (C)	(AP)	(AC)	(PC)	A constrained	P constrained	C constrained	APC constrained
Constant	93.3***	75.2***	62.2***	82.2***	62.2***	62.2***	61.4***	64.3***	65.4***	63.2***
Age										
23-32 (30)	0			0	0		0	0	0	0
33-42 (40)	-2.2			-2.2	-0.1		0.3a	-0.3	-0.5	-0.3a
43-52 (50)	-5.8			-5.8***	-0.6		0.3a	-1.0	-1.5	-0.3a
53-62 (60)	-10.9**			-10.9***	-1.1		0.0	-2.1	-2.9	-1.4
63-72 (70)	-15.8***			-15.8***	0.0		0.8	-2.0	-3.1	-1.0
Period										
1930		0		0		0	0	0	0	0
1940		9.3**		9.3***		3.8***	3.6***	4.3***	4.6***	4.1***
1950		13.8***		13.8***		3.6***	3.3*	4.8**	5.3**	4.2***
1960		15.0***		15.0***		1.3	0.9	3.1a	3.9	2.2a
1970		16.9***		16.9***		0.7	0.2	3.1a	4.2	2.2a
Cohort										
1858-1867 (1860)			0		0	0	0	0	0	0
1868-1877 (1870)			8.8***		9.4***	6.9***	7.4***	6.7***	6.4***	7.0***
1878-1887 (1880)			16.1***		16.7***	13.6***	14.1***	12.7***	12.2***	13.2***
1888-1897 (1890)			22.3***		22.8***	20.1***	20.7***	18.5***	17.7***	19.4***
1898-1907 (1900)			26.2***		26.7***	24.3***	25.1***	22.2***	21.1***	23.2***
1908-1917 (1910)			30.0***		30.6***	27.6***	28.6***	24.9***	23.6***	26.3***
1918-1927 (1920)			32.0***		32.3***	30.1***	31.0***	26.7***	25.0a***	28.5a***
1928-1937 (1930)			32.0***		32.1***	30.9***	32.0***	26.9***	25.0a***	28.5a***
1938-1947 (1940)			33.6***		33.6***	32.8***	34.2***	28.3***	26.2***	30.3***
R-Squared	0.4	0.4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Adjus. R-Squared	0.3	0.3	0.9	0.8	0.9	0.9	0.9	0.9	0.9	0.9
AIC	174.3	172.4	112.9	130.8	119.2	82	85.4	85.4	85.4	83.5
BIC	180.4	178.5	123.9	141.7	135	97.9	104.9	104.9	104.9	100.6

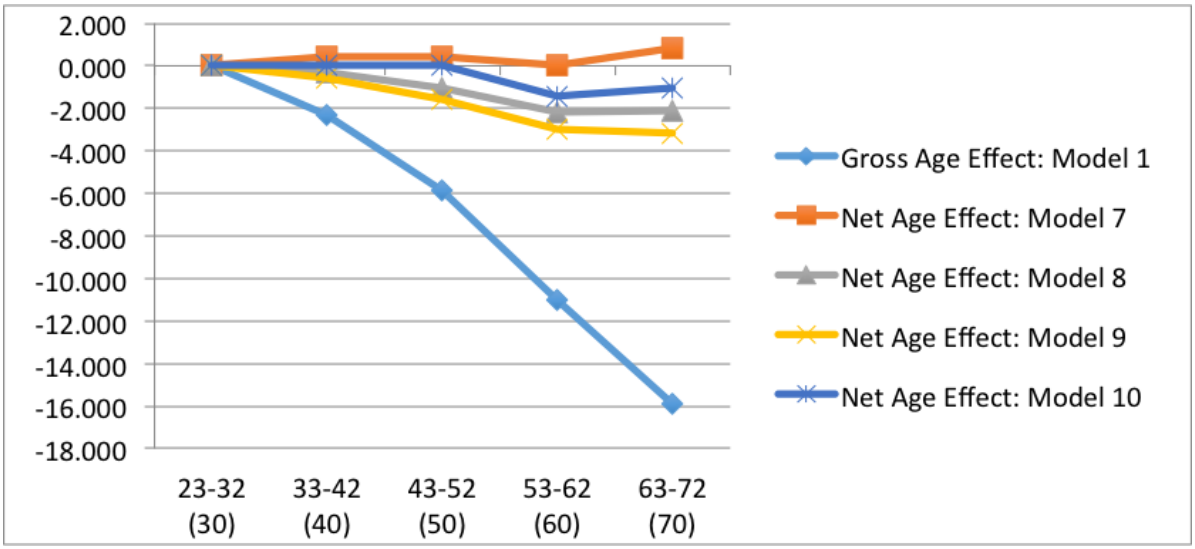
a=Adjacent coefficients constrained to be equal. * Significan at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level.

Graphs of the estimated coefficients that aid the visual inspection of the temporal trends of ABCC index are shown in Graphs Nº7 through Nº9. Graph Nº 7 shows

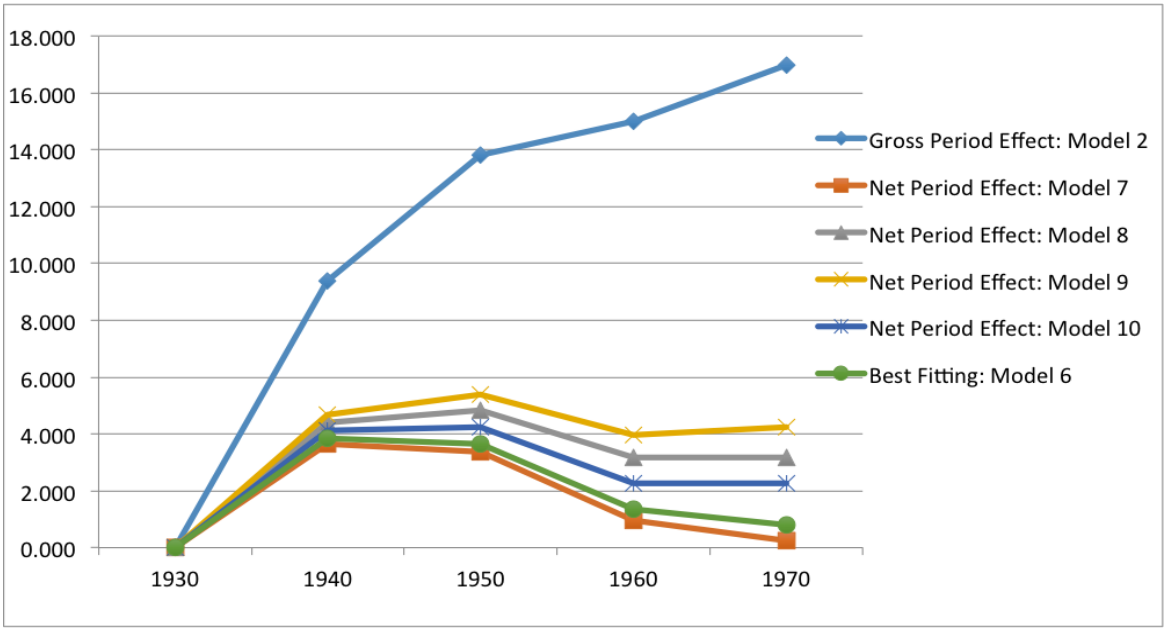
the age coefficients in our multiple specifications as a robustness test; the gross effect can be found in the model that only includes the different age dummies as independent variables and the net effect can be found in all of our constrained models. The same is done for period effect in Graph Nº8 and cohort effect in Graph Nº9 only that this two graphs also include our best specification: Model 6.

Since they indicate changes in numeracy from one age group, time period, or cohort to the next, the estimated coefficients represent the temporal trends of numeracy along each of these three dimensions, first as gross effect and then net of the effects of the other two (with constrains). It is clear the problem of sensitivity associated with the choice of constrains, but they all largely follow the same pattern.

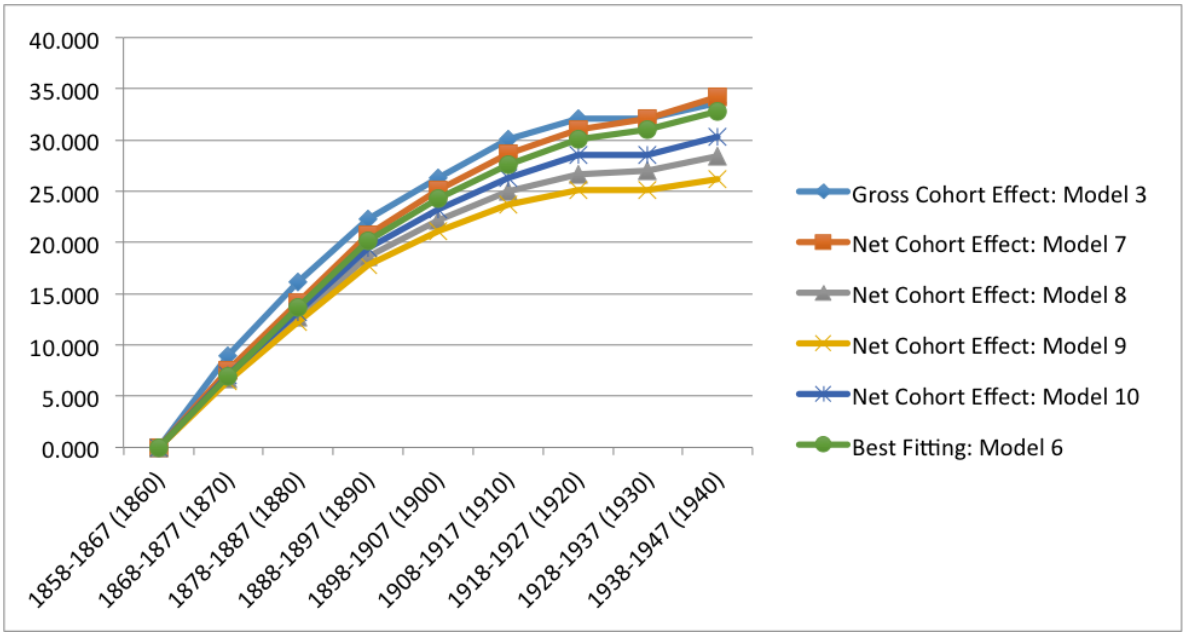
Graph Nº 7: Age effects estimated from the CGLIM



Graph Nº 8: Period effects estimated from the CGLIM



Graph Nº 9: Cohort effects estimated from the CGLIM

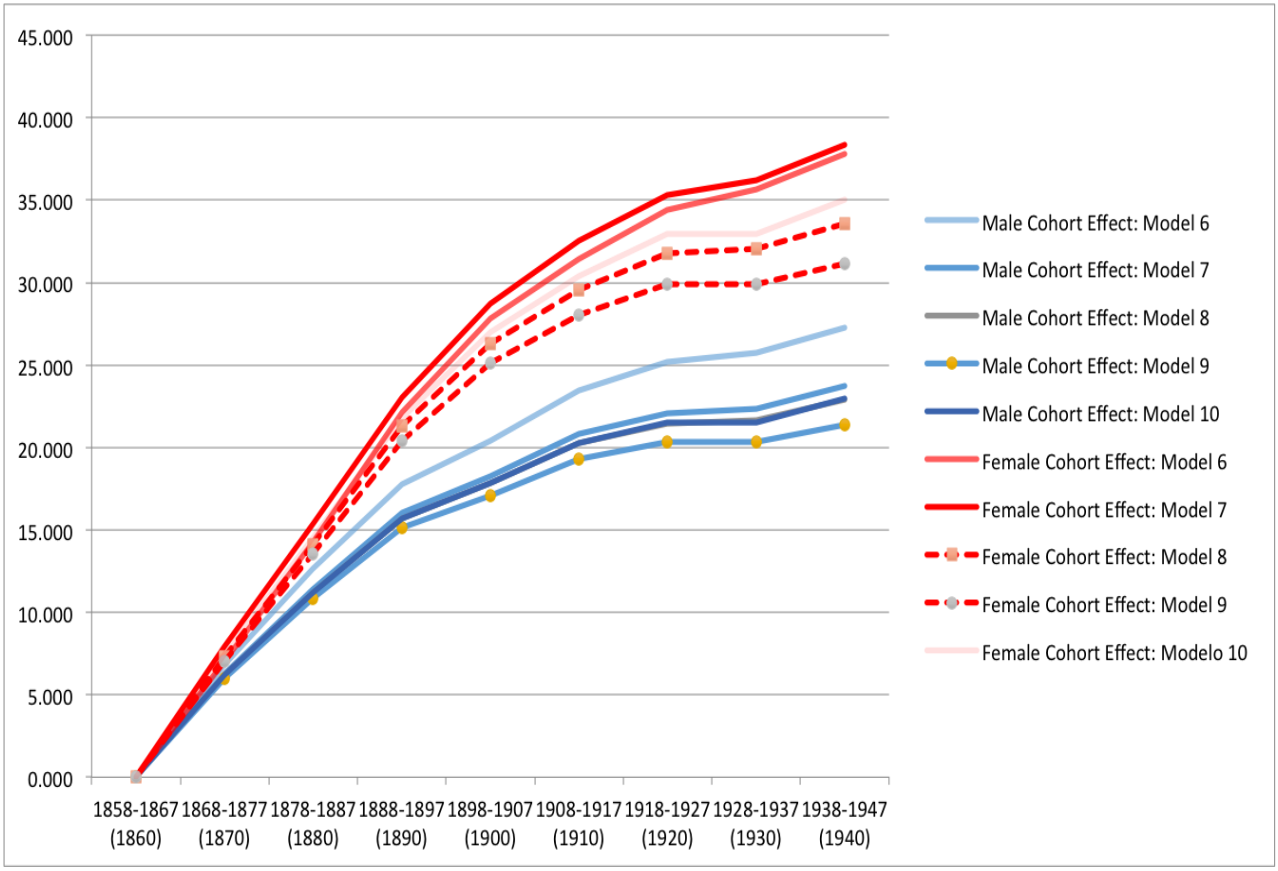


Gross effects show the most intuitive patter, numeracy diminishes as age increases and memory weakens, numeracy increases as period increases and numeracy also increases as the cohorts are born into a more modern world. But when we look at the net effects of these dimensions, the patterns become less clear. After controlling for period and cohort, throughout the different choices of constrains, age effects become closer to a statistical non-significance.

A particular thing happens in cohort effect. Even after controlling for age and period in the different specifications, numeracy systematically rises with older cohorts. The gross and net cohort effect are indeed quite similar and the magnitude and significance of the coefficients points towards the conclusion that the vast majority of the increase in numeracy of our aggregate data can be attributed to cohort effect i.e. an improvement in our individual's birth context.

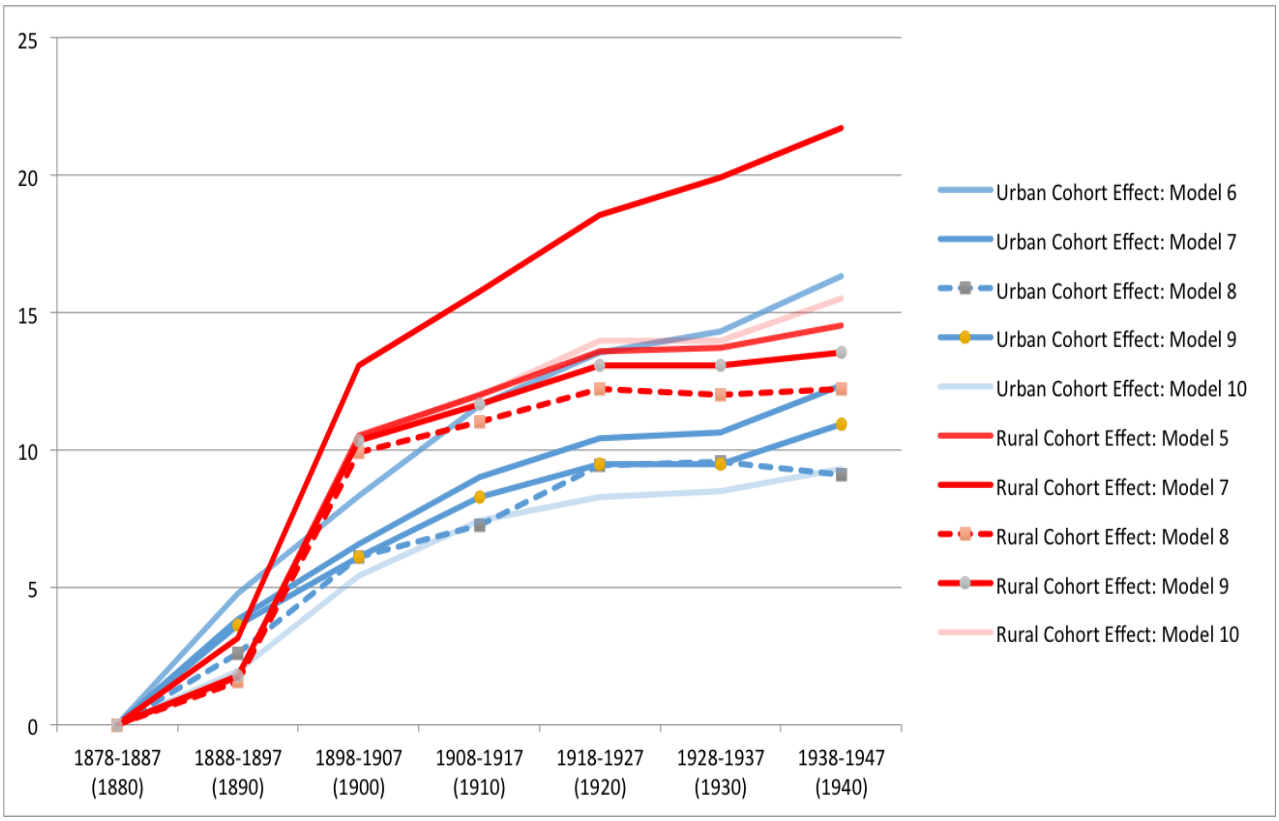
But what about the different patterns between sexes and urbanization? The same CGLIM approach is conducted for each sex and for each of the urbanized and rural zones. As for sex differences an equivalent for table Nº3 is presented in Annex Nº 2 and Nº3. In graph Nº10 we show the net cohort effect for the five best fitting models - model 6 (PC) and models 7 though 10 (APC with different constrains)- as a source of robustness. The results of the visual analysis become clearer. There is in fact a marked difference in the cohort effect between females and males; cohort effects are stronger for females giving strength to the idea that the context of birth and grow is more important for girls, which one can link to the grand expansion of female schooling instigated since 1860.

Graph Nº10: Male and Female net Cohort Effects from constrained generalized linear models



As for urban and rural differences, the same methodology is reproduced (Annex Nº4 and Nº5). Although graph Nº11 does not show a pattern as clear as one seen in Graph Nº10, we still can see a marked increase in rural cohort effect by the late XIX century.

Graph Nº11: Urban and Rural net Cohort Effects from constrained generalized linear models



Male and female start out with significantly different levels of basic numeracy, but because cohort effect is so much greater for females that for males, numeracy eventually converges between sexes. Urban and rural zones also start out with different basic numeracy levels that eventually converge, but in this case is not so clear that the cohort effect, although positive and of a considerable magnitude, was bigger for rural zones as to explain this catching up process. What can be different in the later case?

A possible explanation can be the rural-urban migration. This process begin with strength during the late XIX century and early XX century motivated by the changes suffered by the primary exporting system, based in the production of wheat and silver, that will later be based on the extraction of copper and saltpeter.

The sustained mining growth required unskilled workers to concentrate in small northern urban centers, and port cities. Also, the agricultural land was highly concentrated, leaving lower class workforce with only small pieces of land or no land at all. As family size and soil erosion increased, a substantial number of families were attracted by the city's growing opportunities, seeing in them sometimes the only way to prosper. Other factors contributing with this migration include the expansion of public spending triggered by the saltpeter export's revenue, which created a new set of public Jobs, and the expansion of the railroads[28].

In combination with this intra-national migration, there are also important changes in territorial definition throughout this period. By 1865 78% of the population lived in rural zones and by 1907 this number was 62%. In addition of the rural-urban migration, this can also be explained by the fact that zones that were previously rural, economic growth turned them urban. Between 1865 and 1907 the number of villages with 2.000 to 20.000 inhabitants grew from 36 to 86 and the number of cities with 20.000 or more inhabitants grew from 1 to 6[29].

In sum, these factors together produce that a grand percentage of people that were schooled in rural zones later in life reside in urban zones, therefore contaminating the data and our potential analysis. Since the individual tracking of individuals and their migrations patterns presents significantly obstacles and exceeds the purpose of this study we motivate future researchers to try to answer these questions.

[28] Zemelman (1971)
[29] For a detailed exposition of the migrations patterns of the periods see Hurtado (1966) Chapter IV.

6. Numeracy and Schooling in Chile: 1860-1900 cohorts

We have seen in the previous section that cohort effect- the particular socioeconomic context in which the individual was born and raised- is the strongest determinant of the upward trend in numeracy experienced by Chile in the 1860-1950 period. Schooling is one of the most intuitive components of the cohort effect. Different cohorts are born into different educational scenarios that directly affect their numerical learning. In this section we will test empirically the effects of the public schooling's expansion in the logic of territorial data, i.e, regressing the different provinces' primary schooling rates on the calculated ABCC index.

Although ideally we would have data from before and after the 1860 law to see the real effect of this policy, we only have at our disposal data from after that date. But because the beginning of the XIX century present extremely poor schooling rates, and we understand this law as a process rather than as a dichotomous event, we expect that the improvements in schooling can be attributed to the involvement of the state in public education. We have to mention that our enrolment rates correspond only to public schools, but because this section on the education system is responsible for most of the growth in these rates we expect it to be representative of the system as a whole.

Since we are working with only the 1930 and 1940 censuses as they are the only censuses which registered annualized age by provinces, and we have the enrolment rates by provinces for the year 1870, 1892 and 1910, we can match

certain age groups that were in schooling age for these periods. More specifically, those that were born in 1860 were in age to attend school approximately in 1870 and are the same people that were approximately 70 years old in the 1930 census. The 1892 school data is matched with those born in 1880 and are 50 years old in the 1930 census and 60 year old in the 1940 census. Finally the 1910 school data is matched with the 1900 cohort that is 30 and 40 years old in the 1930 and 1940 census respectively. In sum we cover all age groups; the 30, 50 and 70 years old group for the 1930 census and the 40 and 60 years old group for the 1940 census.

The specifications of the models are the following (each of the specification is conducted separately for men and women)

(1) $ABCC_{jecp} = \propto + \beta Schooling_{ji} + \varepsilon$

(2) $ABCC_{jecp} = \propto + \beta Schooling_{ji} + \gamma Census1940 + \delta Coh1880 + \epsilon Coho1900 + \varepsilon$

(3) $ABCC_{jecp} = \propto + \beta Schooling_{ji} + \gamma Census1940 + \delta Coh1880 + \epsilon Coho1900 + \eta Oldage + \varepsilon$

Where $ABCC_{jecp}$ is the ABCC index for province j, age group e, cohort c and period of census p, $Schooling_{ji}$ is the school coverage for province j and year i, Census1940 is a dummy that controls for period, Coh1880 and Coh1900 are dummies that control for cohort[30]; being the cohort of 1860 the reference category and Oldage is a dummy that takes the value of 0 if the age group is young (30 or

[30] Although we are assuming that schooling is the main factor determining cohort effect, there still can be other elements of cohort effect, besides schooling, influencing the ABCC index that are captured in this dummy.

40 years old) and 1 if the age group is old (50, 60 and 70 year old). The results are shown in table Nº 3.

Table Nº3: Regression: impact of schooling on numeracy measured as the ABCC index for Chilean cohorts 1860, 1880 and 1900.

Dependent variable	ABCC					
	Male			Female		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	67.985***	64.692***	73.678***	58.187***	54.823***	66.547***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Schooling	0.597***	0.415***	0.392***	0.680***	0.465***	0.419***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Census1940		3.196**	3.828***		3.723***	4.465***
		(0.020)	(0.006)		(0.009)	(0.002)
Coh1880		6.779***	6.056***		6.424***	5.791***
		(0.001)	(0.004)		(0.003)	(0.006)
Coh1900		8.558***	-0.027		11.375***	0.979
		(0.001)	(0.993)		(0.000)	(0.833)
Oldage			-8.626***			-11.124***
			(0.033)			(0.000)
						83

Adj. R2	0.513	0.643	0.660	0.671	0.779	0.795
N	83	83	83	83	83	83

Note and sources: * Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level. A detailed explanation on the data used can be found in Annex Nº6.

As a source of robustness we present 3 different models. Model 1 only includes schooling as independent variable, Model 2 also includes dummies to control for period and cohort and finally Model 3 incorporates an age control to all the other regressors. As we can see, in all of our different specifications schooling has a significant coefficient and its effect is stronger for girls, consistent with the marked numeracy catching-up of this subgroup. For men school effect has a range of 0.39 to 0.59 and for females this range is 0.41-0.68. This means that 10 more schooling coverage points raises the ABCC index 3.9 -5.9 point for boys and 4.1-6.8 for girls, magnitudes that are in line with previous data.

It is not a surprise that this coefficient is less that 1 primarily because, as we stated before, the school coverage is calculated based on enrolment rates and not on actual attendance rates and regarding the quality of the education given, one can expect it not to be optimal.

This confirms our hypothesis; primary educational coverage strongly and significantly affected the numeracy levels of the population, and the high growth seen on the female enrollment rates produced that this effect was even stronger for females.

7. Conclusion

The development of a social characteristic as complex as human capital cannot be explained by one particular event or policy but rather has to be studied in the light of an ongoing process in which multiple factors converge.

In this study we tried to examine the evolution of numeracy in the Chilean XIX and early XX century using the age heaping technique in the light of the public primary schooling policies carried throughout the period.

We can say that it was the 1860's primary instruction law the cornerstone of the public education system, but this law only came to formalize a lot that was already going on in that field. The need for homogenization, control and order was already recognized in the foundation of the Normal School of Preceptors, the inclusion of public instruction in the Ministry of Justice and Cult, and in the public position of visitors.

Although the countryside school development had its important obstacles and a proper quantitative analysis was not possible in this occasion, female educational progress can be considered the most remarkable feature of the period; disparities between female and male education practically disappeared towards the beginning of the XX century. Our results show that schooling has a significant correlation with numeracy, measured as ABCC index, and its effect is stronger for girls, consistent with the marked numeracy catching-up of this subgroup. For men school effect has

a range of 0.39 to 0.59 and for females this range is 0.41-0.68. This means that 10 more schooling coverage points raises the ABCC index 3.9 -5.9 point for boys and 4.1-6.8 for girls.

It is interesting to note that, despite the educational proposals for the lower income people's wide range of changes suffered throughout the last couple of centuries, the unique mark of the first proposal has remained unchanged. Characteristics as centralization, hierarchy, systematic norms and controls can also be seen in the current educational system. The growing distance between what is taught in the classroom and the social and economic realities of the attendants is a well-known factor that contributes to the high repetition and drop-put rates (Espíndola and León 2002). The problem of quality and what and how do our children learn was present in the beginning and is certainly still present now. Although it is true that the current system is in better shape to address the matter of quality, it is also true that the demands and expectations that come along with a globalized world grow by leaps and bounds. Every day becomes more explicit the fundamental roll that public education plays in the modernizing advances of our country`s economical arena. ¿How to address the issue of schooling in the popular sectors, combining coverage and quality, social integration and knowledge that is close with the student`s particular reality? This fundamental question has, and will continue to be, in the center of all educational public policy debate and should be approached not only by the government and educational academics but also by the entire set of beneficiaries, i.e., the society as a whole.

Allowing space for cultural diversity and the construction of knowledge not only for the people but also from the people, based in their everyday life, is a discussion that is beginning to take place in public debate. This space for cultural diversity allows multiple forms of knowledge manifestations and it implies a gradual drift from the notion of school teaching “the only truth” to a knowledge that is constructed from the children’s own socio-economical context, giving lower class student, whom are consistently left out of the cultural proposal of the public education system, a better chance to efficiently capitalize its benefits.

8. References

- A"Hearn, B., Crayen, D. and J. Baten (2009) "Quantifying Quantitative Literacy: Age Heaping and the History of Human Capital", Journal of Economic History, Vol. 68, No. 6, pp. 783- 808.
- Bachi, R. (1951) "The tendency to round off age returns: measurement and correction", Bulletin of the International Statistical Institute, No. 33, pp. 195-221.
- Baten, J., Crayen. D. and H. Voth (2008) "Poor, Hungry and Stupid: numeracy and the impact of high food prices in industrializing Britain, 1780-1850", Working Paper Universitat Pompeu Fabra /University of Tuebingen.
- Baten, J., Ma, D., Morgan, S. and Q. Wang (2010) "Evolution of living standards and human capital in China in the 18-20th centuries: Evidences from real wages, age-heaping, and anthropometrics", Explorations in Economic History, Vol. 47, No 3, pp. 347-359.
- Bynner, J., and S. Parsons (2005) "Does Numeracy Matter More?", London, National Research and Development Centre for Adult Literacy and Numeracy.
- Charette, M. and R. Meng (1998) "The Determinants of Literacy and Numeracy, and the Effect of Literacy and Numeracy on Labour Market Outcomes", Canadian Journal of Economics, Vol. 31, No. 3, pp. 495-517.
- Clark, A. and M. Eisenstein (2013) "Interpersonal Trust: An Age-Period-

Cohort Analysis Revisited", Social Science Research, Vol. 42, No.2, pp. 361-375.

- Crayen, D. and J. Baten (2010a) "Global Trends in Numeracy 1820-1949 and its Implications for Long-Run Growth", Explorations in Economic History, Vol.47, pp. 82-99.
- Crayen, D. and J.Baten (2010b) "New evidence and new methods to measure human capital inequality before and during the industrial revolution: France and the US in the seventeenth to nineteenth centuries", The Economic History Review, Vol. 63, pp. 452–478.
- Egaña, Mª L. (2000) "La educación primaria popular en el siglo XIX en Chile: Una práctica de política estatal", LOM ediciones, Santiago de Chile.
- Egaña, Mª L., Núñez, I., Salinas, C (2003). "La educación primaria en Chile: 1860-1930. Una Aventura de niñas y maestras" LOM ediciones, Santiago de Chile.
- Espíndola, E. and A. León (2002) "La deserción escolar en América Latina: Un tema prioritario para la agenda regional", Revista Iberoamericana de Educación, No. 39, pp. 39-62
- Fienberg, S., and W. Mason, Eds. (1985). "Cohort Analysis in Social Research", New York: Springer-Verlag.
- Földvári, P., van Leeuwen, B. and J. van Leeuwen-Li (2012) "How did women count? A note on gender-specific age heaping differences in the sixteenth to nineteenth centuries", Economic History Review, Vol. 65, No. 1, pp. 304-313.
- Glenn, N.D. (1976) "Cohort Analysts' Futile Quest: Statistical Attempts to

Separate Age, Period, and Cohort Effects", American Sociological Review, No. 41, pp. 900–905.

- Glenn, N.D., (1981) "The utility and logic of cohort analysis", Journal of Applied Behavioral Science, Vol. 17, No. 2, pp. 247–257.
- Herlihy, D. And D, Klapisch-Zuber (1978) "Les Toscans et leurs familles: une étude du catasto florentin di 1427", Editions de l'Ecole des Hautes Etudes en Sciences Sociales, Presses de la Fondation Nationale des Sciences Politiques, Paris. Chap. XIII.
- Hippe, R. (2012) " How to measure human capital? The relationship between numeracy and literacy", Economies et sociétés, Vol. 45, pp.1527-1554.
- Hurtado, C. (1966) " Concentración de población y desarrollo económico: El caso chileno", Instituto de Economía de la Univerdad de Chile, Nº 89. Pp. 1-195.
- Manzel, K. and J. Baten (2009) "Gender Equality and Inequality in Numeracy: The Case of Latin America and the Caribbean, 1880–1949", Revista de Historia Económica / Journal of Iberian and Latin American Economic History, Vol. 27, pp 37-73.
- Manzel, K., Baten, J. and Y. Stolz (2012) "Convergence and divergence of numeracy: the development of age heaping in Latin America from the seventeenth to the twentieth century", The Economic History Review, Vol. 65, pp. 932–960.
- Mayorga, R. (2010) "Un nuevo camino de la a la z: enseñanza y aprendizaje de la lectoescritura en la escuela primaria chilena del siglo XIX", Revista de

Pensamiento Educativo, Vol. 46-47, pp.265-284

- Mokyr, J., (1983) “Why Ireland Starved”, George Allen & Unwin, London. Chap.8.
- Murnane, R., Willet, J. and F. Levy (1995) “The Growing Importance of Cognitive Skills in Wage Determination”, Review of Economics and Statistics, Vol. 77, No. 2, pp. 251-66.
- Núñez, J. (2005) “Signed with an x: Methodology and Data Sources for Analyzing the Evolution of Literacy in Latin America and the Caribbean, 1900–1950 “, Latin American Research Review, Vol. 40, No. 2, pp.117-135.
- O'Brien, R.M. 2000. "Age Period Cohort Characteristic Models.", Social Science Research, Vol. 29, pp. 123-139.
- Oppenheim, K., Mason, W., Winsborough, H. and K. Poole (1973) “Some Methodological Issues in Cohort Analysis of Archival Data”, American Sociological Review, Vol. 38, pp. 242-258.
- Robinson, R. and E. Jackson (2001) “Is trust in other declining in America? An age–period–cohort analysis”, Social Science Research, Vol. 30, pp. 117–145.
- Ryder, N. (1965) “The Cohort as A Concept in the Study of Social Change”, American Sociological Review, Vol. 30, pp. 843-861.
- Saski, M. and T. Suzuki (1987) “Changes in Religious Commitment in the United States, Holland, and Japan”, American Journal of Sociology, Vol, 92, pp.1055–1076.
- Serrano, S. And I.Jaksic (2000) “El poder de las palabras. La Iglesia y el Estado liberal ante la difusión de la escritura en el Chile del Siglo XIX”. In:

"Historia" (Vol. 33). Santiago: Ediciones Universidad Católica.

- Serrano, S., Ponce de León, M. and F. Rengifo (2012) "Historia de la Educación en Chile (1810-2010): Aprender a leer y escribir (1810-1880)", Editorial Taurus, Santiago de Chile, Vol. I.
- Serrano, S., Ponce de León, M. and F. Rengifo (2012) "Historia de la Educación en Chile (1810-2010): La educación nacional (1880-1930)", Editorial Taurus, Santiago de Chile, Vol. II.
- Yang, Y., Fu, W. and K. Land (2004) "A Methodological Comparison of Age-Period-Cohort Models: The Intrinsic Estimator and Conventional Generalized Linear Models", Sociological Methodology, Vol.34, pp. 75-110.
- Zemelman, H. (1971) "El migrante rural", ICIRA, Vol. 25, pp.1-153

9. Annexes

Annex Nº1: 1860 primary instruction law in Spanish.

PRIMERA LEY ORGÁNICA DE LA INSTRUCCIÓN PRIMARIA

LEY DEL 24 DE NOVIEMBRE DE 1860; EN *PRONTUARIO DE LEJISLACIÓN ESCOLAR*; POR PONCE, MANUEL ANTONIO; IMPRENTA ERCILLA, SANTIAGO 1890; EN PÁGS 1 A 11.

Santiago, 24 de noviembre de 1860.

Por cuanto el Congreso Nacional ha acordado el siguiente

PROYECTO DE LEI:

TITULO 1

"DE LAS ESCUELAS"

Art. 1º La instrucción primaria se dará bajo la dirección del Estado.

Art. 2º La instrucción que se diere en virtud estay ley, será gratuita i comprenderá a las personas de uno i otro sexo.

Art. 3º Habrá dos clases de escuelas: elementales i superiores.

En las primeras se enseñará, por lo menos, lectura i escritura del idioma patrio, doctrina i moral cristiana, elementos de aritmética práctica i el sistema legal de pesos i medidas.

En las superiores, a mas de los ramos designados, se dará mayor ensanche a la instrucción relijiosa, i se enseñará gramática castellana, aritmética, dibujo lineal, jeografía, el compendio de Historia de chile i de la Constitución Política del Estado, i, si las circunstancias lo permiten, los demás ramos señalados para las escuelas normales.

En las escuelas superiores para mujeres se sustituirá, a la enseñanza del dibujo lineal i de la Constitución Política, la de la economía doméstica, costura, bordado i demás labores de aguja.

Art. 4º Se establecerá en las poblaciones de cada departamento las escuelas de ambos sexos que fueren necesarias, hasta llegar a la proporción de una escuela elemental de niños i otra de niñas, por cada dos mil habitantes que contuviere la población.

Art. 5º En las aldeas en que no hubiere el número de habitantes que queda espresado, i en los campos en que lo permitiere la diseminación de la población, se establecerán escuelas que durarán en ejercicio cada año cinco meses por lo menos.

Art. 6º En la cabecera de cada departamento se colocará una escuela superior para niños i otras niñas, pudiendo darse este carácter, en los departamentos en que hubiere falta de fondos, a una de aquellas que deben fundarse según lo dispuesto en el artículo cuarto.

Art. 7º Todos los conventos i conventillos de regulares mantendrán una escuela gratuita para hombres, i los monasterios de monjas, para mujeres, siempre que el estado de sus rentas lo permitiere, a juicio del Presidente de la República, quien determinará también si la escuela ha de ser elemental o superior.

Art. 8º Se establecerán las escuelas normales para preceptores i preceptoras que sean necesarias, i serán costeadas por el tesoro público.

Art. 9º En las escuelas normales para hombres se enseñará a mas de los ramos señalados para las superiores, elementos de jeometría, de cosmografía, de física i química, historia sagrada, de América i en especial de Chile, dogma, fundamentos de la fe, música vocal, elementos de agricultura, vacunación i pedagojía teórica i práctica.

En las destinadas a preceptoras, se ensañará, a mas de los prescrito en el inciso cuarto del artículo tercero, elementos de cosmografía i de física, historia sagrada, de América i en especial de Chile, dogma i moral relijiosa, música vocal, horticultura, dibujo natural i pedagogía teórica i práctica.

A los ramos designados en este artículo, se agregarán los que fuese necesario según las circunstancias.

Art. 10º La instrucción que se diere privadamente a los individuos de una familia, no estará sujeta a las disposiciones de la presente lei.

Art. 11º Las escuelas costeadas por particulares o con emolumentos que pagaren los alumnos, quedan sometidas a la inspección establecida por la presente lei, en cuanto a la moralidad i orden del establecimiento, pero no en cuanto a la enseñanza que en ella se diere, ni a los métodos que se emplearen.

TITULO II

DE LA RENTA

Art. 12º La instrucción primaria que, con arreglo a la presente lei, deberá darse en cada departamento, será costeada:

1º.- Con la suma que el tesoro nacional aplicará anualmente este objeto.

2º.- Con las cantidades que de sus propias rentas destinarán anualmente al mismo fin las Municipalidades.

3º.- Con el producto de las fundaciones, donaciones i multas aplicadas a la instrucción primaria, i con el de las mandas forzosas que se recaudaren en cada departamento.

4º.- Con el producto de una contribución que se establecerá con este único i exclusivo objeto, i cuyas bases se fijarán por una lei, ya de una manera jeneral, ya de una manera especial, para cada provincia o departamento.

Art. 13º Las Municipalidades llevarán una cuenta especial de los fondos destinados por esta lei a la instrucción primaria, i no podrán darles otra inversión. El que la decrete o ejecutará, quedará responsable con sus propios bienes.

Art. 14º Son gastos de la instrucción primaria que deben satisfacerse con los fondos señalados en la presente lei:

1º.- Los sueldos de los preceptores i ayudantes que necesiten las escuelas existentes, i las que deben establecerse en conformidad a esta lei.

2º.- El costo de adquisición de locales i construcción de edificios para las escuelas en aquellos puntos en que las Municipalidades no los posean aparentes, i el costo del arriendo provisional de los mismos.

3º.- La adquisición i reparación de los muebles precisos para cada escuela, i de los libros i útiles de enseñanza de que haya de proveerse gratuitamente a los niños que por su pobreza no pueden costearlos.

4º.- Las sumas necesarias para la formación i fomento de las bibliotecas populares en cada departamento.

Art. 15º Las Municipalidades presentarán anualmente al Presidente de la República el presupuesto de los gastos que deba hacerse en la instrucción primaria de sus departamentos, para que sea aprobado, previas las modificaciones que juzgare convenientes.

TITULO III

DE LOS PRECEPTORES

Art. 16º Ninguna persona podrá ejercer las funciones de preceptor de instrucción primaria, sin acreditar previamente ante el Gobernador del departamento, con el testimonio de dos sujetos fidedignos, tener buena vida i costumbres.

Si se estableciere una escuela sin este requisito, será cerrada inmediatamente, i su preceptor castigado con una multa de veinte pesos o quince días de prisión, i esta se duplicará en caso de reincidencia.

Art. 17º Las escuelas costeadas por los departamentos o por el fisco, serán servidas por alumnos de las escuelas normales que hayan obtenido el competente diploma de aprobación, i en su defecto, por personas que, a mas de los dispuesto en el artículo anterior, acrediten tener las aptitudes necesarias.

Art. 18º La prueba de aptitudes puede consistir, o en un examen rendido en la forma que se dispongan los reglamentos, o en un título literario otorgado por la Universidad, o en un certificado espendido por el director de algún establecimiento en que se puedan rendir exámenes conforme a la lei, en la cual conste que el individuo, a cuyo favor se da, ha sido aprobado en los ramos de instrucción primaria a cuya enseñanza va a dedicarse.

Art. 19º No pueden ser preceptores de instrucción primarias, aunque cumplan lo prevenido en el artículo 16:

1º.- Los que se hallen procesados por un delito que merezca pena aflictiva o infamante, o hayan sido condenados a pena de esta clase.

2º.- Los que hayan sido destituidos de sus funciones de preceptor por causa averiguada que comprometa su moralidad i costumbres.

Art. 20º Los preceptores de instrucción primaria que hubieren obtenido diploma, o comprobado sus aptitudes para el cargo, mientras estén en ejercicio, gozarán de las siguientes prerrogativas:

1a.- Escepción del servicio compulsivo en el ejército i en la guardia nacional.

2a.- Escepción de cualquiera otra comisión en el servicio del Estado o de un pueblo, a menos que sea relativa a la instrucción primaria.

Art. 21º El que hubiere desempeñado por diez años continuados el cargo de preceptor, si se retirare de la profesión, quedará exento por vida del servicio compulsivo del ejército.

Art. 22º Los sueldos de los preceptores de las escuelas costeadas por los departamentos, serán fijados por las respectivas Municipalidades, con la aprobación del Presidente de la República.

Art. 23º Los preceptores, tanto de las escuelas costeadas por los departamentos como de las fiscales, tendrán derecho a jubilación en la forma i con los requisitos dispuestos por la lei para los empleados públicos. Esta jubilación será costeada con fondos nacionales.

Art. 24º La Municipalidad de la capital de cada provincia concederá anualmente un premio de valor de 25 pesos, por lo menos, al preceptor de la escuela pública o privada de la provincia que mas se haya distinguido en el ejercicio de su profesión, i otro de igual suma a la preceptora que hubiere llenado la misma condición.

Estos premios se concederán en la forma que dispusieren los reglamentos.

TITULO IV

DE LA INSPECCIÓN

Art. 25º Habrá una Inspección que vigile i dirija la instrucción primaria en toda la República.

Art. 26 Esta inspección se compondrá de un Inspector Jeneral i de un visitador de escuelas para cada una de las provincias del Estado.

Art. 27º El Inspector Jeneral será nombrado por el Presidente de la República. Igualmente, los visitadores de escuelas, a propuesta del Inspector Jeneral.

Art. 28º El Inspector Jeneral será miembro del Consejo de Instrucción Pública, tendrá un escribiente para el desempeño de las funciones especiales de su empleo.

Art. 29º El Inspector Jeneral cuidará de la buena dirección de la enseñanza, de la moralidad de las escuelas i maestros, i de todo cuanto conduzca a la difusión i adelantamiento de la instrucción primaria, con las limitaciones establecidas en los artículos 10 i 11 de esta lei.

Art. 30º Anualmente presentará al Gobierno un informe completo sobre el estado de la instrucción primaria, indicando los medios de adelantarla i perfeccionarla, los efectos que haya producido esta lei i las disposiciones dictadas sobre la materia.

Art. 31º Los visitadores de escuelas dependerán del Inspector Jeneral, cuidarán de las escuelas establecidas en su provincia, i las visitarán con la frecuencia i en la manera conveniente.

Art. 32º Los visitadores de escuelas, en aquellas provincias en que fuere posible, tendrán a su cargo o enseñarán algunos ramos en algunas de las escuelas superiores.

Art. 33º Los individuos de la Inspección gozarán de las prerrogativas i premios concedidos por los artículos 20, 21 i 23 a los preceptores.

Art. 34º Las rentas de los individuos de la Inspección serán pagadas por el tesoro público.

Art. 35º Los párrocos tienen derecho a inspeccionar i dirigir la enseñanza relijiosa que se diere en las escuelas públicas de su parroquia; i si no pudieren enmendar los defectos que notaren, los comunicarán a la autoridad competente para que dicte su pronto i eficaz remedio.

Art. 36º La Municipalidad podrán nombrar a comisiones para el cuidado i vigilancia de las escuelas de su departamento; pero estas comisiones no podrán alterar las reglas prescritas por la Inspección.

I por cuanto, oído el Consejo de Estado, he tenido a bien aprobarlo i sancionarlo; por tanto promúlguese i llévese a efecto en todas sus partes como lei de la República.

MONTT

RAFAEL SOTOMAYOR

Annex Nº2: Male Coefficients from constrained generalized linear models of ABCC Index

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
	Age (A)	Period (P)	Cohort (C)	(AP)	(AC)	(PC)	A constrained	P constrained	C constrained	APC constrained
Constant	94.231	79.794	68.269	85.035	68.469	68.269	69.994	70.409	71.173	70.364
Age										
23-32 (30)	0.000			0.000	0.000		0.000*	0.000	0.000	0.000*
33-42 (40)	-1.546			-1.546	0.025		0.000*	-0.103	-0.294	0.000*
43-52 (50)	-3.820			-3.820	-0.007		-0.080	-0.288	-0.670	-0.257
53-62 (60)	-8.059			-8.059	-0.607		-1.163	-1.474	-2.047	-1.429
63-72 (70)	-12.778			-12.778	-0.200		-1.724	-2.140	-2.904	-2.095
Period										
1930		0.000		0.000		0.000	0.000	0.000	0.000	0.000
1940		8.054		8.054		3.371	3.897	4.001	4.192	4.001
1950		12.346		12.346		3.985	5.033	5.240	5.622	5.226
1960		12.068		12.068		1.090	2.561	2.872*	3.445	2.879*
1970		13.510		13.510		0.623	2.457	2.872*	3.636	2.879*
Cohort										
1858-1867 (1860)			0.000		0.000	0.000	0.000	0.000	0.000	0.000
1868-1877 (1870)			8.514		8.718	6.828	6.284	6.180	5.989	6.180
1878-1887 (1880)			15.108		15.180	12.656	11.396	11.188	10.806	11.197
1888-1897 (1890)			19.858		19.855	17.746	16.002	15.691	15.118	15.681
1898-1907 (1900)			22.207		22.165	20.393	18.286	17.871	17.107	17.871
1908-1917 (1910)			25.686		25.633	23.419	20.785	20.266	19.310	20.266
1918-1927 (1920)			27.116		26.910	25.217	22.067	21.445	20.298*	21.516*
1928-1937 (1930)			26.597		26.384	25.740	22.362	21.636	20.298*	21.516*
1938-1947 (1940)			27.916		27.716	27.293	23.733	22.903	21.375	22.941
R-Squared	0.433	0.492	0.946	0.925	0.946	0.988	0.990	0.990	0.990	0.989
Adjus. R-Squared	0.319	0.391	0.919	0.888	0.893	0.976	0.973	0.973	0.973	0.978
AIC	164.459	161.695	113.672	121.656	121.261	83.076	85.611	85.611	85.611	81.741
BIC	170.554	167.790	124.642	132.626	137.107	98.922	105.113	105.113	105.113	98.805

*Adjacent coefficients constrained to be equal.

Annex Nº3: Female Coefficients from constrained generalized linear models of ABCC Index

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
	Age (A)	Period (P)	Cohort (C)	(AP)	(AC)	(PC)	A constrained	P constrained	C constrained	APC constrained
Constant	92.5	70.957	56.721	79.649	56.168	56.721	56.214	58.58	59.806	57.717
Age										
23-32 (30)	0.000			0.000	0.000		0.000*	0.000	0.000	0.000*
33-42 (40)	-3.050			-3.050	-0.303		0.000*	-0.591	-0.898	0.000*
43-52 (50)	-7.962			-7.962	-1.292		-0.732	-1.915	-2.528	-1.421
53-62 (60)	-13.738			-13.738	-1.580		-1.026	-2.800	-3.720	-2.104
63-72 (70)	-18.704			-18.704	0.553		0.507	-1.858	-3.084	-0.995
Period										
1930		0.000		0.000		0.000	0.000	0.000	0.000	0.000
1940		10.671		10.671		4.392	4.172	4.763	5.070	4.596
1950		15.339		15.339		3.578	3.357	4.540	5.153	4.171
1960		17.893		17.893		1.856	1.731	3.506*	4.425	2.938*
1970		20.352		20.352		1.182	1.140	3.506*	4.732	2.938*
Cohort										
1858-1867 (1860)			0.000		0.000	0.000	0.000	0.000	0.000	0.000
1868-1877 (1870)			9.217		10.284	7.021	7.898	7.307	7.000	7.474
1878-1887 (1880)			16.897		18.223	14.240	15.312	14.129	13.515	14.486
1888-1897 (1890)			24.561		25.770	22.105	23.066	21.292	20.372	21.770
1898-1907 (1900)			30.013		31.091	27.811	28.691	26.325	25.099	26.993
1908-1917 (1910)			34.149		35.497	31.397	32.496	29.539	28.006	30.375
1918-1927 (1920)			36.636		37.721	34.430	35.311	31.762	29.923*	32.940*
1928-1937 (1930)			37.137		37.842	35.618	36.209	32.069	29.923*	32.940*
1938-1947 (1940)			38.952		39.505	37.770	38.319	33.588	31.135	35.018
R-Squared	0.441	0.487	0.971	0.929	0.976	0.992	0.994	0.994	0.994	0.994
Adjus. R-Squared	0.330	0.385	0.957	0.894	0.953	0.984	0.985	0.985	0.985	0.987
AIC	182.885	180.750	116.443	139.133	119.412	92.000	88.481	88.481	88.481	85.791
BIC	188.980	186.844	127.413	150.103	135.257	107.846	107.983	107.983	107.983	102.855

*Adjacent coefficients constrained to be equal.

Annex Nº4: Urban Coefficients from constrained generalized linear models of ABCC Index

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
	Age (A)	Period (P)	Cohort (C)	(AP)	(AC)	(PC)	A constrained	P constrained	C constrained	APC constrained
Constant	96.127	91.625		95.748	91.763	83.97	86.601	95.571	87.535	90.882
Age										
23-32 (30)	0			0.000	0.000		0.000*	0.000	0.000	0.000*
33-42 (40)	-1.118			-1.118	-1.140		0.000*	-2.242	-0.233	0.000*
43-52 (50)	-3.047			-3.047	-3.054		-0.573	-5.058	-1.040	-1.992
53-62 (60)	-6.156			-6.156	-5.214		-1.493	-8.221	-2.193	-4.254
63-72 (70)	-10.294			-10.294	-7.793		-2.631	-11.601	-3.565	-6.912
Period										
1950		0.000		0.000		0.000	0.000	0.000*	0.000	0.000*
1960		-0.114		-0.114		-2.976	-2.242	0.000*	-2.009	0.000*
1970		1.249		1.249		-3.922	-2.580	1.904	-2.114	0.188
Cohort										
1878-1887 (1880)			0.000		0.000	0.000	0.000	0.000	0.000	0.000
1888-1897 (1890)			3.287		1.997	4.775	3.839	2.596	3.605	1.958
1898-1907 (1900)			6.030		3.590	8.329	6.572	6.087	6.105	5.441
1908-1917 (1910)			9.333		4.676	11.632	8.998	7.271	8.298	7.441
1918-1927 (1920)			11.239		4.843	13.538	10.406	9.436	9.472*	8.298*
1928-1937 (1930)			10.859		3.636	14.309	10.639	9.572	9.472*	8.298*
1938-1947 (1940)			12.404		4.610	16.326	12.353	9.101	10.952	9.303
R-Squared	0.918	0.025	0.849	0.943	0.974	0.981	0.985	0.985	0.985	0.962
Adjus. R-Squared	0.885	-0.137	0.736	0.900	0.909	0.957	0.934	0.934	0.934	0.894
AIC	55.778	88.924	68.922	54.248	50.503	41.362	43.400	43.400	43.400	54.200
BIC	59.318	91.048	73.879	59.204	58.291	47.735	51.897	51.897	51.897	61.280

*Adjacent coefficients constrained to be equal.

Annex Nº5: Rural Coefficients from constrained generalized linear models of ABCC Index

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
	Age (A)	Period (P)	Cohort (C)	(AP)	(AC)	(PC)	A constrained	P constrained	C constrained	APC constrained
Constant	93.677	85.011	73.589	91.11	79.724	73.589	74.941	81.279	80.398	78.817
Age										
23-32 (30)	0.000			0.000	0.000		0.000*	0.000	0.000	0.000*
33-42 (40)	-1.983			-1.983	-1.134		0.000*	-1.584	-1.364	0.000*
43-52 (50)	-4.011			-4.011	-2.096		0.253	-2.915	-2.474	-1.300
53-62 (60)	-8.493			-8.493	-2.623		0.902	-3.851	-3.190	-1.707
63-72 (70)	-16.002			-16.002	-6.134		-1.352	-7.690	-6.808	-5.227
Period										
1950		0.000		0.000		0.000	0.000	0.000*	0.000	0.000*
1960		2.398		2.398		-1.935	-1.584	0.000*	-0.220	0.000*
1970		5.302		5.302		-2.841	-2.391	0.777	0.337	-0.043
Cohort										
1878-1887 (1880)			0.000		0.000	0.000	0.000	0.000	0.000	0.000
1888-1897 (1890)			3.496		1.740	4.464	3.161	1.577	1.797	1.736
1898-1907 (1900)			13.032		10.515	14.624	13.070	9.901	10.341	10.563
1908-1917 (1910)			16.175		11.991	17.767	15.762	11.009	11.670	11.964
1918-1927 (1920)			18.663		13.605	20.255	18.551	12.213	13.095*	13.959*
1928-1937 (1930)			19.280		13.712	21.668	19.915	11.993	13.095*	13.959*
1938-1947 (1940)			20.675		14.540	23.517	21.714	12.207	13.529	15.491
R-Squared	0.784	0.113	0.965	0.898	0.997	0.989	0.998	0.998	0.998	0.995
Adjus. R-Squared	0.698	-0.034	0.939	0.821	0.991	0.975	0.991	0.991	0.991	0.986
AIC	85.382	102.598	61.894	78.143	31.032	47.95	28.148	28.148	28.148	38.567
BIC	88.922	104.723	66.85	83.1	38.82	54.323	36.645	36.645	36.645	45.647

*Adjacent coefficients constrained to be equal.

Annex Nº6: Notes on Provincial data construction.

The numerator of the school coverage index (number of children enrolled in public primary education) is from Egaña, Núñez and Salinas (2003).

To construct the denominator for the school coverage index we used the number of children in age to attend school i.e. between 7 and 15 years old, from Chilean censuses.

1870 denominator: it was constructed by geometrically interpolating the number of children in age to attend school from the 1865 and 1875 censuses.

There are some territorial definitions differences between those years, for example:

-The Curicó Province is created in 1865. Data from this province and the Colchagua province (previous origin of the Curicó Province department) come directly from the 1875 census without interpolation.

-The Linares Province is created in 1873, previously being part of the Maule Province. Because of this, the 1875 data for the Maule province comes form adding the Maule and Linares Provinces.

-The Bío-bío province is created in 1875, previously being part of the Arauco Province. Because of this, the 1875 data for the Arauco Province comes from adding the Bío-bío and Arauco Provinces.

1890 denominator: it was constructed by geometrically interpolating the number of children in age to attend school from the 1885 and 1895 censuses.

There are some territorial definitions differences between those years, for example:

-The Taltal Department was part of the Atacama Province in 1885 but later will be part of the Antofagasta Province.

-The Imperial Department was part of the Arauco Province in 1885 but later will be part of the Cautín Province.

-In 1887 the Provinces of Malleco and Cautín were created. Population data comes directly from the 1895 census without interpolation.

1910 denominator: it was constructed with the number of children between the ages of 6 and 14 from the 1907 census.

The Chilean geopolitical division changed substantially throughout the period in consideration, and for this the territorial definition in many cases is different for the years in which we have educational coverage and the years for which we have ABCC indexes.

1870 school coverage and 1940 ABCC index:

-The 0'Higgins Province was created in 1883, prior to that date its departments were part of the Santiago Province. We ponder the ABCC index by population size leaving only one data for the Santiago Province.

-The Linares Province was created in 1873, prior to that date its department were part of the Maule Province. We ponder the ABCC index by population size leaving only one data for the Maule Province.

-In 1870 the Osorno Department was part of the LLanquihue Province but in 1940 is part of the Valdivia Province.

1890 school coverage and 1940 ABCC index:

-In 1890 the Caupolicán Department was part of the Colchagua Province but in 1940 is part of the O`Higgins Province.

-In 1890 the Maipo Department was part of the O'Higgins Province but in 1940 is part of the Santiago Province.

-In 1890 the Osorno Department was part of the LLanquihue Province but in 1940 is part of the Valdivia Province.

1910 school coverage and 1940 ABCC index:

-The Tacna Province ceased to exist in 1929, because of this the data on school coverage for this Province is pondered by population density with the Tarapacá Province leaving only one data for the 1940 Tarapacá ABCC index.

-In 1910 the Maipo Department was part of the O'Higgins Province but in 1940 is part of the Santiago Province.

-In 1910 the Caupolicán Department was part of the Colchagua Province but in 1940 is part of the O`Higgins Province.

-In 1910 the Santa Cruz Department was part of the Curicó Province but in 1940 is part of the Colchagua Province.

-In 1910 the Itata Department was part of the Maule Province but in 1940 is part of the Ñuble Province.

-In 1910 the Osorno Department was part of the LLanquihue Province but in 1940 is part of the Valdivia Province.