“Land frontier expansion: concepts and measures applied to settler economies in historical perspective (1850-1910)”

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Abstract

The objective of this paper is to discuss the classical concept of land frontier expansion in historical perspective and to propose several alternative measurements. The analysis focuses on the evolution of selected settler economies (Argentina, Australia, Canada, Chile, New Zealand, and Uruguay) from the middle of the 19th century to the 1910s. Initially, we present the notion of land frontier expansion and review the recent theoretical and empirical literature about the topic. From the consideration of the main shortcomings of the previous approaches, we propose alternative methods to approximate the concept. We introduce three new issues in the discussion –potential vegetation, agricultural aptitude and distance– to identify different types of settlement patterns. The use of Georeferenced Information Systems, the quantification of the process and the consideration of different land qualities are relevant contributions to the current analysis in Economic History.

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Introduction

In a previous paper (Mednick & Willebald, 2010), we proposed a complementary model to the usual framework used in the literature that, based on in the Factor Proportions Approach, presents the Heckscher-Ohlin model to explain the performance of the economies of recent settlement during the First Globalization.

The settler economies of the 19th and 20th century seem to share some common features making them a comparable group of economies. Their economic and social developments present parallel paths, as a result of similar dynamic relations between waves of immigration, marginalization of native people, European capital inflow, land abundance, free labor (at least after the mid-19th century), socially-useful political institutions, and the development of neo-European cultures. Lloyd & Metzer (2006), Willebald (2007) and Álvarez *et al* (2007) discuss the concept and characterize the "club" of the settler economies. The economies considered in this paper are Argentina, Australia, Canada, Chile, New Zealand and Uruguay covering the period of the First Globalization, from the of mid-19th century to the First World War (WWI).

We propose a model of specific factors to stress the importance of domestic conditions exposed to the effects of the First Globalization. In this context, the role of the land frontier expansion becomes a central aspect in explaining how the globalization affects the economic performance of the Atlantic economy. The availability of land resources constituted the main comparative advantage that determined the participation of these economies in the international markets. In order to better understand this process, we made modifications of the model to incorporate different land qualities.

In that paper, our main contributions refer to three central issues. Firstly, it constitutes an application of the recent literature about the relationship between the abundance of natural resources and the economic performance –in terms of the *curse of natural resources hypothesis*[1]– to the Atlantic economy during the First Globalization. Based on this literature we show that the curse of the natural resources does not constitute a deterministic process but it is associated to the specific historical circumstances. Settler economies received the blessing of the abundance of natural resources and had a strong export-led growth, but simultaneously the curse of an increasing income inequality arose. Besides, the consequences of the First Globalization did not affect all economies with the same intensity and probably these discrepancies explain the long-run economic performance of the "club".

[1] It is a prolific analytical and empirical line inspired by the works of Sachs & Warner (1995, 1999a,b) and followed by many scholars but with very scarce application in historical perspective.

Secondly, we emphasize the concept of moving frontier or endogenous land frontier expansion. Abundance of natural resources is not a fixed situation but a process that reacts to the changes in the structure of commodity prices and factor endowments, which require capital, labour, technical progress and institutional arrangements to progress. In that sense, the abundance is not given but it is part of the evolution of the economic system.

Finally, we consider land qualities to represent different types of natural resources. With this framework, it is possible to conjecture that part of the divergent evolutions within the "club" is related to the discrepancies in the endowments in terms of agricultural aptitude and distance. Within this framework, we hypothesize that the settler economies that first occupied the "best" lands experimented a deeper worsening in the income distribution. This evolution would responds to the possibility of obtaining higher differences in the relative factor retributions in favour of landowners (a small and rich "elite") and in detriment of workers and capitalists.

Our aim in this paper is to identify different settlement patterns with two objectives: (i) determine an appropriate empirical approach to represent the concept of *moving frontier* or *endogenous land frontier expansion*; (ii) find a first argument to advance on our hypothesis about the relationship between settlement dynamic and land quality (an issue that will be matter of next steps in the research and other paper).

In Section 1 we present the concept of land frontier expansion and review its recent theoretical and empirical dealt. In Section 2, we discuss the ways to measure the land frontier expansion considering the recent quantification efforts and the main shortcomings of the approaches. In Section 3, we present our quantification proposal based on the use of Georeferenced Information Systems (GIS). After to explain how we can solve the limitations of the previous approaches by considering different land aptitudes and distances on the potential vegetation, we present our results of land frontier expansion (Section 4). We present an overview for all the members of the "club" and illustrate some measures for Argentina and Australia. Finally, we conclude presenting the highlights of our analysis and new hypotheses to advance in the research.

1. Is the land frontier expansion a classical concept that came back?

The most famous work about the relevance of the frontier expansion for economic development is due to Frederick Jackson Turner in 1893. Turner (1920) postulated what is known as the "Turner thesis". The argument is that the availability of the frontier attracted a particular type of person that was crucial for determining the path of the US society and explained the exceptionalism of this nation. The frontier promoted individualism, social mobility, economic equality, freedom and was decisive to the development of democratic institutions.

This study was the first antecedent in a fruitful line of research that applied these notions to other regions in North America, Latin America, and Australasia (Hartz, 1964). [Make a brief literature review].

However, since the 1970s the notion of frontier lost theoretical relevance and other conceptual frameworks arose as analytical support to the study of the settler economies. The recent literature about the expansion of the Atlantic economy during the 19th century and the first decades of the 20th century uses the Stolper-Samuelson theorem from the Heckscher-Ohlin (H-O-S) trade theory to explain the performance of the New World (see Mednick & Willebald, 2010, for a review).

The period 1870-1913 was a real "golden age" for the settler economies. The origin of the expansion was the Industrial Revolution, a process that, initialized in Britain in the second half of the 18th century, started to spread to other European countries during the following decades, transmitting technological growth impulses from the core to the peripheral areas.

The integration of the world markets for commodities, the mass migration and the capital flows constituted one of the most important processes for the world economy in the last two centuries. Recent studies by Lindert, O'Rourke, Taylor, and Williamson on globalization, growth, and inequality provide a prolific line of research and generate a debate about topics that are of great importance to better understand the expansion of the Atlantic economy during the period (Lindert & Williamson, 2001; O'Rourke, Taylor & Williamson, 1996; O'Rourke & Williamson, 1994, 1999; Taylor & Williamson, 1997; Williamson, 1995, 1996, 1999, 2000, 2002).

The economies of the New World participated actively in the expansion of the world capitalism through the exploitation of abundant natural resources that enable to maintain an export-oriented growth during the First Globalization period.

In every cases the stimulus to development came from expanding markets in the world economy –usually expressed as rising prices– that led to an extension of the land frontier internally, accompanied by considerable inflows of capital and labor immigration (not only from outside the country but also from other regions within the political borders). The new sectors or activities related to the production of primary exports generated additional demands for capital, labor and raw materials that were satisfied partially by foreign sources. Thus international and inter-regional mobility of factors were part of the story.

The expansion of the frontier has represented a secondary role in the modern historical analysis of settler economies even though the main "domestic contribution" to economic growth was, precisely, the incorporation of "new" land into the production. Only recently scholars have seriously taken up again the role of the frontier in societies of recent settlement.

Arroyo (2008) proposes a comparative view of some Latin American economies (Argentina, Mexico, Venezuela and Uruguay) during the 19th century and presents a theoretical framework that links the effects of factor endowments and trade on inequality. The article analyses the influence of the movement of labor force, terms of trade and the land expansion on income distribution. Inequality depends critically on the relative scarcity of productive factors and the distribution of their ownership. Land was not a fixed factor in these economies. Large areas were incorporated into the production and they enable the active participation of settler economies in the international primary commodity markets. But, as population grows, land becomes relatively less abundant and inequality increases.

Findlay & Lundahl (1994, 2001) and Findlay (1995) present a simple model that captures the structural pattern of the process to integrate the vision of the "vent-for-surplus" and "staples" theories and to characterize the endogenous land frontier as a central issue. The core of the formalization is the so-called Ricardo-Viner "specific factors" model, which was itself influenced by works of Jones (1971) in the staples theory tradition. Within this conceptual framework, authors articulate the changes in the relative prices, the inflows of labor and capital, the structural change and the movements in the income distribution taking the land frontier expansion as a pivot concept.

Both analytical proposals are not critical to the "mainstream" framework but they can be considered as complementary visions to the general view about the First Globalization and the development of the Atlantic economy. However, other proposals are presented in a more critic line.

In a recent article, Knick Harley argues that: *"Applying the Stopler-Samuelson paradigm from Heckscher-Ohlin trade theory, the result is an approach that sees price convergence as pivotal in defining, identifying, and measuring globalisation. This focus, however, obscures the implications of frontier incorporation and other insights achieved by viewing nineteenth-century globalisation as a mechanism whereby peripheral economies were incorporated into the core of organized economic activity. A frontier-centred perspective also reintroduces the role of economic institutions as a crucial element of economic growth and development."* (Harley, 2007:238). The integration of a frontier in the Atlantic economy contemplates the discovery of export staples, a process of learning how to best exploit them, and the mobilization of capital and labor for production, use and distribution.

Regarding the 19th century globalization in terms of the expansion of the Atlantic economy from the north-western Europe to the frontier periphery instead of a *"regimen switch to openness"* (as O'Rourke & Williamson, 2005:21) allows understanding the globalization as the incorporation of regions –beyond the frontier of organized economic activity– into capitalistic relationships in a world scale. In these terms, it is not necessary to introduce the notion of price convergence to

understand the world integration. Globalization can be *"defined as a shift from an economy where local supply and demand fluctuations dominated price fluctuations to one in which the economy became a price-taker to global forces"* and, if this is the case, *"it need not depend on price convergence"* (Harley, 2007:240-241).

Bértola *et ál.* (2010) propose a compatible framework with this vision to explain the evolution of the inequality in the South America Southern Cone (Argentina, Chile, Brazil and Uruguay) during the First Globalization. According to this analysis, the effect of globalization on inequality depended on the expansion of the frontier and institutional persistence (from the colonial heritage) and changed in old and new areas.[2]

From this perspective, the focus on frontiers –that is, the incorporation of regions that were primarily scarcely occupied and outside European economic influence– adds to the mainstream approach another viewpoint and helps to explain new issues on this matter. Land frontier expansion constitutes a pivotal concept that allows to articulate considerations about technological progress and institutional configuration in a different way. It is based on the combination of endogenous growth in the use of the productive factors and can include regional (and local) perspectives.

In a recent working paper, Camilo García-Jimeno and James Robinson show a renewed interest in the frontier. They analyse the classical view corresponding to F.J. Turner as the "Frontier (or Turner) Thesis" for North, Central and South America from the middle of 19th century to 2007. They suggest *"that if political institutions were bad at the time of frontier settlement, the existence of such frontier land might actually lead to worse development outcomes, probably because it provides a resource which non-democratic political elites can use to cement themselves in power"* (García-Jimeno & Robinson, 2009:18).

Regarding their approach, the consequences of the existence of a frontier depend on the character of the political institutions which were formed in the early independence period. In those cases which institutions meant few constraints on the executive, having a frontier was bad for economic development in terms of economic growth, income distribution and democracy.

2. Measuring land frontier expansion

The literature on the frontier has been quite imprecise on how to determine the frontier. Besides, it is hard to think about the frontier as a dichotomous condition because usually the boundaries are not clear-cut. In the historical literature, the "natural" candidates to identify a frontier are the presence or absence of native communities not subject to state control and authority, the absence or existence of people in considerable quantities, and the existence of state institutions.

[2] Rodriguez Weber (2009) proposes an argument in the same conceptual line.

However, in a great part of the literature, the conceptualization of the frontier does not go beyond an interesting (and intuitive) discourse but with very few efforts to quantify the process. In this section, we comment some of these efforts and propose a new approach to represent the concept and apply it with analytical purposes.

2.1 Recent quantification efforts

In the H-O-S framework, the land frontier expansion is approximated by changes in the factor endowments and is represented by the land/labor ratio. *"The land-labor ratio may decline in the long run as positive Malthusian forces associated with labor scarcity encourage early marriage, high fertility in marriage, and high child survival rates. Labor scarcity may also encourage across-border migration and thus an even greater and quicker decline in the land/labor ratio. Alternatively, high and rising wage-rental ratios may foster land settlement, frontier experience that has received considerable theoretical and empirical attention in the literature."* (Williamson, 2002:77). Diverse articles presented within this line of thinking include, where possible, both arable and pasture lands to measure the process of expansion of the occupied territory in relation to labor.

The relation between the quantity of available land and the labour force is an indicator of the evolution of the use of the land as a productive factor and the intensity of its utilization. Initially, land is an abundant factor that may be accumulated. However, it is a finite input, and its availability decreases with the accumulation of labour. This is the pattern experienced by the settler economies. The "club" indicator[3] took a persistent decreasing trend from the 1870s to the first decades of the 20th century and entered in a stable trajectory after the WWI (Graph 1, plotted line).

[Insert Graph 1]

This was the case of Australia –where the occupation of territories combined agricultural activities with mineral discoveries–, and New Zealand and Uruguay, small territories with easy access. On the other hand, Argentina and Canada had open frontiers during the 1880s-1890s and the indicator increased until the second decade of the century, to start decreasing only after the WWI. Finally, Chile experienced the settler pattern until the first decade of the 20th century, although the trend changed when the agricultural frontier expanded to the south (crops, especially wheat).

These indicators are usually constructed referring to the land effectively used in the production of crops (Williamson, 2000, 2002), without admitting changes in the proportion of productive factors or alternative agricultural uses. Besides, the land occupation is not homogenous in the territory and takes different ways depending on the soil quality, urbanization dynamic and initial settlement (associated with the own colonial conditions).

[3] In all cases we call "club" indicator to the simple average of our six economies.

Arroyo (2008) takes a similar way although introduces additional issues. She proposes a brief analysis of the land frontier expansion considering the institutional and political conditions that characterized the incorporation of new land into the production. In general, she refers to the percentage of arable land transferred to private ownership and the land ownership when considers land indicators. Empirically, the paper concentrates on simulation exercises and, to evaluate the impact of fixed supply of land, assumes that no land expansion occurred after 1850. Therefore, land became progressively scarcer over the century proving unfavourably conditions to labor and worsening in the income distribution. Graph 2 shows her evidence for Argentina and Uruguay. In both cases the evolution of the ratio labour/land is increasing in the long run, although with different trajectories. Uruguay followed an increasing trend that would be consistent with the small territory and the easy access to the different regions (Graph 2.b). Argentina presented a decreasing trend until the 1840s –the land frontier expansion only occurred until the mid-19th century– and afterwards the evolution followed two periods with different intensity. From the 1840s to the 1870s the indicator shows a moderate growth that accelerates until the end of the century (with the strong immigration) (Graph 2.a).

[Insert Graph 2]

García-Jimeno & Robinson (2009) (G&R) study the effects of the frontier on the economic development of North, Central and South America countries but choose a different strategy. These authors estimate the proportion of land which was frontier (territory non-occupied) in each independent country in the Americas in 1850. The empirical work combines these data with current income per capita, democracy and inequality. They classify territories with less than 2 people per square mile (0.7722 people per square kilometre) as frontier land or open frontier.

They work with diverse historical atlas of the regions and the use of Georeferenced Information Systems (GIS) to measure occupied area.

GIS is a system designed for the capturing, storing, checking, retrieving, integrating, analyzing, and displaying spatial information, articulating data bases with maps to obtain relationships between economic and social processes and geographical location. The threshold of *"2 people per square mile"* was officially used by the Census Bureau of US and was the criterion of the Office that led to declare US as closed frontier in 1890.

Therefore, the authors use the following index of frontier:

$$F_{i\,1850} = 1 - [OA_{i\,1850} / TA_{i\,actual}] \qquad (1)$$

Where:

$OA_{i,\,1850}$: is the occupied area (in some surface measure as square kilometre or mile) of country *i*

in *1850* (or any year around), considering as occupied land when the population density is higher than 2 people per square mile.

$TA_{i\ actual}$: is the total area of country *i*, actual data.[4]

The estimates are mapping in continental scale (we reproduce North and South America maps in Figure 1) and the results are 72.5 per cent for US and 85.3 per cent for Canada, proposing three calculations for South and Central American countries according to a narrow and wide criteria and a third source. In the case of the wide criterion, the estimate for Argentina is 74.2 per cent, for Chile is 52.7 per cent and for Uruguay is 100 per cent.

[Insert Figure 1]

2.2 Some observations and shortcomings

Both types of indicator represent different proxies to the evolution of the relative endowments. Williamson's indicators emphasize the flow dimension of the process and G-R's approach concentrates on the stock dimension. In these terms, the first indicators are more appropriated to dynamic analyses but hidden the differences in the levels of the relative factors. On the contrary, the second ones are more useful to compare levels of endowments but working with a static approach that undermines the analytical power of the argument.

Within the neoclassical vision, the expansion of the frontier is a relevant notion to conceptualize the movements in the factor endowments but, beyond these considerations, is found interesting only at a secondary role.

In the case of G&R, the authors are focused on the concept. Therefore, they propose a specific measurement using a novel tool to study the land frontier expansion in historical perspective. Associating the expansion of the land frontier with the settlement of colonizers is conceptually (and intuitively) appropriated. However, four observations are pertinent.

First of all, and independently on the matter, choosing a threshold always is arbitrary and can be subject to discussion. The objection is not with the value adopted (2 persons by square mile) but with the rigidity that it implies. It is possible to contemplate several thresholds to consider different land frontier expansion "levels", and thus to incorporate more actively to the analysis the creation of markets and the economies of agglomeration.

Secondly, just considering one period means to lose the dynamic of the process. The expansion of the land frontier is a concept that incorporates the movement as a fundamental dimension. Comparing different moments in time we will enable to consider different "shapes" in the extension

[4] www.geohive.com for land areas of subnational administrative units.

of the land and to contemplate the possibility that non-frontier land became frontier again.

In the third place, using the actual administrative divisions (national boundaries and internal divisions) implies the non-incorporation of the historical formation of those institutional arrangements and to reduce the notion of "economic space" to "administrative space".

Finally, taking all national territory of the countries as the reference of "maximum frontier" is a questionable assumption. In a theoretical sense, it is proper to assume that all area is potentially achievable but in historical terms is arguable that by institutional and technical reasons there were regions of the territory that were not accessible.

We discuss these arguments and present alternatives to give some steps to solve these limitations.

3. A proposal for approaching the land frontier expansion

The starting point is to know the settlement of inhabitants in the territory because our interest is the incorporation of land into the market production and, in the case of settler economies, the participation in international markets. We assume that the presence of population in a relative high proportion is the best proxy to land incorporated in the economic activity. Another approach would be considering the creation of institutions that establish ownership rights on the land and the state control over the regions.[5] In this article we put the emphasis on the first concept to stress the productive conditions associated to the extension of available land for production. We focus on institutional issue in other paper (Willebald, 2010).

3.1 How can we solve the shortcomings of the previous approach?

Firstly, it is possible to work with several levels of frontier expansion using different thresholds and admitting that the concentration of the people can "shape" the land frontier expansion. We work with three levels; we start the analysis with the "classical" threshold of 0.7722 inhabitants by km^2 ("medium") and, afterwards, we divide by two ("lower") and double up this value ("upper") to identify regions of transition.

Secondly, we construct our indictor for 10-year periods for 1850-1910 to overcome the static perspective of the previous approach (in next versions of the paper, we will extend the period for the beginning of the 19^{th} century to the mid-20^{th} century).

In third place, original data consider actual local administrative divisions as reference, but the use of different measures of population density makes possible to "paint the map" (i.e. to identify different regions in the territory) independently on local jurisdictions.

[5] However, this would mean assuming that the native people's rights would not be valid.

We illustrate our approach presenting series of map (Figure 2) representing the regional evolution of population count in three large regions –Oceania, North America and the Southern Cone of South America– for six benchmarks –each 20-year from 1820 to 1930– and ten ranges from 0-10 inhabitants per cell to more than 25,000 (Figure 2.a).[6] Mapping the quantity of population for selected years represented the first approximation within our approach. The objective of the exercise is to identify periods in which the process of land frontier expansion was more intense and to appreciate the regional dynamics. The location of new economic activities and the settlement and movements of the population was an intense process that characterized the settlers at the turn of the century, and that may be considered exhausted before the 1930s.

[Insert Figure 2]

Australia presented a costal location of the population. South-eastern (Victoria and Tazmania) and north-eastern (New South Wales and Queensland) regions were the first areas occupied, presenting increasing population density and, just in the end of the century, people located in the South-western territory (Western Australia, around Perth city). South and Northern Territory showed, historically, characteristics of open frontier. In New Zealand, North Island was the first region populated while the South Island, with a more rugged terrain and indigenous population, experienced a delayed settlement (Figure 2b).

Canada constituted an immense territory where colonizers settled the east areas and just in the last decade of the 19th century the central fertile prairies were occupied in a process that was possible with the construction of the transcontinental railways (Figure 2c).

In the Southern Cone of South America, the expansion of the frontier around the River Plate meant a common pattern that characterized to Uruguay, the Argentinean provinces of Buenos Aires (around the port) La Pampa and Córdoba (in the west-centre) and Santa Fe and Entre Ríos (in the *litoral*) and even the south of Brazil (in the state of *Rio Grande do Sul*). Chile presented a process of the most intensive settlement in the *Núcleo Central.* During the last two decades of the century, Chile evidenced a progressive frontier expansion to the north after the *Guerra del Pacífico* (1879-1883) and the incorporation of lands with rich nitrate deposits. Settlement in the South during the first decades of the 20th century was associated with de agricultural expansion (Figure 2d).

Other interesting issue is the early development of large cities in a quick urbanization process that accompanied the land frontier expansion. Sidney, Melbourne, Adelaide and Perth in Australia, Auckland and Wellington in New Zealand, Ottawa and Quebec in Canada, Santiago in Chile, the

[6] Each cell measures 81 km^2.

cities of Buenos Aires, Rosario, Tucumán and La Plata in Argentina and Montevideo in Uruguay are clear examples in this sense.

3.1.1 Settlement and the potential vegetation

We can describe the movement of the population along the territory but, which was the area effectively achievable? Related with the fourth limitation mentioned previously, we do not take the total national territory of the countries as the reference of "maximum frontier" because, in productive and economic terms, is an option non consistent with the historical development of the settler economies.[7]

Is all the territory adequate to create means to sustain the population (food, clothes)? Are colonizers willing to settle anywhere? Are all places safe enough?

Initially, colonizers will settle in satisfactory places to develop the human life. Early settlers in large parts of the planet (especially settler economies as North America in the 18th century and the South American Southern Cone and Australasia in the 19th century[8]) faced quite restricted in their options to settle and develop agricultural activity. Geography (swamps, mountains, dense forests, and poor soils), climate (temperatures, humidity) and hostile indigenous population limited the accessibility in many regions. Besides, extensive parts of the world were not reachable due to the lack of infrastructure. The early spreading of people (and agriculture) was restricted considerably.

Which was the "wildness" that the settlers faced in the 18th and 19th centuries in our regions? Can we replicate those historical conditions to understand their decisions and possibilities? Some concepts of the environmental and climatic change literature can be useful for our issue. Data representative of the world's "potential vegetation" are a proxy of the nature that people confronted in the settlement times in a good way. The world's potential vegetation is the vegetation that would most likely exist now in the absence of human activities[9] and it is estimated according to georeferenced information of current ecosystems framework, diverse information sources and a hard work of classification and analysis (Ramankutty and Foley, 1999).

Our interest is to identify land able to "support" the settler people and, potentially, to produce goods to the international commodity markets. In the case of the settler economies, a basic condition is to consider that lands can be used to raise animals. An alternative criterion would be to consider arable land or adequate land to grow plants (typically wheat in the settler case) but it

[7] Even, it is controversial to argument about the idea of a "national" territory in 1850.
[8] South and North Africa presented similar patterns.
[9] These data do not necessary represent the preagricultural vegetation because vegetation types have changed according to environmental conditions such as climate and CO_2 concentrations (Ramankutty and Foley, 1999:1001)

would be an excessively rigorous standard. [10] Our settler economies have extensive areas where was (almost) impossible to cultivate but they were successful to rear cattle or ships. Therefore, we consider that the "maximum frontier" will be represented by those regions of the territory able to raise animals or, in general terms, the possibility of allocation of grassland. Figure 3 shows the distribution of biome types according to the potential vegetation for our regions.

[Insert Figure 3]

Biomes are climatically and geographically defined regions of similar ecological climatic conditions such as communities of plants, animals, and soil organisms and are often referred to as ecosystems (University of California, Museum of Paleontology, 2009). Plant structures (trees, shrubs, grasses), leaf types (broadleaf and needleleaf), plant spacing (forest, woodland, savanna), and climate define biomes types (Figure 3a).

The biome types appropriate to allocate grassland are presented in Table 1. Klein Goldewijk & Van Drecht (2006) assign ordinal values to construct a ranking of allocation of grassland including grassland and steppe, open shrubland, savanna, dense shrubland, tundra and several varieties of woodland (with the exception of boreal forest and tropical evergreen woodland).

It is clear that settler people faced different "wildness" according to each economy and the region occupied within each territory. In Oceania (Figure 3b), while Australia exhibited the predominance of shrubland and savanna and a very low participation of grassland/stepe, in New Zealand grassland/steppe was the main vegetation biome (although with important differences between both islands). In Canada (Figure 3c), we have the presence of grassland and open shrubland in the prairies, but with large extensions of tundra and boreal forests between this region and the Atlantic and the Pacific coasts. Finally, in the Southern Cone (Figure 3d), we have the predominance of grassland in Argentina and Uruguay and the succession of colors in Chile from the hot desert in the north to the polar desert in the south.

[Insert Table 1]

Therefore, following G&R, we calculate the index:

$$F_{i\,t}=1 - [OA_{i\,t}/PVG_i] \qquad (2)$$

Where:

$OA_{i\,t}$: is the occupied area (in km^2) of country *i* in period *t*, with *t=1850, 1860…and 1910.*[11]

PVG_i: is the "potential vegetation grassland" area (in km^2) of country *i.*

[10] In general terms, the land conditions (fertility, roughness, temperature) to raise animals are less strict than to cultivate (and specially cereals, one of the main product of settler economies).

3.1.2 Frontier expansion and agricultural aptitude

Soils are no homogenous along the territory, climate changes and terrain slops differ significantly, imposing specific set of constraints and creating different conditions to the development of agricultural activities. The ranking presented in Table 1 enables to distinguish two land types of "high" and "low" aptitude to allocate grassland, grouping categories 6, 5, 4 and 3, 2, 1, respectively.[12]

Therefore, we are in conditions to compose two sets of indicators.

On the one hand, the following indicators show the "extensive" character of land frontier expansion considering the shares of each type of land occupied in the total grassland area.

$$OA^{HA}{}_{i\,t}/PVG_i \qquad (3)$$

$$OA^{LA}{}_{i\,t}/PVG_i \qquad (4)$$

On the other hand, the following indicators show the "intensive" character of the process considering the shares of each land type occupied in each land aptitude category. I^{HA} and I^{LA} represent the intensity in the use of land of high and low intensity in each period *t*.

$$OA^{HA}{}_{i\,t}/PVG^{HA}{}_i = I^{HA}{}_{i\,t} \qquad (5)$$

$$OA^{LA}{}_{i\,t}/PVG^{LA}{}_i = I^{LA}{}_{i\,t} \qquad (6)$$

Besides, considering that:

$$OA_{i\,t}/PVG_i = OA^{HA}{}_{i\,t}/PVG_i + OA^{LA}{}_{i\,t}/PVG_i$$

$$= OA^{HA}{}_{i\,t}/PVG_i.\ PVG^{HA}{}_i / PVG^{HA}{}_i + OA^{LA}{}_{i\,t}/PVG_i.\ PVG^{LA}{}_i/PVG^{LA}{}_i$$

$$= PVG^{HA}{}_i / PVG_i\ .\ I^{HA}{}_{i\,t} + PVG^{LA}{}_i/PVG_i.\ I^{LA}{}_{i\,t} =$$

$$= \beta_1.\ I^{HA}{}_{.} + \beta_2.\ I^{LA} \qquad (7)$$

Where β_i are fixed and known and I^{HA} and I^{LA} change along the time and tend to 1 in the long run. Therefore, evaluating the evolution of the intensity in the use of land we can identify patterns of land frontier expansion in the settler economies.

Suppose that the land frontier expansion followed the "Ricardian Model", where the more fertile lands are first cultivated and afterwards –when population and the necessity of food increase– are put in production the less fertile territories. The evolution of our indicators would follow a pattern similar as the represented in Figure 4. The indicators show the different phases of expansion

[11] We have data from the beginning of the 19th century that will be used in next versions of the paper. Now, we focus our attention on the First Globalization period.

[12] We will consider a third category in next versions of the paper: "high" (6 and 5), "medium" (4 and 3) and "low" (2 and 1).

according to the fertility and the quantity of land used for the agricultural production. We hope that each economy presents a specific path according with different circumstances –historical, institutional and geographical– and diverse consequences in terms of economic growth and income distribution.

[Insert Figure 4]

The determination of *PVG* is an adequate criterion when land is used to produce consumption goods. Was this always the case? Some times, the decision to move from one location to another uninhabited place is related with economic activities different than biological production. Mining discoveries are typical cases.[13] It is an important issue because Australia and Chile, and to certain extent Canada and New Zealand, experienced important mining development and the population movement –and the frontier– could be related with different factors than those that determine the *PVG*. Therefore, in any case can be necessary to include as frontier territories non-adequate for grazing but appropriate to mining. Strictly, these considerations would deserve a specific research with a different approach. Instead of working with settler economies as central category –which have a bias towards the study of agricultural activities– we would have to propose an approximation according to the mineral development of the territories. In this sense, Denoon (1983) argue that Chile is a limit case of settler economies [14] and we introduce changes in our conceptualization to contemplate this speciality.

In the case of Chile, the First Globalization coincided with the expansive cycle of the nitrate production as consequence of the incorporation of large regions with rich mineral deposits after the *Guerra del Pacífico* (1879-1883). *Antofagasta* (a province of Bolivia) and *Tarapacá* (a province of Peru) were annexed to Chilean territory from the beginning of the 1880s and the mineral production transformed in the main determinant of the economic growth until the Great Depression of the 1930s (Cariola & Sunkel, 1982). According to our distribution of biome types, both provinces correspond to desert regions and would not be considered as territory potentially colonisable. Therefore we include both territories as part of the *"PVG"* of Chile to calculate our indicators and, considering that the nitrate deposits were very rich, we consider them as "high aptitude" land.

3.1.3 Frontier expansion and distance

Is it enough to know the agricultural aptitude to qualify the occupied land? In settler economies the land quality not only depended on the agricultural aptitude but the distance from the production regions to the markets and, especially in the case of settler economies, to the ports. The effective

[13] The economic history of many countries knows about real "gold rushes" and the 19th century was a prolific period for these stories.
[14] Author argues the same concept to South Africa.

materialization of the natural wealth was in the possibility to participate in the international markets of commodities. Our indicator must consider that excellent soils very far located are, in facts, bad soils in productive and economic terms. How can we introduce any idea about distance?

We will present empirical evidence in next versions of the paper considering a longer period of analysis (from the beginning of the 19th century to 1950). This subsection only proposes a conceptual discussion.

In the recent literature several concepts derived from the Economic Geography are applied to Economic History analysis (Crafts, 2005; Martinez-Galarraga, 2009; Rosés, 2003; Schulze, 2007; Tirado, *et al*, 2006). In particular, the "market potential" is a notion that incorporates the distance as a main factor and that may be useful for our purpose. The Harris market potential equation (Harris, 1954) can be defined as:

$$MP_i = \sum_{j=1}^{j=n} \frac{M_j}{d_{ij}} \qquad (8)$$

Where M_j is a measure of the size of region j (state, province or other division), usually the GDP, and d_{ij} is the distance, usually represented as the bilateral transport costs between i and j.

In our case, we can estimate an indicator of "land quality" according to the agriculture aptitude "adjusted" by the distance to specific places that, given their economic, political or historical conditions, result a sort of "centre of gravity". We consider a place in these terms when it represented a geographical point that spread population in different directions. Therefore, each type of occupied area –of high or low agricultural aptitude– can be expressed, initially, in adjusted terms to represent land quality:

$$OA^{HQ}_{it} = OA^{HA}_{it} / d_{it\ OA\ CofG} \qquad (9)$$

$$OA^{LQ}_{it} = OA^{LA}_{it} / d_{it\ OA\ CofG} \qquad (10)$$

Where $d_{it\ OA\ CofG}$ represents the distance from the "new" occupied area to the "centre of gravity" of the region in the economy i during the year t.

When did the interior distance become a relevant issue? During the first decades of the settlement, distance was not matter. The expansion in the territory was an activity of expeditionary people in the search of adventures and wealth, but it did not respond significantly to productive objectives. Each economy had its own characteristics but, for our exercise, we choose 1850 as the moment when the land frontier extension was seriously considered and distances became a central point in the process.

In that sense, our index is an indicator of incremental nature. The variable distance adjusts the "new" land incorporated, decade by decade, from 1850 to 1950. Thus, to be rigorous, our equations (*9)* and *(10)* can be expressed as the sum of several components. For instance, for 1900 and regarding the "high" agricultural aptitude, the equation is as follows:

$$OA^{HQ}_{i\,1900} = OA^{HA}_{i1800} + (OA^{HA}_{i1810} - OA^{HA}_{i1800}) + \ldots + (OA^{HA}_{i1850} - OA^{HA}_{i1840}) + (OA^{HA}_{i1860} - OA^{HA}_{i1850})/d_{it\ newOA\ CofG} + (OA^{HA}_{i1870} - OA^{HA}_{i1860})/d_{it\ newOA\ CofG} + \ldots + (OA^{HA}_{i1900} - OA^{HA}_{i1890})/d_{it\ newOA\ CofG} \quad (13)$$

This is the expression for the cases when the expansion occurs and, on the contrary case, the negative addend is not adjusted by distance (or, equivalently, we consider *d=1*). For "*newOACofG"* we understand the distance from the new occupied area (represented by OA^{HA}_{it} - OA^{HA}_{it-1}) to the closest "centre of gravity".

We illustrate our work with diagrams in Figure 5. Georeferenced information presents data in terms of grid cells and our database represents the distribution of population with a global 5 x 5 minute resolution, i.e. approximately 9 km at the equator (Klein Goldewijk *et al*, 2007: 168). Therefore, we have grid cells that have approximately 9 km in length, 12.7 km in diagonal and the surface area is 81 km^2.

[Insert Figure 5]

We can assume that Figure 5.a represent the situation for a country in 1850. The occupied surface contains 89 cells of 81 km^2 representing a total area of 7,209 km^2. In 1860, the land frontier expansion meant the incorporation of only one cell (*"A"*) and it was possible after to cover s_1 km. According to our analytical framework (see Mednick & Willebald, 2010) the cost of clearing land is an increasing function in the quantity of land incorporated to the production.[15] We can exploit this idea considering than the "marginal income" that "renders" this new land is inferior than the immediately before one. Therefore, we need a coefficient to "penalize" the new area and, instead of incorporating 81 km^2, we add in a smaller area (our adjusted measure of land).

In the margin, we cover 9 km after going trough s_1 km in the territory and the ratio between both components $(9/s_1)$ can represent the additional increment in the process of expansion.[16] Our coefficient to adjust the "new" land is: $d_1 = 1+9/s_1$, and we correct each new incorporated cell dividing the area in the previous benchmark by d_1. In terms of our diagram in Figure 5.b, our total occupied area will be the surface just covered in 1850 (7,209 km^2) plus (81 km^2 / d_1).

In 1870, the land frontier expansion meant the incorporation of 40 additional cells. We repeat the

[15] $K_A = \phi(N)$. With $\phi'(N) > 0$ and $\phi''(N) > 0$. $\phi'(N)$ is the marginal cost of "clearing" a unit of land. $\phi(N)$ is a convex function of the amount of land cleared.
[16] We can propose a similar exercise considering the diagonal of the cell (12.7 km).

previous procedure considering the remotest cell as reference (*"B"*) and adjust all the "new" cells with the same coefficient. In this case, agents cover s_2 km and we calculate d_2 to adjust the cell area obtained after the correction of the previous benchmark. In terms of our diagram in Figure 4.c, our total occupied area will be the surface covered in 1850 (7,209 km^2) plus (81 km^2 / d_1) plus 40 x (81 km^2 / d_1 / d_2). We repeat the procedure for 1880, where the total occupied area will be the surface covered in 1850 (7,209 km^2) plus (81 km^2 / d_1) plus 40 x (81 km^2 / d_1 / d_2) plus 10 x (81 km^2 / d_1 / d_2 / d_3).

How can we make operative our definitions?

Distance is an important point in the case of the large economies of the group –Argentina, Australia and Canada– and loses relevance for the small economies –Chile, New Zealand and Uruguay. However, even in the latter, certain geographical conditions make necessary to consider the distance.

Considering that the settler economies based their expansion on the external conditions associated to the First Globalization, the ports are the "natural" candidates as possible "centres of gravity" or expansion axis. This will be the situation en all settler economies but in some cases we will need to take into account other possibilities. Then, the first point is to choose some important ports of the settler as spatial references to measure distances. We assume that the producers decide to direct their products to the closest port according to provinces, states or large regions. It is impossible to know the real destine of the production but we consider that our assumption is reasonable. In those cases in which is evident the existence of other type of "centre of gravity", we argue about the feasibility of our assumption (Figure 6).

[Insert Figure 6]

The *Official Yearbook of Australia* of 1910 includes a description of the main ports of the Commonwealth classified by states and a ranking according to regional relevance (specially considering width of entrance, depth, facilities, security and cargo capacity). We choose one port by state as reference.

In New South Wales we consider Port Jackson, which is the harbour of Sidney city. In Victoria, we consider Port Phillip, in the Hobson's Bay, in the mouth of River Yarra, which is the harbour of Melbourne city. In Queensland, the more relevant port is in Brisbane city, in the mouth of the Brisbane River and next to Moreton Bay. In South Australia, we consider Port Adelaide in the city with the same name. In Western Australia, form the beginning of the 20th century the most relevant port was Fremantle, at the mouth of Swan River. It is located 19 km southwest of Perth, the capital of the state, and we take this city as the reference point of the state. North Australia only had one

main harbour, Port Darwin, in the city with the same name. Finally, Tasmania had several ports a long the coast island but the most important was Horbart, at the mouth of River Derwent. Figure 6 shows the locations of the ports that we use as references to calculate distances.[17]

In the case of Argentina, the most important port was Buenos Aires and the remainder harbours of the Republic were specialized in coasting ship. The *National Census* of 1914 reported that 56 per cent of the total cargo corresponded to Buenos Aires (included sailing and steam ships) and that almost 180 of the 610 vessels were large ships (deep draught). We use Buenos Aires as one our reference distance (see Figure 6). However, this option is not enough and we need to consider a second reference.

Historically, the land expansion in Argentina followed the action of two axes. On the one hand, the "*litoral*" and "*pampeana*" regions, developed from the beginning of the 19th century, with a firm external "vocation" and led by Buenos Aires and its port. On the other hand, the *"andino"* inside region, with deep roots in the colonial past of the Hispanic Crown in South America that, centered in the Alto Perú and the rich zone of Potosí, extended its influence to the Argentine north (Cao & Rubins, 1996). The city of Tucumán officiated as one of the more important economic and political centers. It presented a strong demographic development and was sited in a region with a productive structure based on plantations (sugar) that contrasted to the pastoral activity of the south and east of the country. We consider it as our second reference distance point.

In a previous paper (Willebald, 2009), we define five regions in Argentina: North-West (Jujuy, Salta, La Rioja, Tucumán, Catamarca and Santiago del Estero); North-East (Formosa, Chaco, Misiones and Corrientes); Cuyo (San Juan, San Luis and Mendoza); La Pampa (Córdoba, Santa Fé, Buenos Aires, Capital Federal, La Pampa and Entre Ríos); and Patagonia (Neuquén, Río Negro, Chubut, Santa Cruz and Tierra del Fuego.). Buenos Aires constitutes the "centre of gravity" of La Pampa and the Patagonia and Tucumán the reference distance for the North (West and East) and Cuyo (See Figure 6).

Canada is a very extensive country with coasts at the Atlantic and the Pacific oceans and, initially, would be convenient to consider both "exit doors" to the international market. During 1913-1914, the four more important harbors of Canada in terms of cargo were Halifax and Montreal in the eastern coast (Nova Scotia and Quebec provinces, respectively) and Vancouver and Victoria in the western coast (both in British Columbia) (see Figure 6). In the east, both ports transported similar cargoes in tonnage[18] but the average cargo per vessel was significantly superior in Montreal

[17] Coghlan (1904):222-223 notices that some figures –as the statistics of Melbourne– are inflated by the counting of the great ocean steamers as twice entering and clearing at. However, this limitation is not important for our purpose because the adjusting does not change the ranking within each state.
[18] Halifax: 3.5 millions tons. Montreal: 3.9 millions tons (year average, 1913-1914).

and it will be our eastern distance reference. In the west, the differences between Vancouver and Victoria are minors and they are located very near one to the other (Statistics Canada, 1914:474, and 1915:501-502). However, the settlement dynamic aroused doubts about the role of these last two ports as "centre of gravity". The demographic development of the middle of the country was more related to the expansion from the east than the engine of the west coast and we need an alternative distance reference.

Winnipeg, the actual capital of Manitoba, is located near to the longitudinal centre of North America, in south central Canada, close to the eastern border of the Canadian Prairies, at the confluence of the Red and Assiniboine Rivers. Historically, this area played an important regional role as a fur trading post (18th century), a leading post for the Hudson's Bay Company (during the first half of the 19th century) and enjoyed a rapid progress after the coming of the Canadian Pacific Railway in 1881.

As in the case of Argentina, in a previous paper (Willebald, 2009), we had identified regions in Canada that, given their conditions, facilitated the analysis. The regions were the following: Atlantic Canada (Nova Scotia, New Brunswick, Prince Edward Island, and Newfoundland and Labrador); Quebec; Ontario; West (Manitoba, Saskatchewan, and Alberta); British Columbia and North (Northwest Territories, Yukon and Nunavut). We consider the three first regions as the "East", where Montreal constitutes the "centre of gravity" and the three last as the "West", considering Winnipeg as the distance reference point.

In the case of the small economies of the "club" it can be interesting to consider some geographical conditions.

Chile, a country that is 4,270 km long and 175 km wide (average), has a particular shape that offers all climates and a broad topography (Hurtado, 1966). In this sense, we may consider three ports as distance reference, corresponding to the North, the South and the central region.

In the north, the principal harbor was Iquique, in the province of Tarapacá, followed by Tocopilla and Antofagasta in the province of Antofagasta. In 1910, the former exported a volume of nitrates that exceed the sum of the latter together (Cariola & Sunkel, 1982: 133).[19] In the south, the most important port –especially in the trade of cereals as wheat– was Talcahuano, which exceed the movement of other ports as Constitución or Tomé in the end of the 19th century and the first decades of the 20th century. Finally, the main port in the *Nucleo Central*, the region with the higher concentration of population and with a long run agricultural development, was Valparaiso from the colonial times.

[19] About the ports of the northern region see Badía-Miró (2008).

Therefore, we use three ports as distance references: Iquique, Talcahuano and Valparaiso (see Figure 6).

New Zealand is composed by two main islands. In the beginning of the 20th century, the two ports with the greatest total tonnage entered and cleared were Auckland, in the North Island (followed closely by Wellington), and Bluff Harbour, in the South Island. (Coghlan, 1904:223). (See Figure 6). In the South Island, other interesting geographical point for our exercise is Christchurch, although the urbane development of the city resulted more relevant than the territorial expansion and we works with that port as our distance reference point.

Finally, in the case of Uruguay, Montevideo was, historically, the main harbor and the international "exit door" of the economy from the colonial times (see Figure 6).

3.2 Data

A recent literature related with the negative effects of economic growth on environment and the global climatic change includes historical approximations to the evolution and geographical location of people, consumption and production in a world scale that is very useful for our purpose.

The "Netherlands Environmental Assessment Agency (MNP)" includes two programmes: the History Database of the Global Environment (HYDE 3.1) and the Integrated Modelling of Global Environmental Change (IMAGE) and information about population is available on the website.[20]

Data corresponding to biome types derives from Atlas of the Biosphere, a product of the Center for Sustainability and the Global Environment (SAGE), part of the Nelson Institute for Environmental Studies at the University of Wisconsin, Madison. [21]

4. Land frontier expansion in terms of "quality": our results.

We propose several measures of the land frontier expansion from 1850 to 1910. Initially, we present the results considering the total surface of the actual national territory as reference (as G&R) and then we began to review the different criteria of construction of the series according to our comments of Section 3. As we mention previously, we do not present measures including distance. This will be matter of next advances in the research.

4.1 According to the surface of the actual national territory

Table 2 presents the indicators taking as reference –that is, considering as the maximum frontier– the surface of the actual national territory of each country. We begin with the least rigorous criterion, considering occupied land independently of any benchmark.

[20] http://www.pbl.nl/en/themasites/hyde/index.html
[21] http://www.sage.wisc.edu/atlas/

[Insert Table 2]

The systematic decline of the indexes indicates the decreasing open frontier or, equivalently, the expansion of the occupied area. On the one hand, the results show clearly the differences between the large and the small economies. Argentina, Australia and Canada began the period with extensive part of their territories as open frontier and the advance of population is gradual until the WWI. Our numbers are, in general, consistent with G&R's records. They calculate (with the wide criterion) 74.2% for Argentina, 52.7% for Chile and 85.3% for Canada. The difference is higher in the case of Uruguay because they propose a proportion of 100%. This means that Uruguay would have a frontier completely open in the mid-19th century, a result that contradicts the historical evidence. However, it is important to take into account that our results do not consider any benchmark while G&R's number contemplate a benchmark of 0.7722 inhabitant by km^2. We are not in conditions to replicate their results but as our interest is in levels and, fundamentally, in evolutions, we do not go into these differences in depth.

On the other hand, the small economies began with relatively low indexes and they reduce rapidly until the end of the period.

However, the pace of the processes was different. Within the large economies (see Graph 3), the indicators of Australia and Canada fall barely during the period while the index of Argentina sustain a firm descendent trajectory. Uruguay and New Zealand began with similar levels (see Graph 4) but the advance of the occupied land was quicker in the former. In 1850, Chile have almost a half of its actual territory as frontier and the posterior decline is slower that the rest of the small economies.[22]

[Insert Graphs 3 and 4]

We illustrate our analysis considering two cases: Argentina and Australia. The literature about the economic development of the settler economies has traditionally discussed the timing of the frontier expansion and the comparison between both economies has been attractive for many scholars. *"In the Argentine pampas, and in the south-eastern and south-western regions of Australia, the fertility of the soil and mean rainfall declined as the farming frontier moved inland from the coasts –though more rapidly in the case of Australia"* (McLean, 2005: 20).[23] What do our indicators tell us about the issue?

[22] Chile changed the national boundaries significantly during the period and the interpretation of the index is restricted by this reason.

[23] Similar concepts are proposed in Rock (1986) and Díaz Alejandro (1975) (in the latter the comparison is between Argentina and US). Adelman (1994):5 proposes the comparison between Argentina and Canada: *"If the 1890s saw beginning of large-scale settlement on the prairies* [Canada] *and the pampas* [Argentina]*, the era of the open frontier of settlement was over by 1914"*.

Our estimates for Argentina are presented in Graph 5 considering four indicators: without benchmark (as Table 2), 0.7722 (medium; as G-R), 1.545 (upper) and 0.3863 (lower) inhabitants by km^2. Levels differ but trajectories are similar. The evolution contrasts with Australian case (Graph 6) where the decreasing trend is only apparent in the beginning of the period and afterwards predominate stable trajectories. Besides, in the last case, the decreasing is similar among indicators and it is not the case of Argentina where the changes differ significantly. In Australia, the decreasing in "lower", "medium" and "upper" indicators are 3, 2.5 and 1.9 per cent and, in Argentina, 20.9, 14.7 and 8.5 per cent. As the results change when we admit different benchmarks, the land frontier expansion meant a process of gradual dispersion of the population that is (almost) absent in Australian case.

The second important issue is to determine the dynamic of the process. With few data it is not possible to use sophisticated tools to find breakpoints so we propose working with growth rates. Graph 7 presents the growth rates of our indicators for 10-year periods and a polynomial trend approximation to the variations of the "medium" index to illustrate the evolution. In these terms, the land frontier expansion was a slow process in the mid-19^{th} century, interrupted in 1890 that accelerated from the change in the century. This evolution contrasts significantly with Australian case, where the process slowed down and even showed periods with reversion of the land frontier expansion (Graph 8).

4.2 According to the land aptitude: grassland

Considering the limitations of the previous indicators (see sub-section 2.2), we contrast different land frontier expansion indicators that take as reference the land suitable for agricultural activity (grassland).

In the case of Argentina (Graph 9), the indicator that considers the land occupied with more than 0.7722 inhabitants by km^2 and the total grassland as the reference (*O/G*) decreases quicker than the G-R's index (*O/TT*).

We propose a first approximation to the land "quality" considering only two land types: high and low aptitude lands (*HA* and *LA*). Therefore, if we consider the occupied land of high aptitude in relation with the total land under this condition (*HA/THA*), the expansion of the frontier is yet more intensive.

The relative movement among indicators is different than the Australian case. All more precise indicators show an evolution over the G-R's index (*O/TT*) and, in contrast with Argentina, the *HA/THA* present an expansion even less intensive than the occupied grassland (*O/G*). Using the relation *(7)* we can clarify this point.

We compare the evolution of the *HA/THA* with the index of the occupied low aptitude land in relation to the total low aptitude land (*LA/TLA*). The difference is clear. While Argentina moves its land frontier expansion through the high aptitude territory, Australia did it through the low one. Even in the last case, the evolution by the low aptitude land reverted in the 1880s to advance in the other type on land.[24]

4.3 Highlights and some hypotheses

The results show two patterns according to the dynamic of the settlement.

While Australia shows an evolution of slow advance in the frontier in which the first stages of settlement were more intensive by low quality land, Argentina evidenced a quicker process in which the first stages went by high quality land. It is true that in the case of Australia would be interesting to consider the previous decades to 1850 (which will be matter of a next version of the paper), but the levels of the indicators ensure that we will maintain our conclusions.

During the period, within a similar productive and trade pattern, the economic performance of Argentina and Australia was different. Both economies, exposed to the effects of the First Globalization, experienced economic growth and worsening in the income distribution. However, the process was more intensive in Argentina than Australia.

In the eve of the WWI, both economies achieved the higher GDP per capita of the period (our indexes are 1911=100), although starting from different levels (almost 40 in Argentina in 1870-1874 and around 70 in Australia). Simultaneously, the worsening in the income distribution in Australia was a progressive process that implied a lower reduction of the wage/rental index, from levels of 400 in 1870-1874 to others close to 100 in 1910-1914. In Argentina, the changes were more abrupt, with a quick decreasing trajectory from levels close to 600 in the 1880s.

Willebald & Bértola (2010) analyze the economic performance of settler economies in the long-run and find that, within the "club", the differences in terms of the evolution of the inequality are notorious when we evaluate incomes but are less clear in the case of land ownership. As they argue, it *"is also possible that, even in countries where competitiveness still is highly dependent on natural resources, other forms of capital ownership may be more significant for the wealth distribution (financial assets, urban property, industries processing primary products, etc.)".*

Our analysis shed new light on the issue. Literature has concentrated in the land ownership with out pay enough attention to the quality of the factor. We introduce this issue in the discussion considering agrarian aptitude and distance and the interaction with the institutional quality.

[24] It is interesting that this reversion coincides with that experienced by the Williamson's indicator for Australia (see Graph 1) and can correspond to the same circumstances.

In a previous paper (Mednick & Willebald, 2010), we present a model that articulates these factors in an appropriate way.

The inferior economic growth in Australia would be explained by the productive application of land with lower quality than Argentina. Under these assumptions, the different intensity of the worsening of the income distribution in the settler economies during the First Globalization may be explained because they occupied land of diverse quality and thus their agents received different rewards. The extending of the gap between land rentals and wages that characterized the period depended on the effective existence of returns to appropriate. The abundance of excellent land in *La Pampa* or Uruguay opened a higher possibility to capture rents –compared to wages– than the case of Australia (where the territory became more arid when the producer moved away from the coast) or Canada (where the exceptional prairies were 2,000 km far away from the eastern coast).

It is common to associate the differences in inequality within the club of settler economies with institutional arrangements. *"Of course, in those places where the family farm dominated and where land was distributed more equally, a fall in w/r* [Wage/Rental ratio] *would not have translated into such a sharp rise in inequality"* (Williamson, 2000:14). *"The rise in the returns to land could lead to the emergence or consolidation of wealthy land-owning elite […] while real wages of workers in both sectors may have stagnated or fallen. In the case of more 'open' Anglo-Saxon regions, such as the United States, Canada, and Australia , the extension of the frontier largely meant an extension of the family farm, with the returns to land as well as the wage of labor accruing to the same individual, leading to a rise in general prosperity* (Findaly, 1995:133).

It is unquestionable the influence of institutional arrangements on the evolution of economic growth and income distribution during the period but the theoretical and empirical research has paid scarce attention in the different types of natural resources. Our proposal attempts to contribute in this sense considering the diversity of land quality in interaction with the quality of the institutions. This assertion is the main hypothesis of another paper. [25]

5. Final comments and agenda

We discuss the classical concept of land frontier expansion in historical perspective proposing several alternative measurements. Our analysis focuses on the evolution of selected settler economies (Argentina, Australia, Canada, Chile, New Zealand, and Uruguay) from the middle of the 19th century to the 1910s.

[25] Willebald (2010).

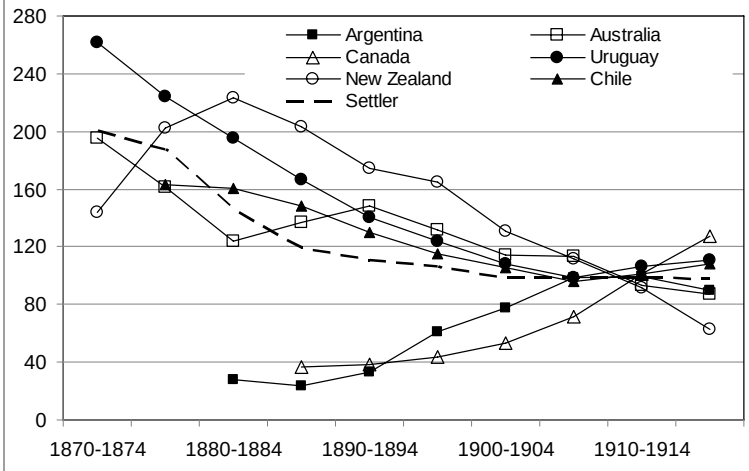
We present de notion of land frontier expansion and review the recent theoretical and empirical proxies to the concept in the literature. From the consideration of the main shortcomings of the previous approaches, we propose alternative methods to measure the process.

We introduce three new issues in the discussion –potential vegetation, agricultural aptitude and distance– to identify different types of settlement patterns. The use of Georeferenced Information Systems, the quantification of the process and the consideration of different land qualities are relevant contributions to the current analysis in Economic History. We illustrate our results with the cases of Argentina and Australia.

According to our analysis and the application of a specific theoretical framework, we propose an hypothesis that will be contrasted in next steps of the research. Considering the process of land frontier expansion in settler economies, the movement through different land qualities created diverse patterns of growth and distribution. The interaction with the institutional quality consolidated economic growths more egalitarian and diversified in ex-Brittanic colonies than ex-Hispanic territories.

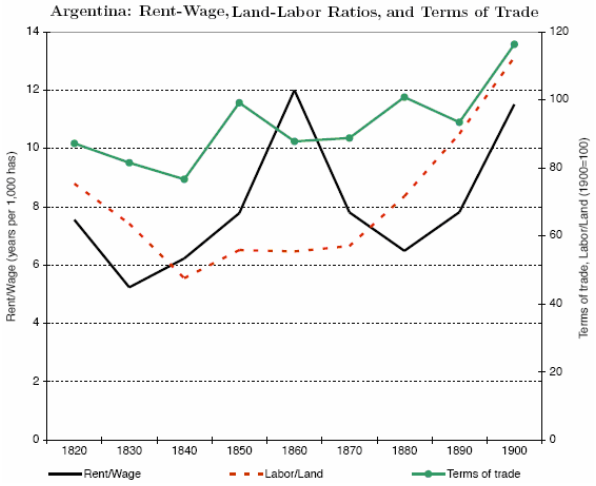
Graphs, maps and tables

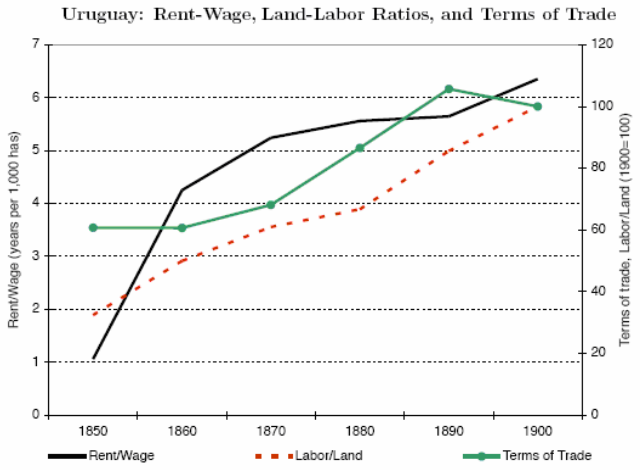
Graph 1
LAND-LABOR RATIO: SETTLER ECONOMIES
Index 1911=100 (1870-1920)



Source: Maddison(2001), Mitchell(1993), Sunkel (1982),Willebald (2009), Williamson (2000, 2002).

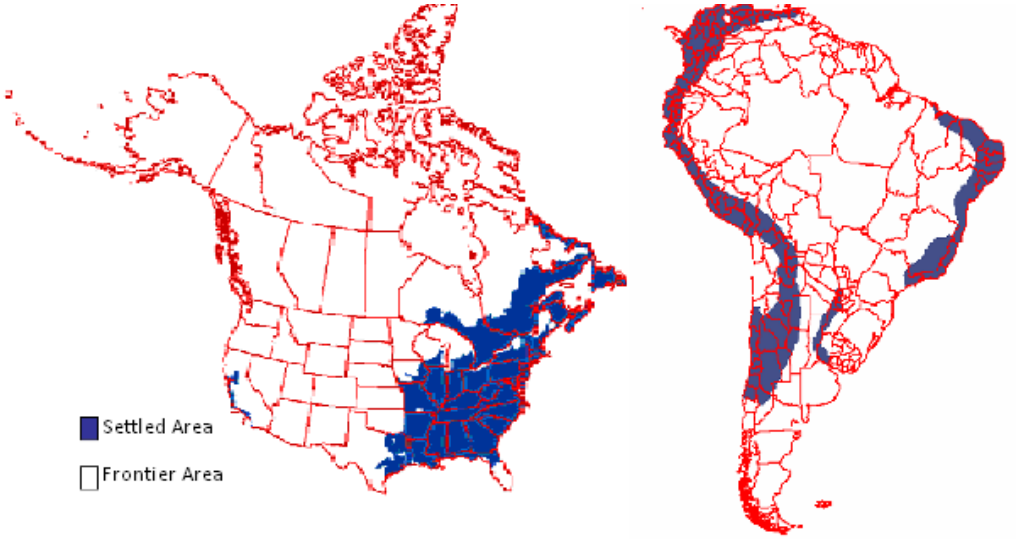
Gráfico 2 (a: Argentina; b: Uruguay)
LABOR/LAND RATIOS: ARGENTINA AND URUGUAY (1820-1900)





Source: Arroyo (2008): v-vi

Figure 1
THE FRONTIER IN NORTH AMERICA AND SOUTH AMERICA CIRCA 1850



Source: García-Jimeno & Robinson (2009): 28-29

Figure 2: POPULATION COUNT

Figure 2a. References

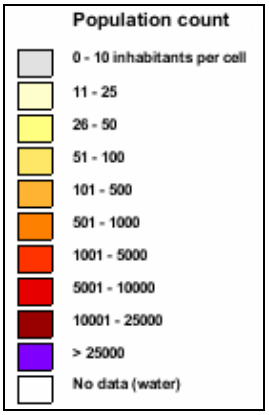


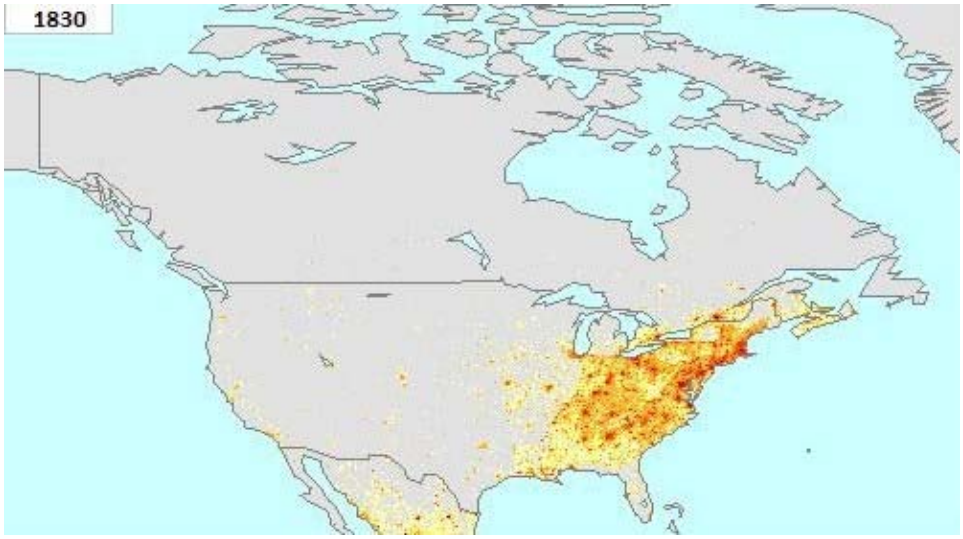
Figure 2b. Oceania: Australia and New Zealand

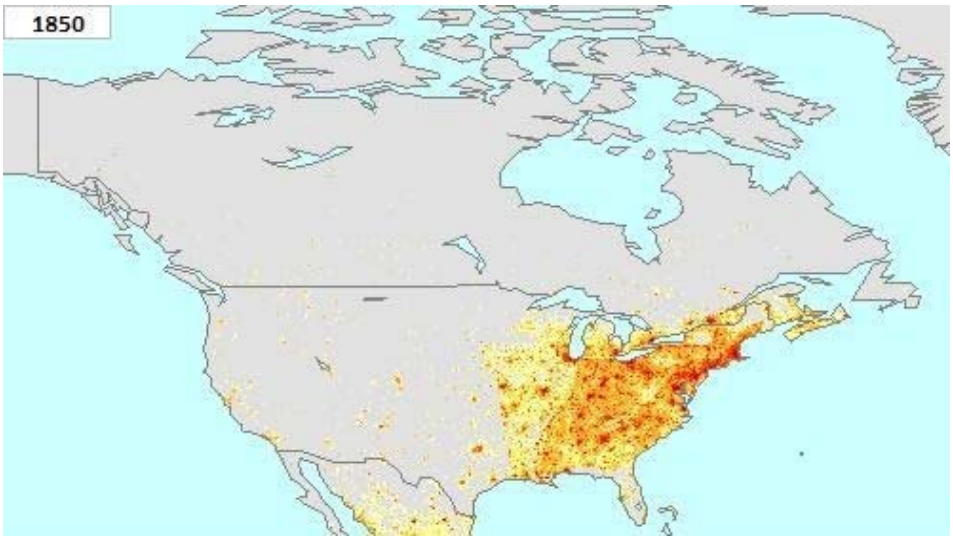

1870

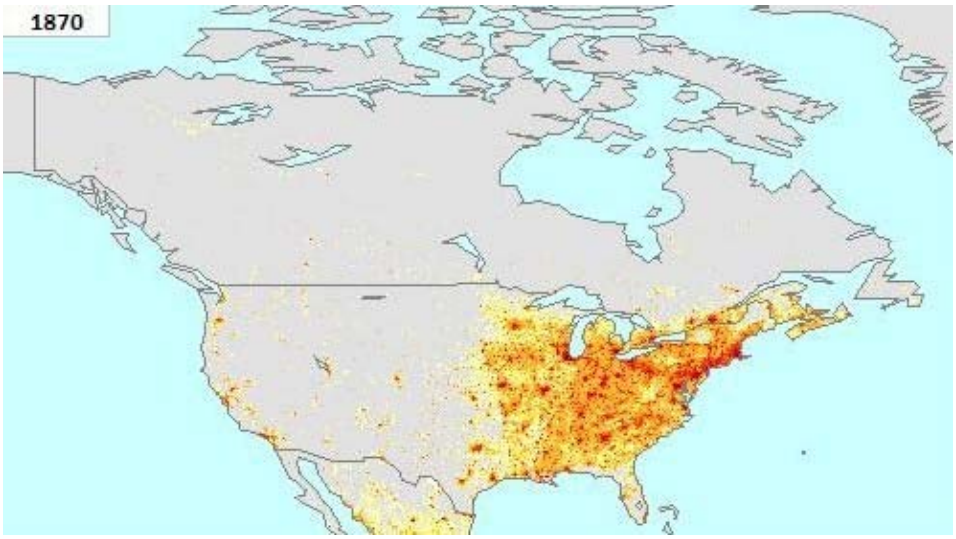

1890

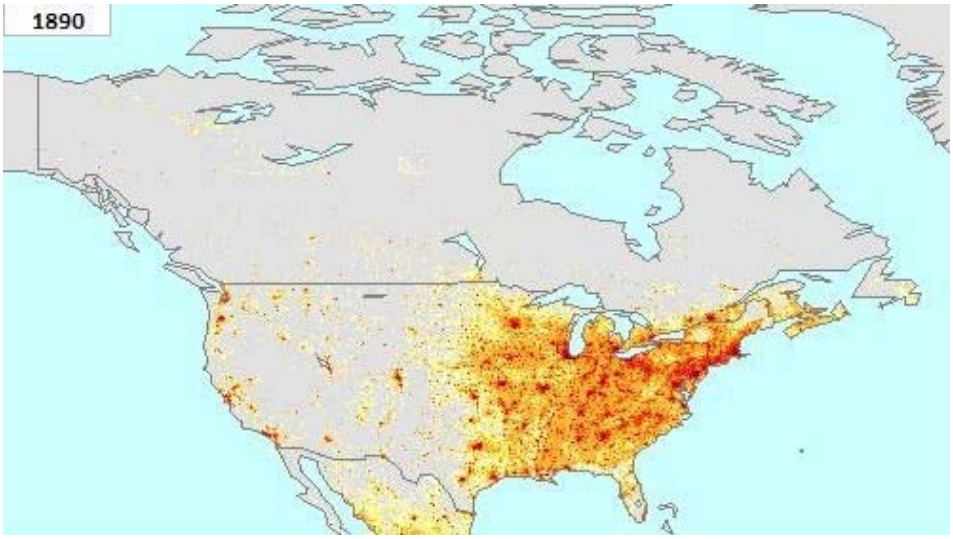

1910

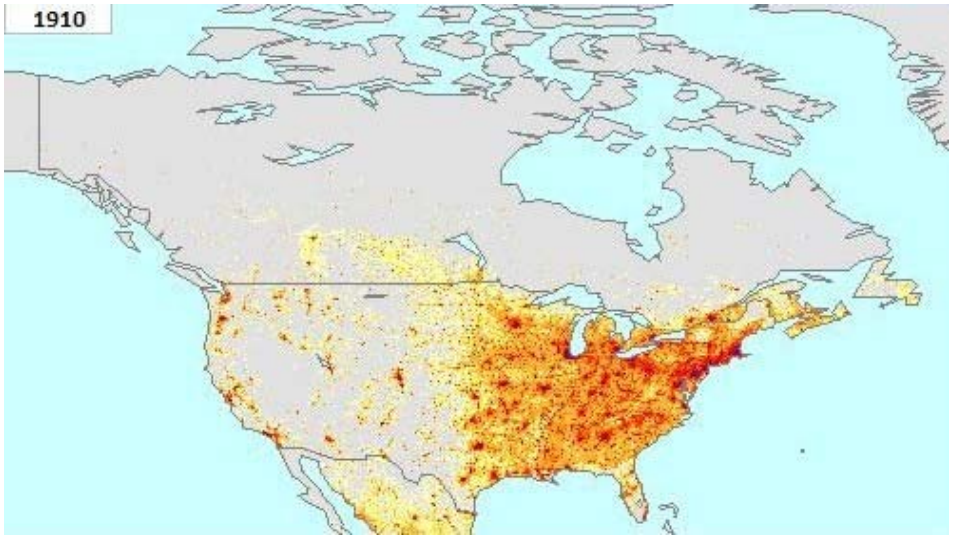
Figure 2c. North America: Canada and US






1870


1890


1910

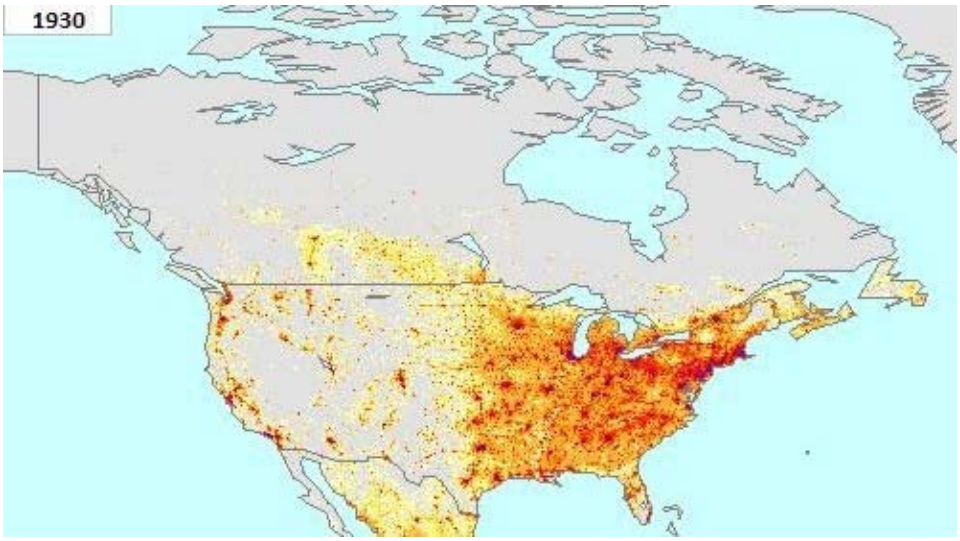


Figure 2d. Southern Cone: Argentina, Chile and Uruguay

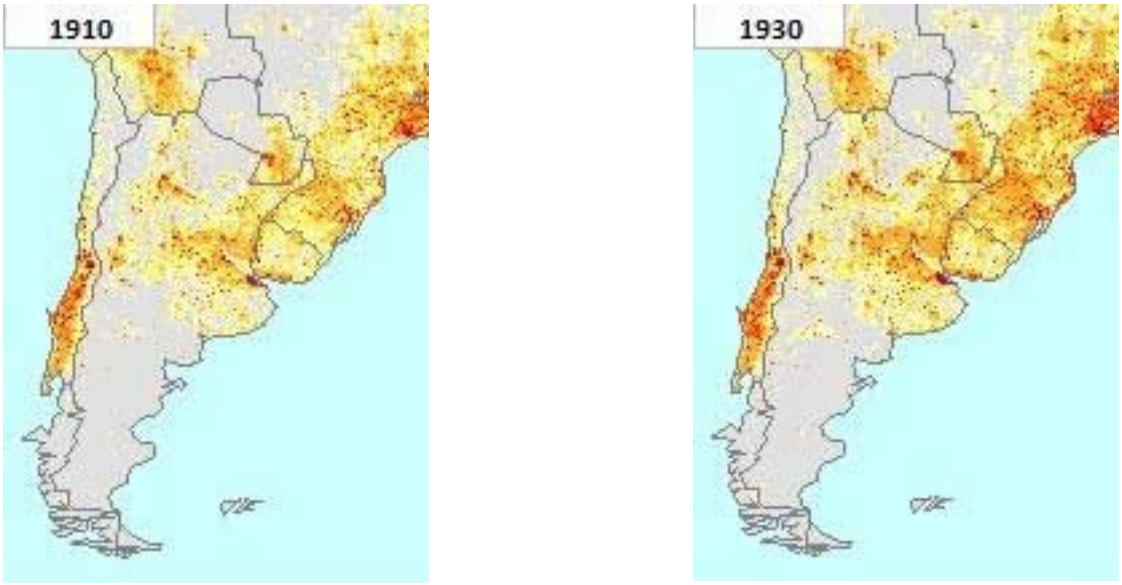


Figure 3
POTENTIAL VEGETATION: BIOME TYPES
Figure 3a. References

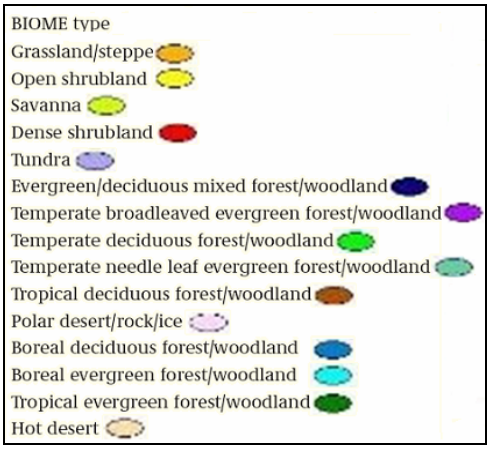


Figure 3b. Oceania: Australia and New Zealand

Figure 3c. North America: Canada and US

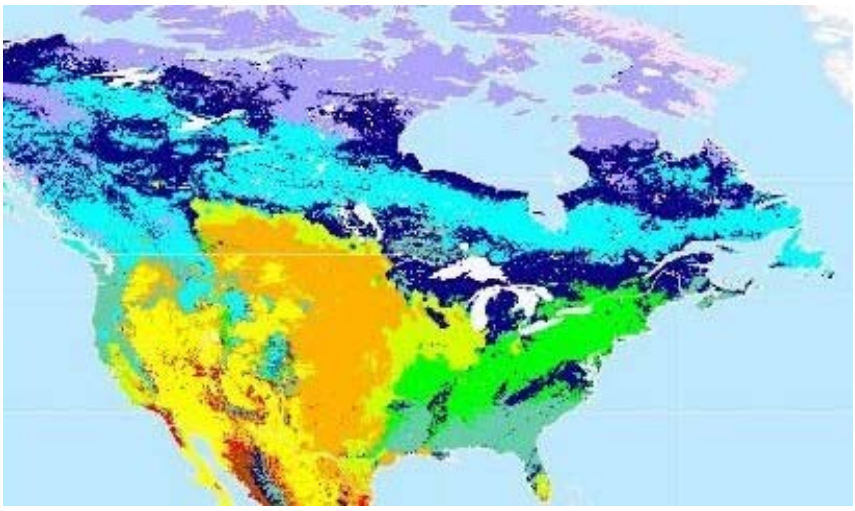
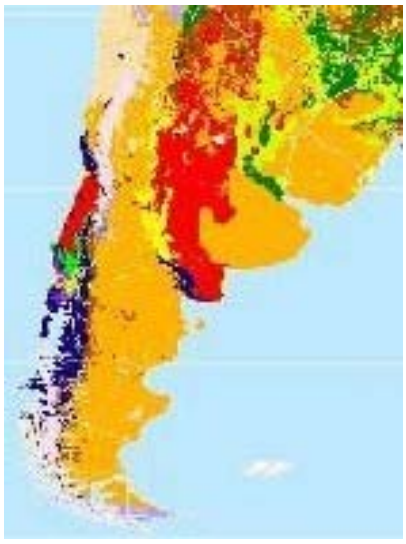


Figure 3d. Southern Cone: Argentina, Chile and Uruguay



Source: Atlas of the Biosphere.

Table 2
BIOME TYPES AND THE ALLOCATION OF GRASSLAND

	Rank
Grassland / steppe	6
Open shrubland	5
Savannah	4
Dense shrubland	3
Tundra	2
Evergreen / deciduous mixed forest / woodland	1
Temperate broadleaved evergreen forest / woodland	1
Temperate deciduous forest / woodland	1
Temperate needle leaf evergreen forest / woodland	1
Tropical deciduous forest / woodland	1
Polar desert / rock / ice	0
Boreal deciduous forest / woodland	0
Boreal evergreen forest / woodland	0
Tropical evergreen forest / woodland	0
Hot desert	0

Source: Klein Goldewijk & Van Drecht (2006):105.

Figure 4
RICARDIAN MODEL AND INTENSITY INDICATORS

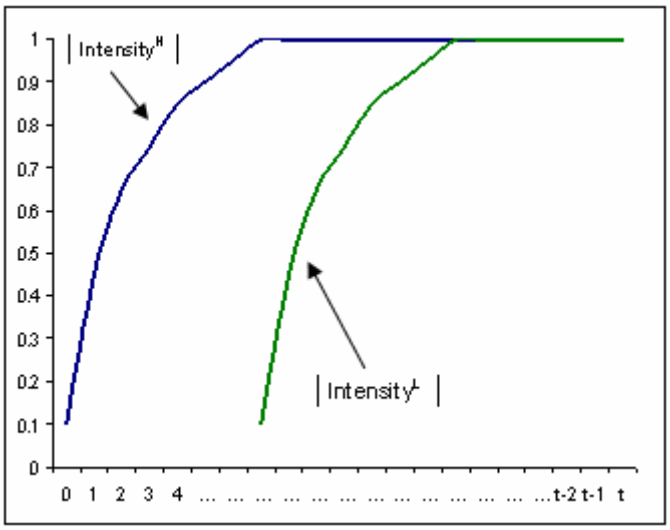


Figure 5: MEASURING DISTANCE

Figure 5.a (1850)

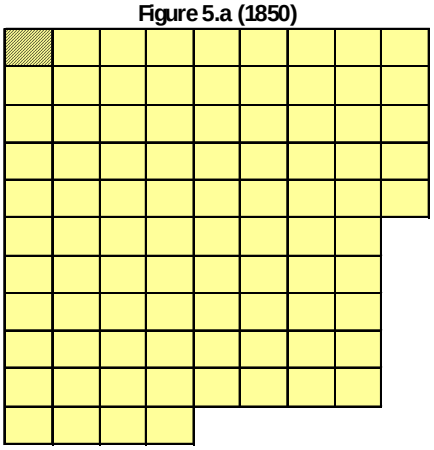


Figure 5.b (1860)

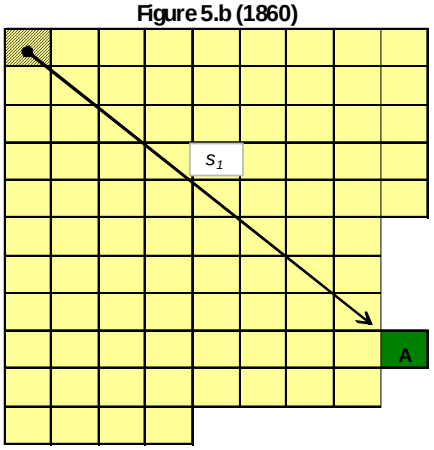


Figure 5.c (1870)

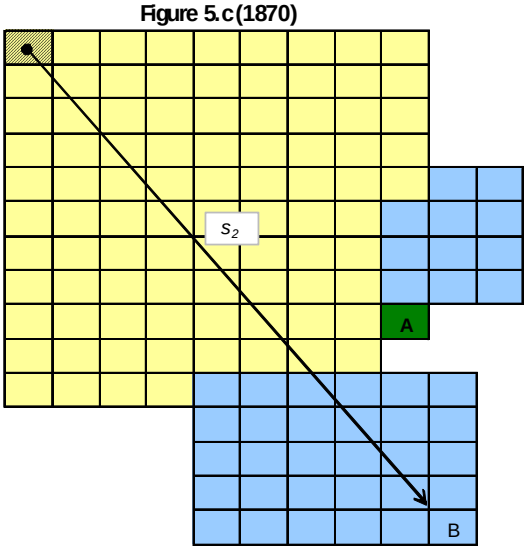


Figure 5.d (1880)

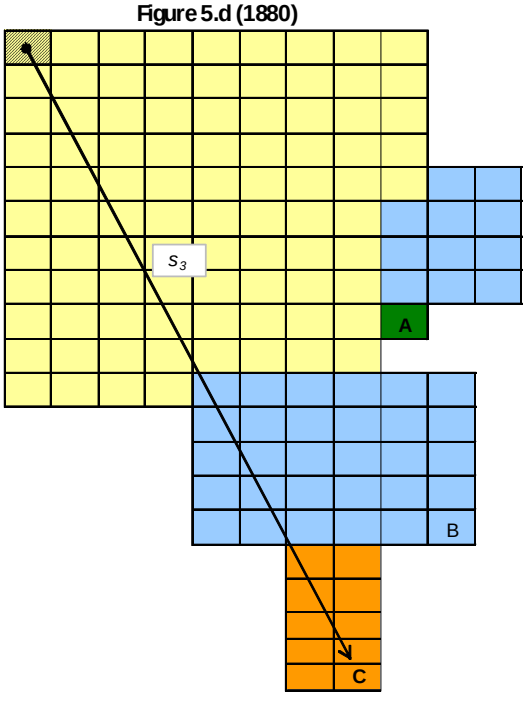
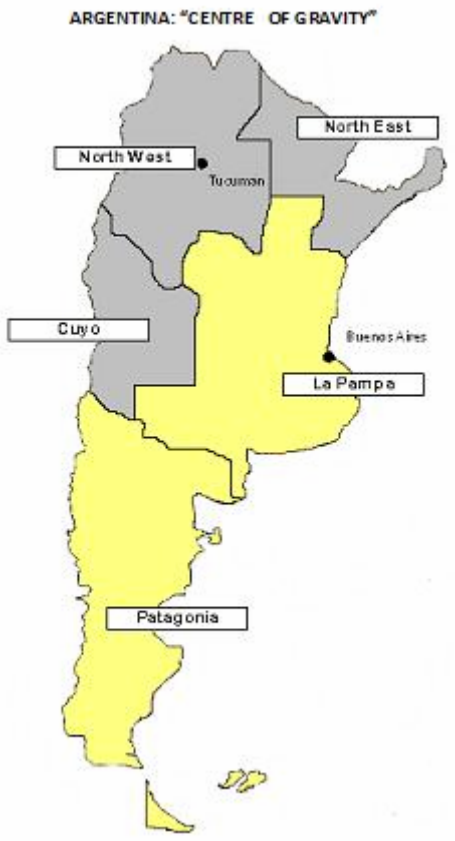
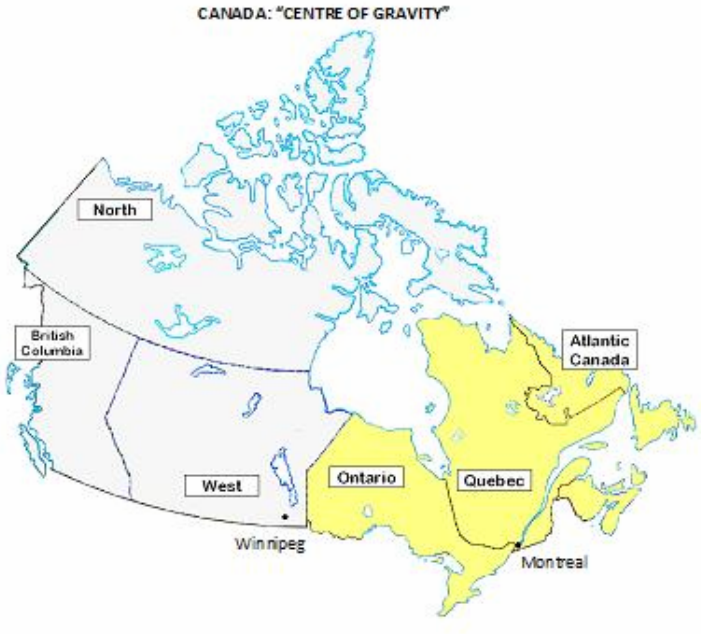


Figure 6: DISTANCE AND CENTRES OF GRAVITY





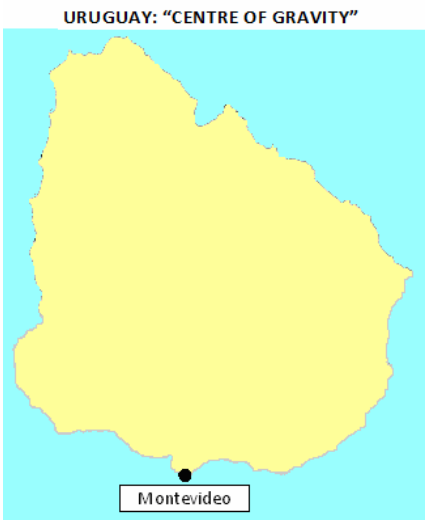
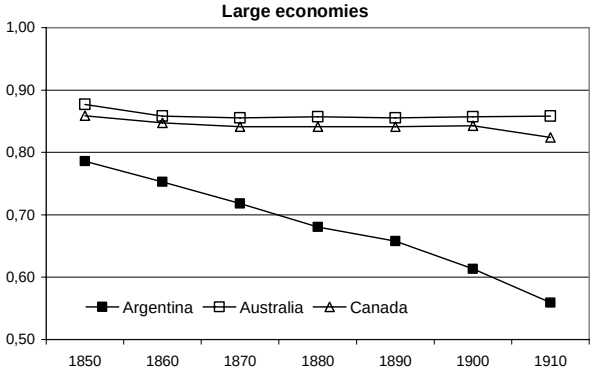


Table 2.2
LAND FRONTIER EXPANSION INDICATORS
According to Actual National Territories

	1850	1860	1870	1880	1890	1900	1910
Argentina	0.79	0.75	0.72	0.68	0.66	0.61	0.56
Australia	0.88	0.86	0.86	0.86	0.86	0.86	0.86
Canada	0.86	0.85	0.84	0.84	0.84	0.84	0.82
Chile	0.53	0.51	0.49	0.48	0.44	0.44	0.44
New Zealand	0.69	0.64	0.50	0.38	0.33	0.30	0.28
Uruguay	0.66	0.48	0.37	0.27	0.16	0.09	0.06

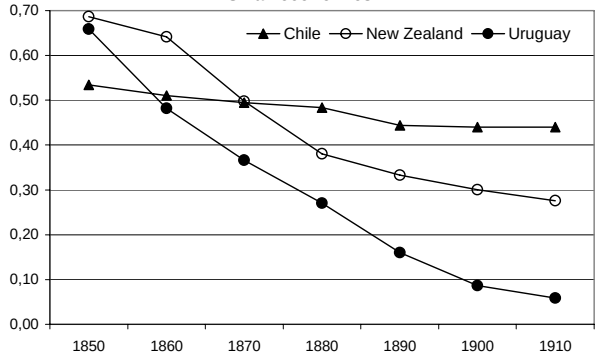
Source: own elaboration from Netherlands Environmental Assessment Agency, HYDE 3.1 and IMAGE Programmes.

Graph 3
LAND FRONTIER EXPANSION INDICATORS:
ACCORDING TO ACTUAL NATIONAL TERRITORIES
Large economies



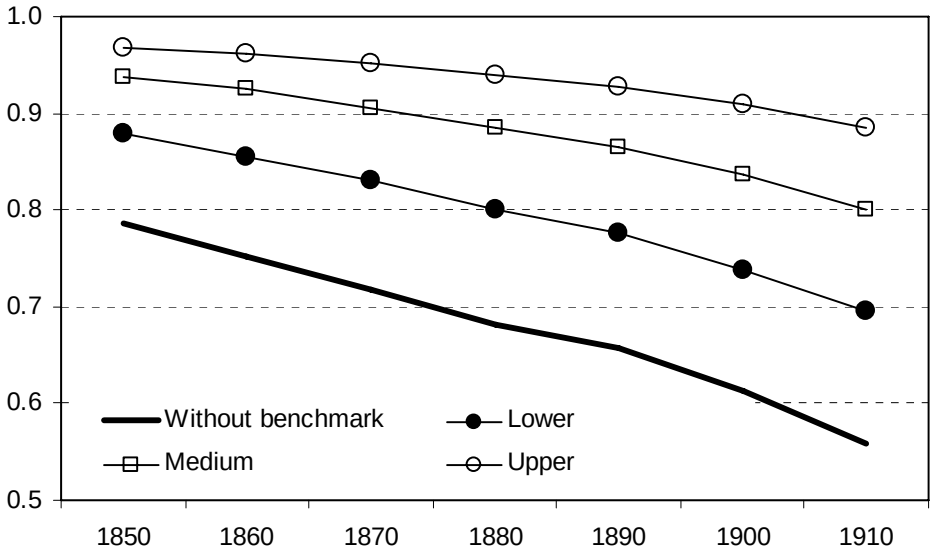
Source: own elaboration from Netherlands Environmental Assessment Agency, HYDE 3.1 and IMAGE Programmes.

Graph 4
LAND FRONTIER EXPANSION INDICATORS:
ACCORDING TO ACTUAL NATIONAL TERRITORIES
Small economies



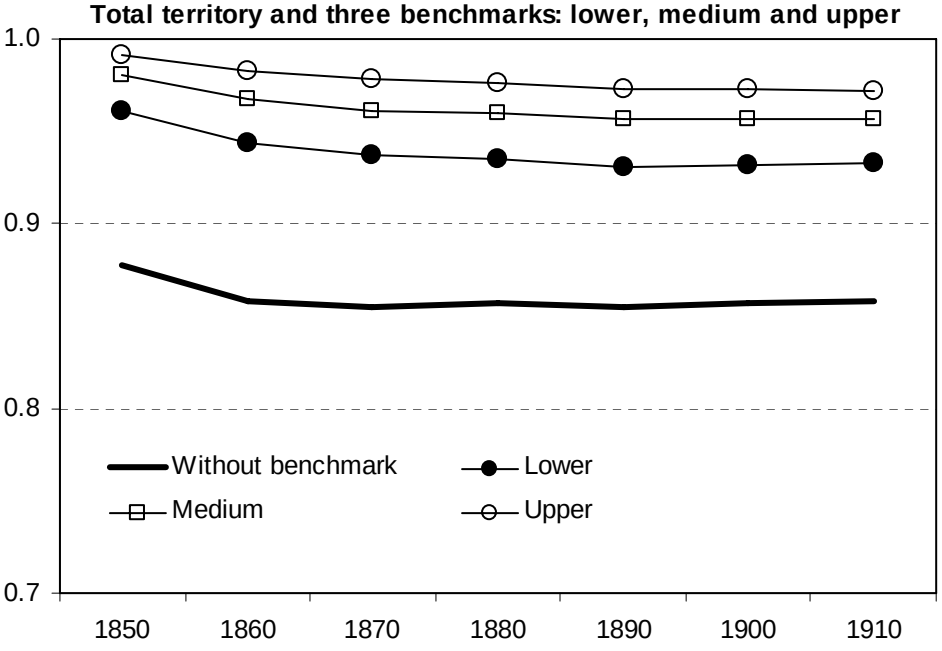
Source: own elaboration from Netherlands Environmental Assessment Agency, HYDE 3.1 and IMAGE Programmes.

Graph 5
ARGENTINA: FRONTIER EXPANSION INDICATORS
Total territory and three benchmarks: lower, medium and upper



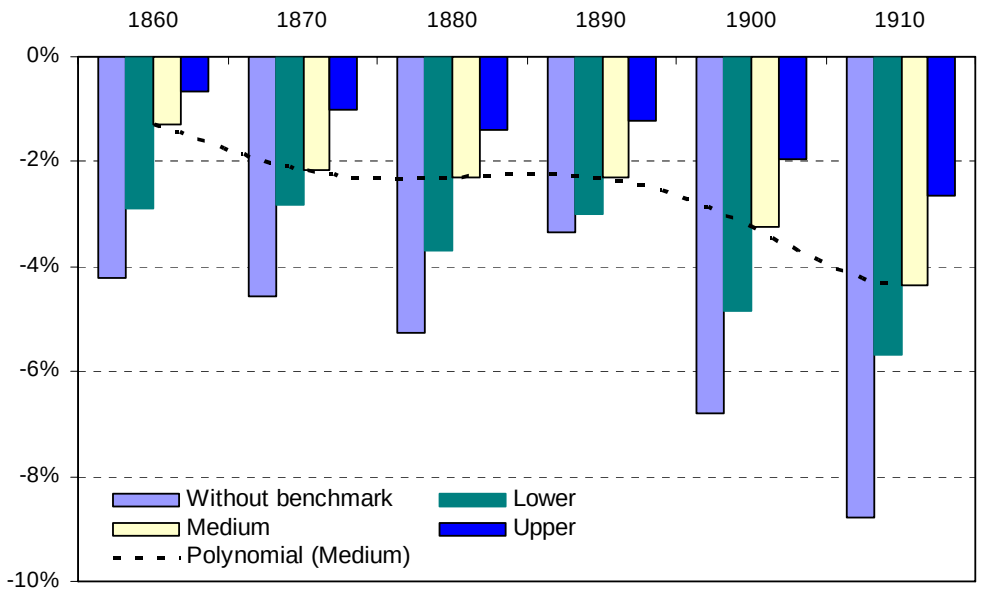
Source: own estimates.

Graph 6
AUSTRALIA: FRONTIER EXPANSION INDICATORS
Total territory and three benchmarks: lower, medium and upper



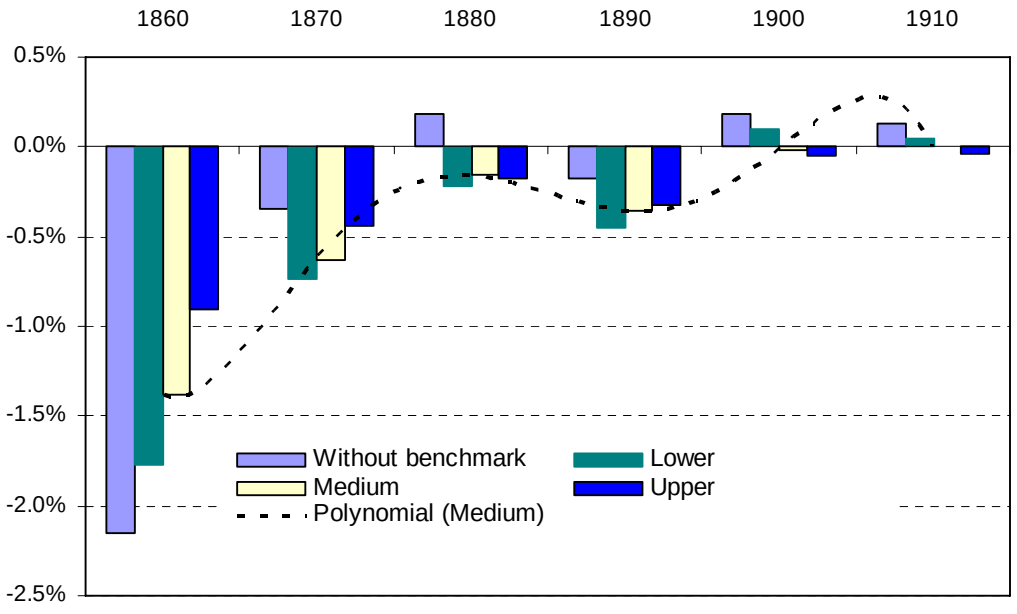
Source: own estimates.

Graph 7
ARGENTINA: VARIATIONS IN FRONTIER EXPANSION INDICATORS
Total territory and three benchmarks: lower, medium and upper



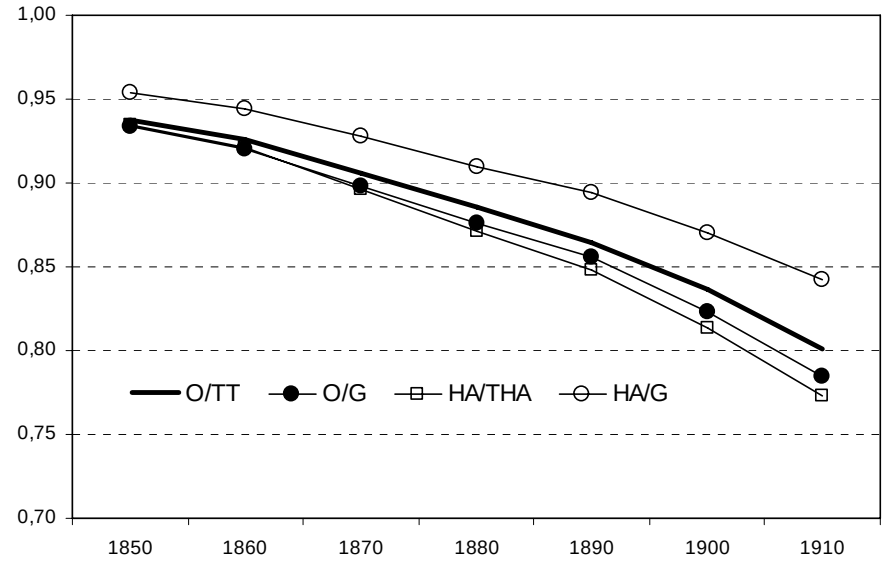
Source: own estimates.

Graph 8
AUSTRALIA: VARIATIONS IN FRONTIER EXPANSION INDICATORS
Total territory and three benchmarks: lower, medium and upper



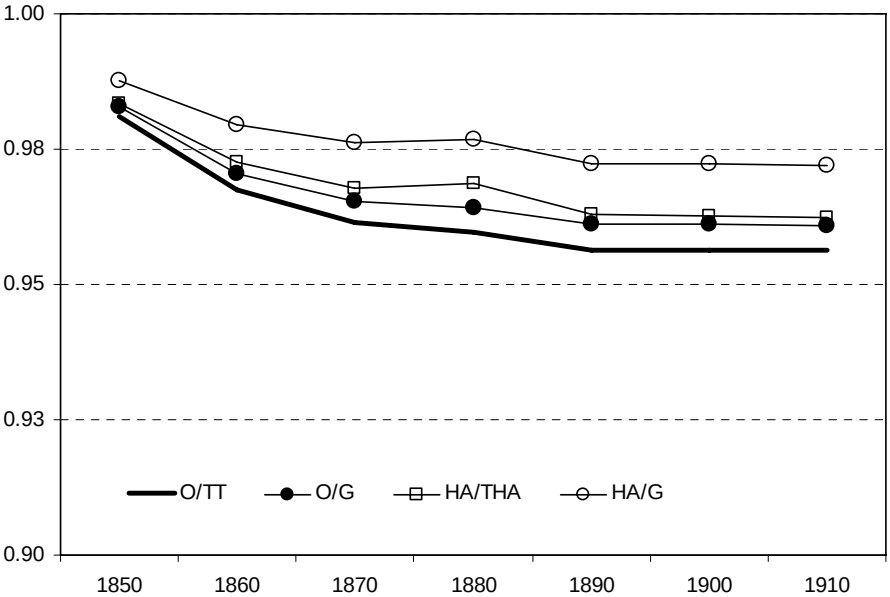
Source: own estimates.

Graph 9
ARGENTINA: FRONTIER EXPANSION INDICATORS
Total territory, Grassland and High Aptitude indicators



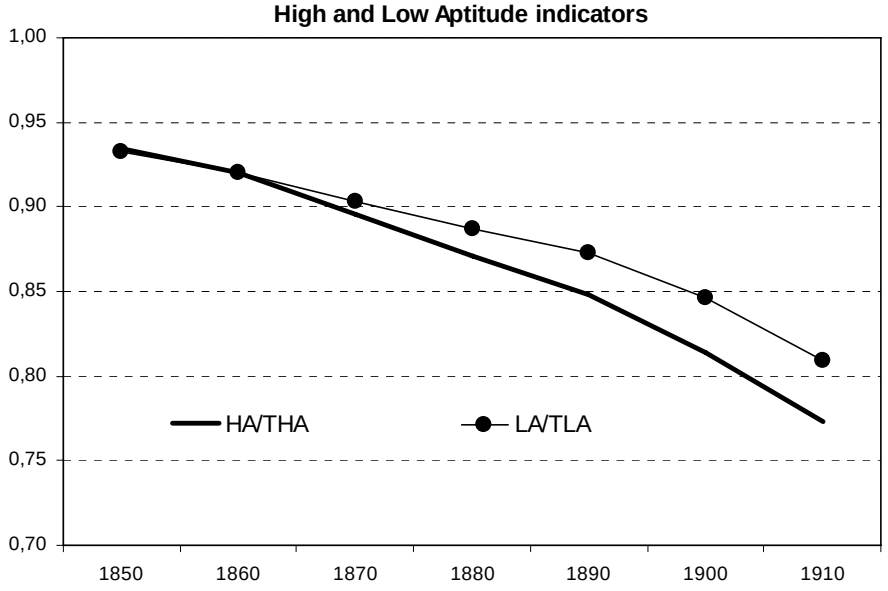
Source: own estimates.

Graph 10
AUSTRALIA: FRONTIER EXPANSION INDICATORS
Total territory, Grassland and High Aptitude indicators



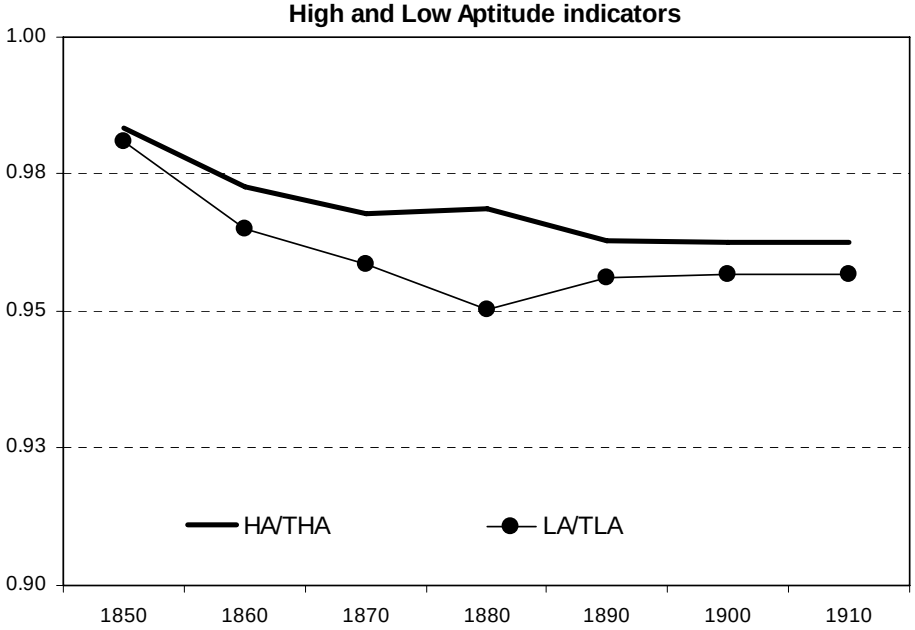
Source: own estimates.

Graph 11
ARGENTINA: FRONTIER EXPANSION INDICATORS
High and Low Aptitude indicators



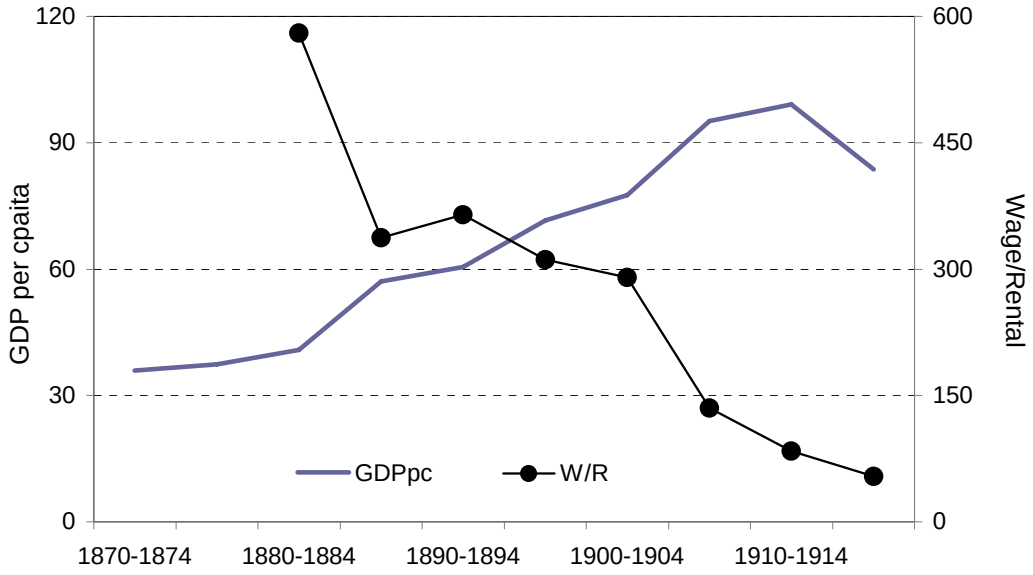
Source: own estimates.

Graph 12
AUSTRALIA: FRONTIER EXPANSION INDICATORS
High and Low Aptitude indicators



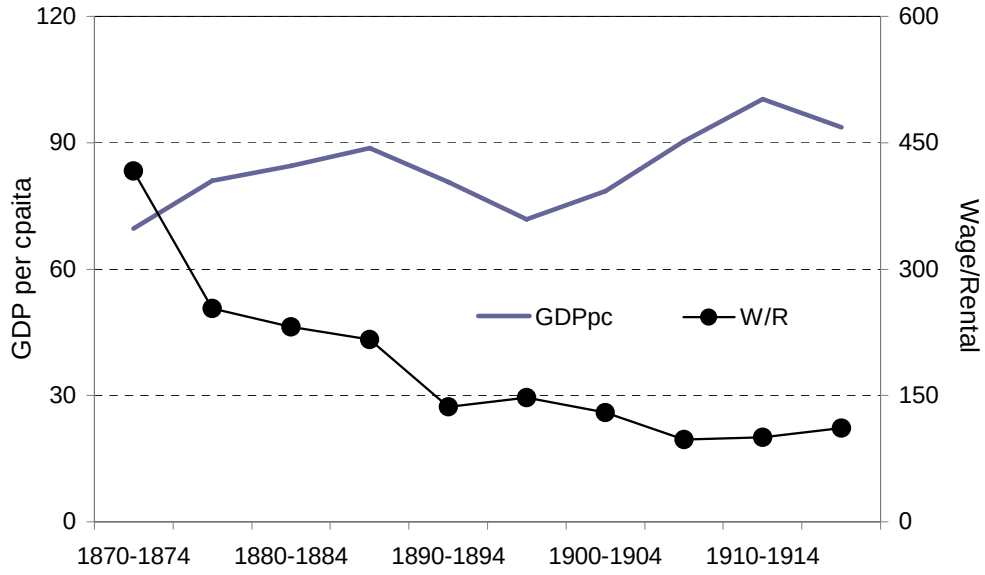
Source: own estimates.

Graph 13
ARGENTINA: GDP PER CAPITA AND WAGE/RENTAL RATIO
Index 1911=100



Source: Maddison (2001); Williamson (2000, 2002).

Graph 14
AUSTRALIA: GDP PER CAPITA AND WAGE/RETAL RATIO
Index 1911=100



Source: Maddison (2001); Williamson (2000, 2002).

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