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DO ENERGY NATURAL ENDOWMENTS MATTER? NEW ZEALAND AND URUGUAY IN A COMPARATIVE APPROACH (1870-1940)

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Do energy natural endowments matter? New Zealand and Uruguay in a comparative approach (1870-1940)

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Abstract

Settler economies are characterized by abundant natural resources, but natural capital is not homogeneous between countries and it can produce different consequences in terms of economic performance. This paper discusses the effect of natural resources on economic performance as part of the debate about the "curse of natural resources hypothesis". We consider energy natural resources and focus on two settler societies, New Zealand and Uruguay. There is very little literature about the economic development of settler economies that identifies differences within the "club" countries that have different natural resources. We look for differences in energy natural endowments, basically coal and suitable conditions for hydroelectric generation, to explain at least partially the different welfare levels between the two economies. In the nineteenth century and the early decades of the twentieth century, New Zealand and Uruguay were similar in many ways such as production structure, movements in production factors and insertion in international markets, but there were huge differences in income per capita levels. To explain this, we need to study other aspects of the economic system. The analytical framework associated with the curse of natural resources offers some interesting lines of argument for our inquiry. The conformation of a "modern" production structure requires there to be sufficient energy supply at competitive costs, to justify exploiting the corresponding natural resources. Our analysis shows that New Zealand's better performance in coal production and better natural conditions to generate electric energy at low cost –thus offering energy at low prices– explain those differences. New Zealand's advantage in energy endowments at least partially explains the development of a dairy sector, certain energy-intensive manufactures and a more efficient use of railways

Keywords: settler economies, curse of the natural resources hypothesis, coal production, hydroelectric generation
JEL Classification Number: N50, N70, Q41

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Introduction

Settler economies are characterized by an abundance of natural resources, but the stock of natural resources is not homogeneous between countries and there can be different outcomes in terms of economic performance. We discuss the effect of natural resources on economic performance as part of the debate about the "curse" (and the "blessing") of abundant natural resources, and we focus on energy resources. There is scant literature about the economic development of settler economies that identifies differences between the countries that integrate this "club" with differences in the natural resource endowments. We shall look for sizeable differences in energy natural endowments (basically coal endowments, and suitable conditions for hydroelectric generation) to at least partially explain differences in the development levels of these economies.

The settler societies of the nineteenth and twentieth centuries seem to share common features that make them comparable. The settler "club" comprises what Lewis (1983, p. 209) calls *"template economies"* and Foreman-Peck (1995, p.105) identifies as *"the group of non-European countries which in the twentieth century can be classified as developed"*.[1] As regards economic and social development, these countries followed parallel paths as a result of similar dynamic relations between waves of immigration, the marginalization of native people, European capital imports, land abundance, free labour (at least after the mid-nineteenth century), socially-useful political institutions[2] and the development of neo-European cultures (Lloyd & Metzer, 2013). By the late nineteenth century the settler economies were well integrated into the world economy and this "success" was achieved regardless of a country's size. We will focus on the small economies in the "club", New Zealand and Uruguay, which were similar in many ways including production structure, movements in production factors and insertion in international markets, but markedly different in income per capita and production diversification even in the First Globalization, which was the golden age of

[1] The author includes Argentina, Australia, Canada, Chile, New Zealand, South Africa, the US and Uruguay. When the author stays "*twentieth century",* he refers to the period from 1900 to the First World War.

[2] Institutions designed to develop the economy rather than extract rents for some domestic or foreign elite.

the settler economies. This means we need to study other spheres of their economic systems to find new explanations for these differences.

There is a long tradition of comparative analysis of New Zealand and Uruguay. In the 1970s and 1980s there was a considerable wave of studies about the comparative evolution of these countries: Barrán & Nahum (1978); Denoon (1983); Kirby (1975) and Rama (1979). However, interest in comparative approaches faded in the 1990s, when economic recommendations were more general and focused on trade liberalization and monetary policies. Comparative studies revived at the start of the 21st century. The resurgence of this subject probably stemmed from a combination of a broader debate in economics –that actively incorporated concepts like institutional and technological change– and increasing discussion of the contrasting Australasia and River Plate development models. This new interest in the comparative economic history of these two regions can be seen from articles such as Álvarez (2007 a, b); Álvarez & Bortagaray (2007); Álvarez et. al (2011); Bértola & Porcile (2002, 2007); Carbajal & De Mello (2007); Greasley, Madsen & Oxley (2000); Duque & Román (2007); Willebald (2007, 2011).

The "golden age" of the settler societies coincided with the First Globalization (1870-1914), a process characterized by the integration of world markets for goods and production factors, convergence, free trade and peace. In the twentieth century the main challenge for these economies was how to deal with the transition from a settler society to some form of post-settler configuration. This process followed different trajectories in different countries with varying degrees of success. As usual in the literature, our empirical evidence is from the period 1870-1940 so it covers a complete economic cycle from the expansion that started in the 1870s-1880s and the prosperity that went with boom prices prior to First World War, to the moderate outcomes of the 1920s and the subsequent contraction and recession of the 1930s.

After this introduction we outline some of the main stylized facts of the period (Section 1) and consider, from a comparative perspective, economic growth, convergence –relative to the "core" of the world economy and also within the "club" of small settler economies– and structural change, in terms of domestic economies and trade structure. In Section 2 we review the debate about the varying economic performance of the countries in the “club” so as to differentiate particular conditions for economic development. This evidence enables us to suggest possible explanations for the countries’ unequal performance. In Section 3 we present our analytical framework and a strategy to test our hypothesis, and we answer our main question: were energy natural resources different in New Zealand and Uruguay? In Section 4 we make a descriptive and comparative analysis of the “natural endowments” for energy production. In Section 5 we consider the prevailing technological and market conditions so as to put forward some possible explanations. In Section 6 we examine the development of the dairy sector, certain energy-intensive manufactures and the use of railways, as an expression of differences in energy use intensity in the two countries. In Section 7 we make some concluding remarks and present our agenda for future research.

Our analysis shows that the differences between the two countries in terms of welfare and production structure are due to New Zealand’s advantages in coal production and the natural conditions to generate electricity at low cost. New Zealand's advantage in energy endowments explains –at least partially– the development of a dairy sector, certain energy intensive manufactures and a more efficient use of railways. Our findings support the hypotheses that Australasia’s sizeable mining sector is an important factor in explaining why it developed more strongly than the River Plate (Álvarez et al., 2007), that we should consider different qualities of natural resources (Willebald, 2011), and that it is important to consider geographical and climatic conditions in explanations of Uruguay’s energy dependence (Bertoni, 2011).

1. Some stylized facts

The period 1870-1914 was a real “golden age” for the settler economies. At the root of their expansion was the Industrial Revolution, a process based on tremendous technological advances that changed social and economic relationships all over the world. One of the most important processes in the world economy in the last two centuries was that markets for commodities and factors became integrated on a world scale during the first great globalization boom. In the nineteenth century the liberal dismantling of mercantilism together with the transport revolution generated global markets. The cost of transport fell steadily throughout the century. In the 1870s there was a reaction and anti-globalization policies were implemented, but this reversal was not strong enough to cause a return to the 1820 levels of economic isolation. Mass migration was still free at the end of the century (although immigrant subsidies had ceased) and global capital markets became steadily more integrated as European investors gained faith in good prospects for growth overseas.

Recent studies of globalization, growth and inequality have generated a rich line of research and debate about a subject that is vitally important for understanding the expansion of the Atlantic economy (Lindert & Williamson, 2001; O'Rourke, Taylor & Williamson, 1996; O'Rourke & Williamson, 1994, 1999; Taylor & Williamson, 1997; Williamson, 1995, 1996, 1999, 2002).

In this conceptualization, when the thinly-populated template regions were exposed to the effects of the First Globalization they took advantage of their abundant natural resource endowments and received the "blessing" of their natural capital. These economies grew quickly from the closing decades of the nineteenth century until First World War, encouraged by dynamic international demand and inflows of production factors (labour and capital). However, "the blessing was diabolical"[3] because it was associated with a persistent worsening in income distribution (see Willebald, 2011). Economic growth and inequality were channelled through the combination of technological and institutional factors that delineate several differences within the "club".

It is true that our countries had similar development patterns but when we focus on specific features important differences emerge. Willebald & Bértola (2011) and Willebald (2011) report that while the intensity of the First Globalization and its consequences for the settler economies followed a broad common pattern, the countries reacted in different ways and this probably determined their economic performance in subsequent decades. These economies based their production on primary activities but in spite of this, at around the time of First World War, they achieved levels of development close to the "core". However, income per capita was

[3] Here we are paraphrasing Barran and Nahum (1978), p.189.

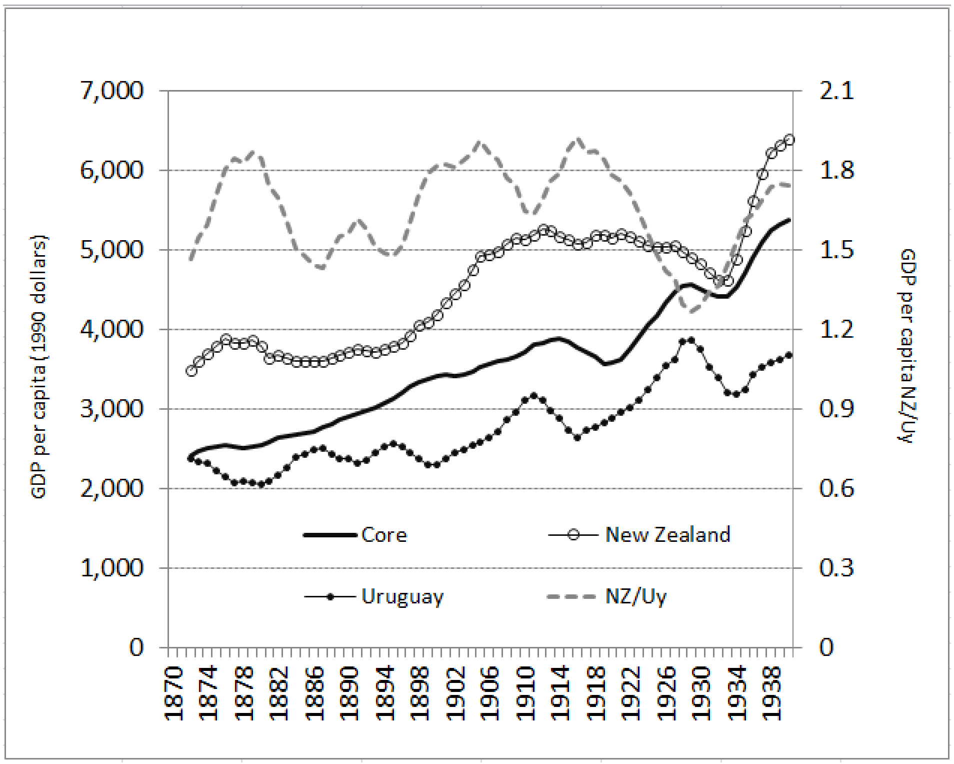
higher and inequality was worsening less in the former British possessions (Australia, New Zealand, Canada) than in the South American Southern Cone (Argentina, Chile and Uruguay), and in the former group economic specialization was relatively less concentrated on primary activities. In terms of the curse/blessing of natural resources, the former British colonies were more blessed and less damned by their abundance of resources than the other former colonies.

We consider this assertion and examine the economic performance of New Zealand and Uruguay. Effectively, both economies ended the nineteenth century with income levels very close to the "core" of the world economy (considering the average of UK, France and German GDP per capita) but the gap was very illustrative of the difference. Both economies were rich in relative terms but the differences in favour of New Zealand were huge (Figure 1).

Figure 1

GDP per capita in New Zealand and Uruguay

Geary-Khamis (1990 dollars) and ratio between New Zealand and Uruguay data



Source: Bolt & van Zanden (2013).

Both economies expanded strongly in the period but there was no catching-up process in the "club". From 1870 to 1939, Uruguay's average income per capita was 60 per cent of New Zealand's but the trajectory was irregular and there was no clear trend (Figure 1, right hand axis)

In fact, irregularity was one of the main features of Uruguay's long term economic evolution (Bértola & Lorenzo, 2004). Figure 2.1 shows deviations from the trend line of GDP per capital levels (expressed in log) for the two economies, and the differences in terms of variability are clear. Uruguay's GDP deviated 9.8 per cent from the long-run trend (1870-1940) and New Zealand's 6.9 per cent, so the volatility of income per capita in Uruguay was 1.4 times higher than in New Zealand. Considering evolution over time, we calculate the ratio of deviations in a 9-year moving average of Uruguay compared to New Zealand (Figure 2.2). The coefficient is systematically over one and has very high peaks at the end of the 1890s and on the eve of the First World War, two periods characterized by strong dynamism in the River Plate.

Figure 2

GDP Volatility in New Zealand and Uruguay

Deviations from the trend and 9-years moving average

Figure 2.1. Deviations from the trend

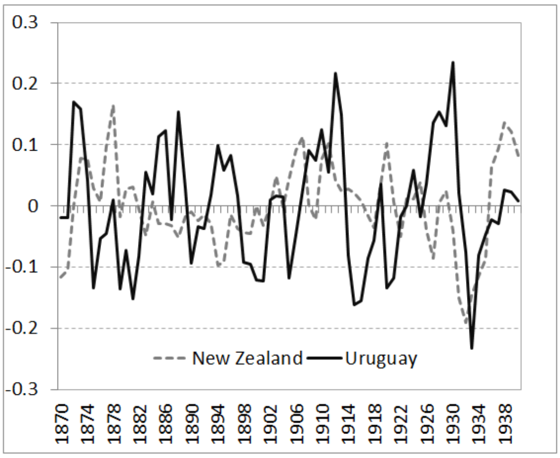
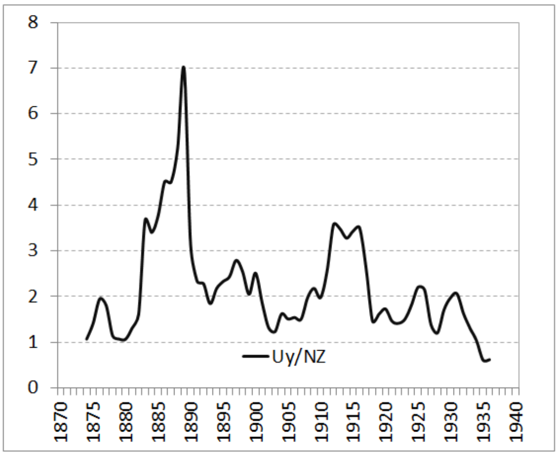


Figure 2.2. 9-years moving average



Source: Bolt & van Zanden (2013).

As regards production structure, both economies had a high and decreasing share of agriculture value-added during the early decades of the twentieth century, with similar levels and dynamics. However, the main differences can be found in other activities, in particular the fact that manufacturing participated only marginally in

Uruguay's production structure whereas it was an important activity in New Zealand after First World War (Figure 3).[4]

These features in production structure developed parallel to export structure. In New Zealand the share of exported commodities other than pastoral and agriculture goods increased continuously after 1870, whereas Uruguay remained dependent on primary products (Figures 4). In Uruguay, the trend in manufactured goods began to increase just after the First World War, coinciding with the definitive installation of meat packing industries, which was several decades after New Zealand.

Figure 3

GDP structure in New Zealand and Uruguay

Shares (%) of total GDP by economic activity

Figure 3.1. New Zealand

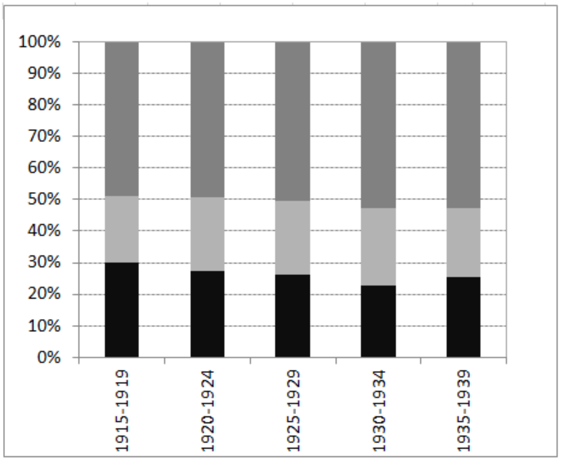
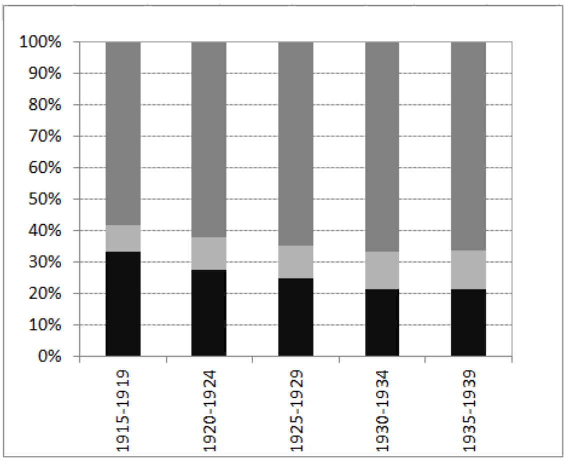


Figure 3.2. Uruguay



Source: Bertino & Tajam (1999), Bértola (1998), Bonino et al. (2012), Linehman (1968).

The two countries had a similar development pattern but New Zealand had a richer, more stable and more diversified economy that was probably better suited to adapt to the structural changes stemming from changes in the techno-economic paradigm of the 1920s.

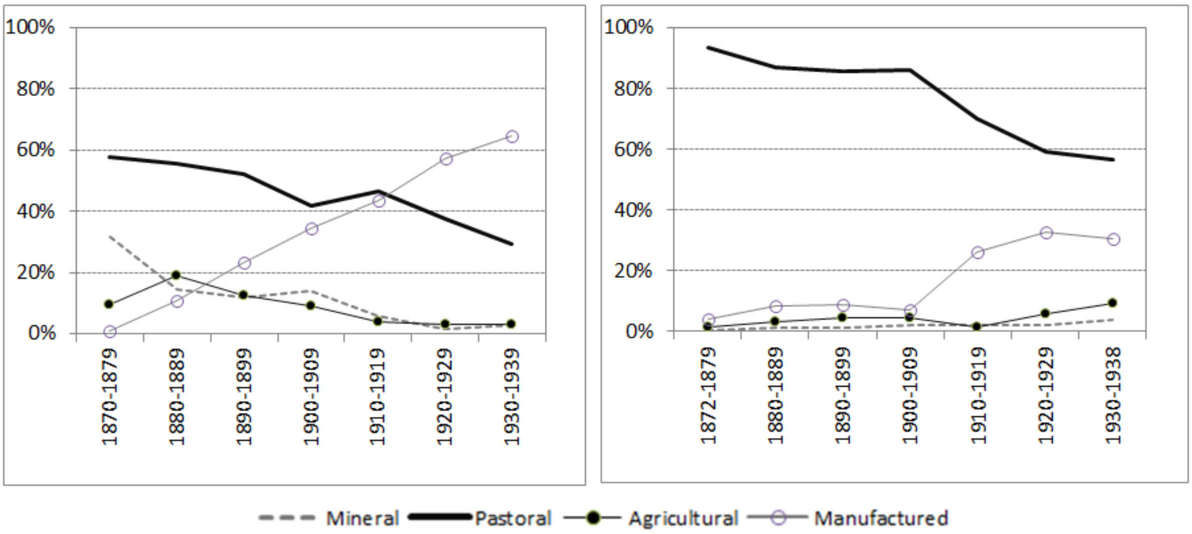
[4] Strictly, our category "Other" corresponds to the rest of the sectors, and by construction it can include not only services but a set of varied activities.

Figure 4

Export structure of New Zealand and Uruguay

Shares (%) of total exports by group of commodities

Figure 4.1. New Zealand **Figure 4.2. Uruguay**



Source: Bloomfield (1984), Bonino et al. (2013).

2. Debate about varying economic performance in the "club"

In the recent literature, differences in development within the "club" have been attributed to a range of causes including the institutional matrix that produces a set of organizations, rights and privileges; the stability of the structure of exchange relationships in political and economic markets; and to a State that provides (or does not provide) a set of political rules and promotes the enforcement of rights. In general, studies contrast the Latin American experience with that of North America and propose concepts such as disorder vs. order in economic change (North et al., 2000), the "South American way" (Landes, 1998, p. Ch. 20), cultural heritage (North, 2003), and different ways of organizing a society (a social order) identified with a "limited access order" (North et al., 2007). The application of these concepts to contrasting the South American Southern Cone countries with the former English colonies is straightforward. As regards Uruguay and New Zealand, some academics demonstrate that their divergent paths *"can be explained by the existence of different institutions governing the agricultural sectors of the* [two] *countries, which in turn generated* *different distributions of both land property rights and product shares in the agricultural sector"* (Álvarez et al., 2011, p. 165) (also see Álvarez & Willebald, 2011). However, up to now little attention has been paid to differences in natural resource endowments. In some way this is the "natural" result of comparing economies that exactly define a "club" because they share the common feature of having abundant natural resources. Nevertheless, some exceptions can be mentioned.

First, Álvarez, et al. (2007), p. 12, state that *"Australia, and to a lesser degree New Zealand, had a significant mining sector, and this meant more diversified exports and also a supply of raw materials and energy for the country's own industry. Mining explains why GDP per capita in Australia was initially so much higher than in Argentina (around 1880)"* (own translation). Second, Willebald (2011) focuses on the different types of land to explain differential performances within the settler "club". An economy that expanded its frontier onto the best land "received" the blessing of abundant natural resources in terms of growth, but faced the curse of a more severe worsening of income distribution in the agriculture sector (Willebald, 2013). In technical terms, land quality determines the appropriability conditions of the natural resources, and the quality of institutions (in terms of their capacity to moderate concentrated rent appropriation) conditioned long-run performance over the period.[5] Our aim is to contribute to this line of research by finding new elements in the comparative analysis of the "club", and energy resources seem to be a good candidate.

Bertoni (2011, p. 18) states that *"Uruguay is a small country [and] it does not have very steep slopes suitable to create waterfalls that could be used to generate energy. However, agents chose this kind of power generation so the necessary waterfalls had to be created artificially. In addition, the territory has an extensive hydrographic system but the hydraulicity is random because the water flow is the consequence of an extremely irregular rainfall regime… The inexistence of fossil fuels completes a complex picture as regards natural resources related to energy supply"* (own translation). Was Uruguay damned by its lack of energy natural resources? Can this shortage help to explain, at least partially, its poor economic performance compared to New Zealand?

[5] Denoon (1983), Dieguez (1969), Duncan & Fogarty (1984) and Platt & Di Tella (1985) suggest similar elements in their analyses of comparative development for some members of the club, but do not stress the point.

3. Framework and analytical strategy

After outstanding articles by Sachs & Warner (1995, 2001), there has been a profusion of studies dealing with the –sometimes paradoxical– inverse relationship between natural resource abundance and economic growth, and the scope of research has spread to other expressions of development like inequality, specialization and well-being. However, the debate is still open.

Van der Ploeg (2011) presents a review of the recent debate and identifies eight arguments that support the hypothesis that natural resources are a curse. First, an abundance of natural resources leads to real appreciation of the country's currency, the decline of tradable sectors, the expansion of non-tradable activities (deindustrialization) and production contracts after the initial boom (*the Dutch disease*). Second, if manufacturing rather than agriculture or primary activities is the economic sector that generates processes of learning by doing and the spillover of human capital, the sudden windfalls derived from natural resources put pressure on the "primarization" of the economy and can hinder economic growth. Third, the "curse" is conditional upon the existence of weak institutional arrangements in terms of the definition of property rights, contract enforcement, the rule of law and the perpetuation of a reduced elite in government, and these complicate economic development. Fourth, the empirically observed resource curse seems to be mostly driven by presidential and non-democratic regimes because these systems are less accountable and less representative and thus offer more scope for resource rent extraction. Fifth, resource dependence usually fuels corruption and rent seeking via protection measures and exclusive licenses so political elites, oligarchs and their cronies can exploit and export resources and capture wealth and political power. It also crowds out social capital, erodes the legal system and can lead to armed conflict or civil war. Sixth, the fact that commodity prices are highly volatile can lead to sudden booms and busts that harm investment, exports and output. Seventh, the political economy of massive resource rents combined with badly-defined property rights, imperfect markets and poorly functioning legal systems, provide ideal opportunities for producers to engage in rent seeking, and thus divert resources away from more productive activities. Eighth, in general, a sudden resource bonanza tends to erode politicians' critical faculties and induces a false sense of security.

In spite of these considerations, Van der Ploeg himself argues about the conditionality of these relationships and says it is important not to see the "curse" as something inevitable. Experiences are varied and the examples of Botswana, the Scandinavian countries and South East Asian countries are evidence that the (supposed) curse can be transformed into a blessing. From the economic history perspective these concerns are important because the historical specificity of the curse –and the blessing– seems evident. Depending on the historical stage in question and the prevailing institutional and technical conditions, the types and quality of natural resource endowments probably had different effects on the economic development of countries and regions (Willebald, et al. 2015).

One approach to the historical specificity of the role that abundant natural resources play in economic development is to adopt concepts from the Neo-Schumpeterian and Evolutionist Schools (associated with the second argument previously mentioned). Perez (2002, 2009) identifies five technological revolutions and techno-economic paradigms in the world in the last 250 years. These are the great British leap (the "Industrial Revolution" from the 1770s onwards), the Victorian Boom (the age of steam and railways, from the 1830s onwards), the Belle Époque (the age of the steel, electricity and heavy engineering, from the 1870s onwards), the Age of Oil, Automobiles and Mass Production (from the end of First World War to the 1970s), and the current Information Technology Revolution. There is a period when the new paradigm for innovation and growth is widely applied across the whole economy and the consequent social benefits are much more widely spread, so that the income polarisation of the "installation period" is at least partially reversed. Investment is led by production capital, a process usually favoured by government policies and supported by a more regulated financial system. This period ends when the technological revolution and its paradigm mature, their potential for further innovation or increased productivity becomes exhausted, and markets are saturated. This scenario prompts financial capital to seek other outlets, including loans to faraway countries and the funding of new and possibly revolutionary technologies.

However, when revolutionary new technologies appear there is no automatic guarantee that they will spread from sector to sector on a world scale. In the early stage, diffusion requires a simple propagation vehicle that is accessible to millions of individual decision agents and coherent with their decision-making criteria. That vehicle is long-term cost effectiveness. Although many of the products of each technological revolution can be prohibitively expensive at first, at the core of each of these great waves of innovation there is a key input, which is very cheap and promises to remain cheap, and in conjunction with a constellation of generic innovations radically transforms the relative cost structure confronting entrepreneurs, managers and engineers. Steam applied to transport, and electricity, were two of the main key inputs of the techno-economic paradigm that dominated the evolution of the word economy in the second half of the nineteenth century and the First Globalization. Therefore research into the relationships between abundant natural capital and the types of natural resources that an economy possesses can show the extent to which economies are "prepared" for a new techno-economic paradigm.

According to Smil (1994, p. 157), access to fossil fuels and electricity led to enormous advances in agriculture and fast growth in industrializing economies. But even if the production specialization has been based on agriculture, this approach is applicable. As Smil (1994 p. 189) notes, *"fossil fuel and electricity are essential inputs in modern farming"*. In addition, we should consider the indirect energy costs of modern industrial food processing such as the costs of packaging, refrigeration, etc. (Smil, 2010, p.11). Certain economic activities need fossil fuels and/or electric power to develop all their potentialities and then technological change can lead to energy constraint**.** Therefore coal, oil or hydro energy abundance could be a factor in explaining differences in economic growth.

To sum up, access to modern energy encouraged the dynamic of the techno-economic process that has prevailed since the middle of the nineteenth century and early decades of the twenty. In this context we can formulate a series of questions. Were our two "club" economies in a similar condition when they had to face the new techno-economic paradigm? Were they physically prepared to generate the quantity and quality of energy required by the economic process? Or, on the other hand, were their energy conditions a limitation on economic development?

We considered how New Zealand and Uruguay differed considerably in income levels, welfare and production diversification, and we noted how important energy natural resources are for generating abundant cheap energy. Our hypothesis is that New Zealand was more blessed than Uruguay in terms of energy resources and this explains, at least partially, the two countries' different performance as regards economic development. To test this hypothesis, we adopted an analytical strategy with a descriptive and comparative analysis in two stages. First, we compare "natural endowments" that can be used to produce energy. This means gauging to what extent a country was physically prepared to take advantage of an opening window of opportunity (Perez & Soete, 1988) related to a new techno-economic paradigm. Therefore we consider two main issues, (i) coal production, and (ii) suitable conditions to generate hydroelectric energy. The main consequence of these differences should be that New Zealand would have lower power generation costs and lower energy prices than Uruguay. Our second analytical stage is to consider three elements to represent the main expressions of this process in terms of (i) investment, (ii) operation costs, and (iii) prices for users (which represent the prevailing technological and market conditions).

If natural endowments are to be transformed into economic development these resources have to be correctly applied to transform production potential into effective output. The creation of a "modern" production structure requires sufficient energy sources at competitive costs that are exploited at the right time to generate higher incomes and increasing welfare. Using the classical sector classification into agriculture, manufacturing and services, we selected production activities characterized by high energy consumption, and we examine some of the main differences between countries in terms of (i) dairy industry; (ii) metal products, engineering and transport equipment together with various manufacturing indicators; and (iii) railways.

Therefore, if the conditions for taking advantage of the opportunity created by a new techno-economic paradigm were clearly different, and high energy consumption industrial sectors vary greatly between economies, we will conclude that those countries' non-convergence is explained, at least partially, by a natural "blessing" in New Zealand that Uruguay never enjoyed.

4. Were energy natural resources different? A statistical appraisal

4.1. Coal

The shortage or abundance of given natural resources can be considered a determinant for the adoption and diffusion of technology associated with modern economic growth. In the period under analysis neither country had any oil. Mineral fuel is an important resource as it can be used directly in economic activities or to generate electricity, but waterfalls are a determinant factor as well. The outstanding difference as regards energy endowments was that New Zealand had coal but Uruguay did not. According to Oxman (1961, p.8), the country had only a few deposits of peat, a very poor fuel because it has low carbon content: from 45 per cent to 60 per cent, whereas lignite, the lowest rank of coal, has 60-75 per cent. New Zealand, on the other hand, had various types of coal. In the early twentieth century its reserves were estimated at around 2.4 million tons (Table 1).

Data about coal mining in New Zealand are available from 1867 onwards (Bloomfield, 1984, p.154) but it was only in 1878 that this activity began to develop dynamically. Between 1878 and 1910 annual coal output increased from 162,218 tons to 2.2 million tons (New Zealand Official Yearbook, 1911), which was an annual growth rate of 8.5 per cent, but after First World War the industry's output tended to oscillate. Meanwhile coal imports increased dramatically from 232,400 tons in 1910 to 572,600 tons in 1925 (Bloomfield, 1984:201) to take up the slack in domestic production. In any case, the coal produced in the country covered around 80 per cent of domestic demand.

As a consequence of their different energy endowment there was a very wide gap in coal consumption between Uruguay and New Zealand (Figure 5). For fifty years Uruguay's coal consumption was around 10-15 per cent of New Zealand's, and this could explain why the former had less energy available. The fact that this gap persisted for so long suggests a structural feature.

Table 1

New Zealand coal reserves estimates

ca. 1920

Class of Coal	**Proved** [1/] Imperial Tons	**Probable** [2/] Imperial Tons	**Possible** [3/]
Anthracite	Very little	Very little	Small.
Bituminous	187,000,000	477,000,000	Moderate.
Semi-bituminous	68,000,000	196,000,000	Moderate.
Brown	194,000,000	728,000,000	Large.
Lignite	161,000,000	420,000,000	Large.
Totals	610,000,000	1,821,000,000	Large.

1/ Estimated quantity and grade of that part of coal for which the size, grade and distribution of values, together with technical and economic factors, are so well-established that there is the highest degree of confidence in the estimate. The term should be restricted to that part of a deposit being mined, or being developed and for which there is a mining plan.
2/ Estimated quantity and grade of that part of coal for which the economic viability has been demonstrated by adequate information on engineering, operating, and legal factors, at a confidence level that will allow positive decisions on major expenditures.
3/ Estimated quantity and grade of that part of an inferred reserve that are determined from limited sample data for which geology, grade continuity, and operating parameters are based, to a large extent, on reasonable extrapolations, assumptions, and interpretations.

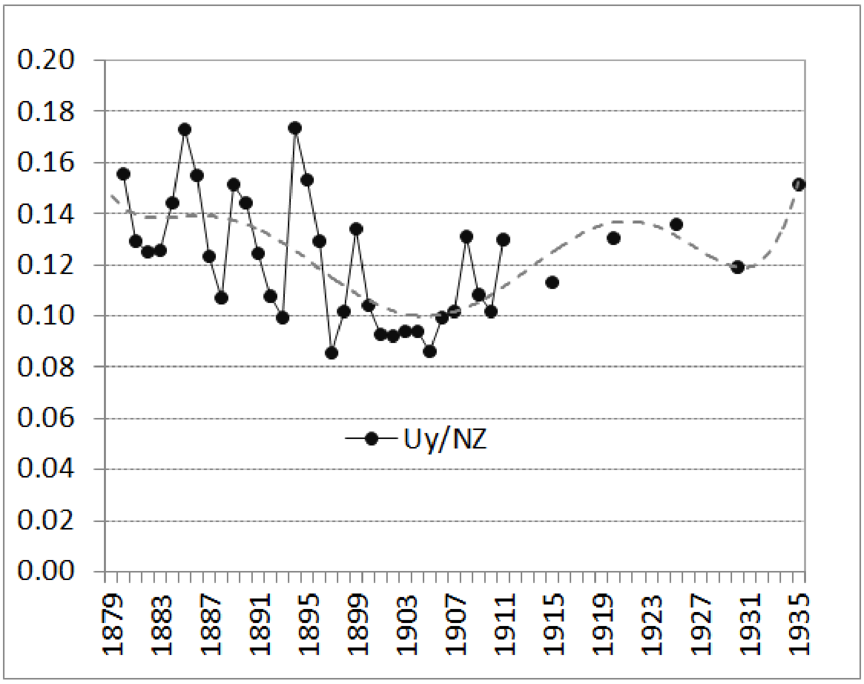
Sources: New Zealand Official Yearbook (1919); Society of Petroleum Engineers (http://www.spe.org/)

All the coal consumed in Uruguay was imported and therefore availability was dependent on international prices and the market situation, which means there were supply problems in times of war. If economic modernization, including modern farming techniques, required a more intensive use of energy then New Zealand had a clear advantage over Uruguay. The fact that coal was available could have encouraged the industrialization process as this fuel was needed for trains and to generate electricity.

Figure 5

Coal consumption ratio in Uruguay

New Zealand = 1 (in tons)



Source: New Zealand Yearbooks (several years); Bertoni & Román (2013).

4.2. Hydroelectricity

The energy modernization process towards the end of the nineteenth century and in the early twentieth century was characterized by intensive introduction of electricity in a wide range of economic and social activities. The distribution of electric power and its use in heavy engineering imposed a new pervasive techno-economic paradigm (Freeman, 1989; Pérez, 1983). The coal and steam paradigm led modern economic growth from the beginning of the nineteenth century until the 1880s, when it was overtaken by the more technically sophisticated system of electricity. Electric power made it possible to separate the production of goods from energy generation, and this meant new manufacturing sectors could be progressively mechanized.

Electric power is a secondary energy source, which means it is derived from primary sources, and the technological options available to produce it were thermal and hydropower generation. Therefore, countries with abundant coal reserves, oil reserves or hydropower capacity had relative advantages when incorporating the new technical system[6] and thus inserting themselves into the new techno-economic paradigm. Bertoni (2002, p.41) estimates the per capita consumption of electric power in different small countries during the early decades of the twentieth century. Table 2 shows the difference between New Zealand and Uruguay at three benchmarks, 1913, 1920 and 1930. At the first of these, electricity consumption in the two countries was similar, but New Zealand subsequently surged ahead, as can be seen from the table below.[7]

Table 2

Electricity consumption per capita

In KWH

	1900	1913	1920	1930
Norway	20	765	1386	2290
Switzerland	52	352	614	1085
Sweden	18	219	377	710
Belgium		146	139	452
New Zealand		**14**	**80**	**417**
Finland	5	51	78	298
Denmark		29	69	139
Uruguay	**2**	**17**	**33**	**70**

Source: Bertoni (2002, p.41) Cuadro Nº IV.3.

By 1930 hydroelectric power was more developed in New Zealand, which had already built several hydroelectric dams while Uruguay had none. This disparity clearly gave the former country greater hydropower potential.

Hydroelectric energy is produced by the force of falling water. Production of this energy is dependent on the flow and on the height from which it falls. When water is accumulated behind a high dam it is potential energy. It is transformed into mechanical energy when it rushes through sluices and hits the rotary blades of a turbine. The amount of electricity that can be generated at a hydroelectric plant depends on two factors: (i) the vertical distance that the water falls, which it is called

[6] As stated in Myllyntaus (1999, p. 94): *"In the early twentieth century, contemporaries had already observed that countries with considerable hydropower resources tended to have more electricity to consume than other countries"*.

[7] In 1920 the ratio between the two indicators was 2.4 in favour of New Zealand, and it increased to 6 by 1930.

the "head"; and (ii) the flow rate, measured as volume per unit of time. There are no historical statistics to estimate hydroelectricity generation by this means but we can use topographical characteristics and the quantity and regularity of rainfall as indirect evidence.

Uruguay has a dense hydrographic network with two main rivers, the Uruguay and the Negro. The former forms the border with Argentina and the hydropower generated on it is shared between the two countries. The River Negro is by far the greatest source of water for irrigation in Uruguay. It runs from east to west and divides the country into two main regions, the north and the south.

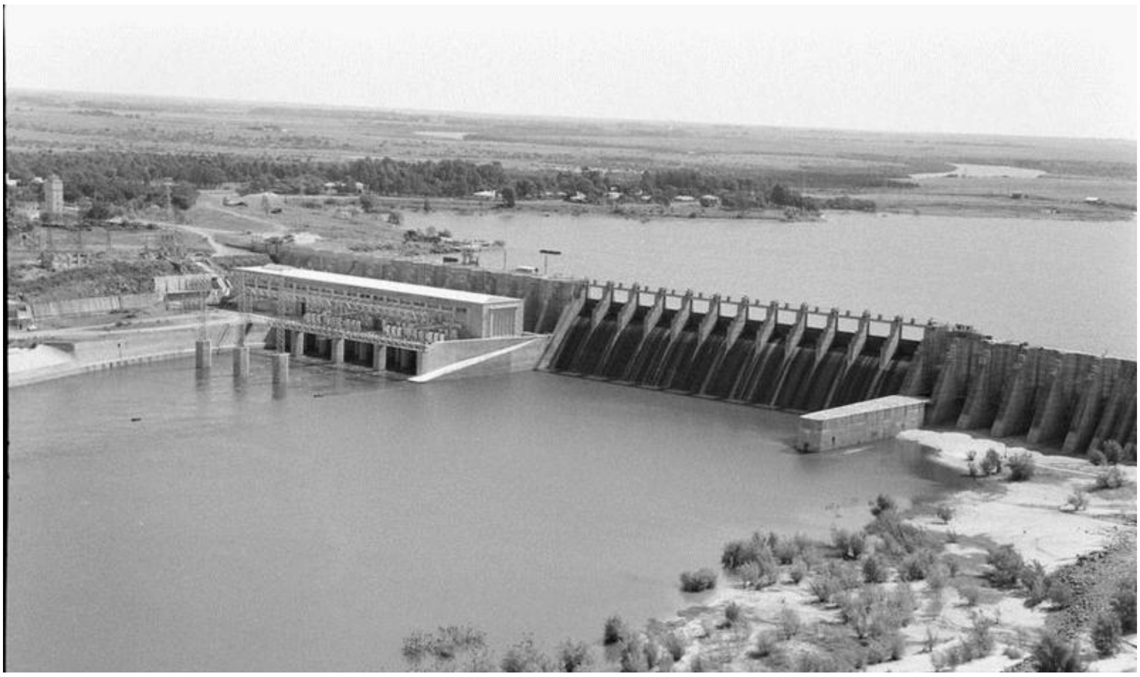
As regards topography, Uruguay has broad grasslands and low hills and as a consequence the caudal of the water flows is closely related to rainfall. In general, rainfall is abundant but it is irregularly distributed over the year and even between years. In some years rainfall is heavy but in others there is very little and it is no surprise that large parts of the country suffer from serious drought from time to time. Absence of natural lakes and high lands allow an easy displacement of rainfall water and, consequently, water storage is problematic. The solution was to invest in hydroelectric dams to create these conditions artificially, but these were very costly and the energy sector has always relied on thermal stations to provide backup power (see Figure 6, Panel A).

New Zealand, in contrast, has generous water reserves for generating energy, thanks to its more favourable topography and rainfall patterns. A large proportion of the country is mountainous and much of the mountain area is high (Ogilvie Buchanan, 1930, pp. 444-446). The country's rainfall and hence its river flows are relatively regular and there are numerous lakes –the best natural regulator of river flow– many of which are quite large (Ogilvie Buchanan, 1930, p.449)[8] (see Figure 6, Panel B).

[8] According to Te Ara-The Encyclopedia of New Zealand, *"New Zealand is a land of lakes… Excluding offshore islands, New Zealand has 775 lakes… Lakes cover about 1.3 per cent of the land area."* (http://www.teara.govt.nz/en/lakes).

Figure 6

Panel A. Uruguay: Rincón del Bonete



Source: http://cw5o.cx.uy/?4,2

Panel B. New Zealand: Lake Coleridge Power Station

The Lake Coleridge Hydro-Electric Plant, showing the Rakaia River, Tail Race, Power House and Pipe Lines. (65 miles west of Christchurch)

Source:http://ketechristchurch.peoplesnetworknz.info/site/images/show/1742-lake-coleridge-power-station#.U4eAdCh2AdU

Source: http://www.ipenz.org.nz/heritage/itemdetail.cfm?itemid=2407

As topographical factors are fixed, we shall start by examining the effect of hydroelectric energy production on economic development and compare rainfall in the two countries.

Table 3 shows the average annual rainfall in Uruguay and New Zealand in the early decades of the twentieth century. It can be seen that there are two big differences. Over the period, rainfall in Uruguay was less than in New Zealand and more irregular. On average, precipitation was between 22 and 25 per cent lower, and the standard deviation (an indicator of variability) was three times greater.

Table 3
Uruguay and New Zealand: average rainfall
In mm

	Uruguay	New Zealand
Years	**mm**	**mm**
1901	727.8	1388.7
1902	928.7	1289.8
1903	977.6	1403.9
1904	742.8	1591.9
1905	756.6	1199.1
1906	638.9	1165.2
1907	550.5	1309.3
1908	920.2	1157.5
1909	868.3	1317.3
1910	676.9	1241.4
1911	1,271.0	1170.6
1912	1,496.8	1205.8
1913	1,075.2	1122.4
1914	2,399.7	917.3
1915	1,068.5	980.2
1916	574.4	1119.7
1917	706.6	1259.4
1918	856.3	1294.0
1919	1,207.0	944.3
Average		
1901-1915	**1,006.6**	1230.7
1901-1919	**970.7**	1214.6

Uruguay			
Standard deviation		Variation coefficient	
1901-1915	459.40	**1901-1915**	45.6
1901-1919	426.21	**1901-1919**	43.9

New Zealand			
Standard deviation		Variation coefficient	
1901-1915	166.97	**1901-1915**	13.6
1901-1919	164.08	**1901-1919**	13.5

Note: we calculate two averages because Uruguay suffered a serious drought in 1916-1917.

Sources: Uruguay: Dirección General de Estadística (1921) "Anuario Estadístico 1919". Montevideo. New Zealand: The New Zealand Official Year book (several years).

As Uruguay has no natural lakes it is more difficult to manage the irregular rainfall and flows, and this made it necessary to build artificial lakes to store water. The seriousness of this problem was understood perfectly at the time and in 1925 technical experts in the country reported that building a hydroelectric dam on the River Negro would create "the largest artificial lake of world".[9]

If we accept that hydroelectric power is closely linked to rainfall, New Zealand has a clear potential advantage over Uruguay. Ogilvie Buchanan (1930) gave an extraordinary overview of New Zealand's potential hydropower in the second decade of twentieth century. For Uruguay, Oxman (1961) produced a similar report about the situation in the 1950s. Using the information provided by these two authors we compare the hydropower potential of the two countries. The data is given in Table 4.

It can be seen that New Zealand had twice as much hydroelectric potential as Uruguay. This figure represents nominal potential energy and does not take into account the effects of irregular rainfall that we considered above. Furthermore, Uruguay's topographical characteristics made it necessary to invest more in hydroelectric systems, which are expensive.

Table 4
Potential Hydropower in New Zealand and Uruguay
In MW

Uruguay		**New Zealand**	
Río Negro	493	North Island	475
Río Uruguay	700	South Island	2,088
Other sites	39		
	1,232	TOTAL	**2,563**

Sources: Ogilvie Buchanan (1930) and Oxman (1960).

5. Were technological and market conditions different? Investment, operation costs and prices

To exploit natural endowments and put them at the service of economic development they have to be developed under suitable technological and market conditions, and then applied appropriately so as to transform production potential into effective

[9] See, for instance, Libro del Centenario (1925), p. 266.

output. Therefore we can ask: what were the technological and market conditions in the two countries?

To answer this question we consider three main aspects of costs and prices in relation to electricity generation and consumption: (i) investment, (ii) operation costs, and (iii) prices for users. These capture the prevailing technological and market conditions in each economy. We compare specific years for which information for both countries is available, and construct indicators to contrast specific aspects of electricity generation and consumption (Table 5).

Table 5
Technological and market energy conditions
In Uruguayan pesos ($)

	New Zeland	Uruguay
Capital_Hydro-electric power station	**1918**	**1923**
Capital expediture ($)	3,953,340	15,000,000
Installed HP (number)	24,000	32,000
Capital per installed HP ($)	165	469
Capital_Thermal power station	**1911**	**1912**
Capital expediture ($)	628,683	1,550,503
Installed HP (number)	8,080	15,694
Capital per installed HP ($)	78	99
Operation costs	**1911**	**1912**
Expenditure ($)	298,999	537,380
Generated KWH (number)	18,392,733	16,281,410
Cost of generation per KWH ($)	0.016	0.033
Prices	**1912**	**1912**
Retail rates by category:		
Lighting ($/KW)	0.059	0.120
Power and heating ($/KW)	0.014	0.051

Source: see Appendix.

5.1 Investment in electricity generation

Electricity can be generated from a range of primary resources, and to reach the final consumer a network of transmission and distribution infrastructure is needed. The cost of this infrastructure depends on the endowment, technology, and economic and institutional factors, but whatever these conditions may be the investment required is always very considerable.

Uruguay did not have hydroelectric power until 1945 even though studies of this option began early in the twentieth century. We found estimates of the investment costs involved in building hydroelectric power station in Uruguay and we use this information to compare these preliminary conditions with equivalent installations that were built in New Zealand. We define the capital needed for a hydroelectric power station as the investment costs of installing the system in terms of monetary unit per installed unit of power (Table 5, first panel).

We assume that electricity generation technology was standardized, so the main factor that explains differences in investment levels is the cost of the engineering work needed to build falling water systems in Uruguay. In fact, historical sources indicate they had to build a wall 1.4 kilometres long to obtain a fall of 20 meters.[10] An additional factor to be taken into account is the distance from the power station to consumers. We find that in New Zealand the average distance was half the mean in Uruguay. In consequence, we find greater sunk costs in Uruguay than in New Zealand for power transmission lines, which mean greater investment to generate electricity.[11]

As in the previous section we present natural condition differences between New Zealand and Uruguay as regards hydroelectric potential, and when we focus exclusively on technical factors we find that the investment needed to generate hydropower was three times greater in Uruguay than New Zealand.

Finally, both countries had thermal electric power around 1911-12 and we compare the effective investment made to generate electricity by steam technology. The installation cost is called thermal-power station capital (Table 5, second panel). The information available shows that thermal plants were cheaper than hydroelectric ones.[12] This is more important in Uruguay, where the opportunity cost to build a hydro-plant was five times greater, which may explain why the country lagged behind in incorporating this technology into the energy matrix. Comparisons show that the

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[10] Libro del Centenario (1925), p. 267.

[11] The average distance from plant to consumers was 141 km in North Island and 127 km in South Island while in Uruguay it was 270 km.

[12] These estimations are consistent with those reported by contemporary New Zealand sources; see: http://atojs.natlib.govt.nz/cgi-bin/atojs?a=d&d=AJHR1904-I.2.2.2.2&e=-------10--1-----..-0--.

small differential between the two countries –around 25 per cent– is explained by the fact that the technology used was mature, although New Zealand again had advantages over Uruguay.

5.2 Operation costs for generating electricity

Initially, these differences in capital expenditure can explain differences in operation costs, but these depend on production efficiency. The cost of a kilowatt per hour (KWH) can be interpreted as a measure of these differences, and we calculate this indicator in both countries considering generation, distribution, systems management and other costs.[13]

In New Zealand the cost considers the whole electric current system including thermal and hydroelectric generation because we are interested in welfare (the costs that will determine the consumer price). In Uruguay, on the other hand, we consider the operation costs of the largest and probably most efficient thermal power station, which is located in Montevideo. It is very close to the port so the main input, coal or fuel oil, incurs lower transport costs. Thus we make a comparison between the best case in Uruguay –in terms of operation costs– and the average in New Zealand.

Table 5 shows the total KWH generated in each country (1911 for New Zealand and 1912 for Uruguay) and the total operation costs involved in generating electric power. The cost per KWH in New Zealand was half that of a Uruguayan power station, and it would be reasonable to expect that there was a similar difference in the final price for the consumer.

5.3 Use and prices of electricity

The final uses of energy are household and industrial consumption, so in this way we capture welfare and production conditions. With this aim, we consider retail rates ($/KW) for two categories: lighting, and power and heating, and our initial predictions are confirmed (see Table 5, the last panel).

As we saw above, the retail price of lighting was 50 per cent lower in New Zealand than in Uruguay but the final price for power and heating was only a quarter of that paid in Uruguay. In other words, a typical household consumer in New Zealand paid

[13] We exclude capital expenditures like interest, sink funds, depreciation and reserve funds.

less for electricity but the comparative rates for industry and businesses were even lower.

6. Was the production structure different? Differences in energy intensity

Some sectors use energy more intensively than others. The conformation of a "modern" production structure requires there to be sufficient energy consumption at competitive costs to justify the exploitation of the corresponding natural resources. The traditional broad classification of sectors is agriculture, manufacturing and services, and we selected one representative high energy consumption industrial branch in each, namely (i) the dairy industry; (ii) the metal products, engineering and transport equipment group (using various manufacturing indicators); and (iii) railways.

Since the early nineteenth century the dairy industry in New Zealand has gone from farmers keeping a few domestic cows on bush blocks to being a world leader today (Stringleman & Scrimgeour, 2012). However, that activity developed late in Uruguay even though the natural resources in the two countries were apparently similar (Bertino & Tajam, 2000), and it was not until the 1960s that we can identify a real dairy area where farming and manufacturing worked in a coordinated way. Table 6 gives an overview of the dairy industry on the eve of First World War. It can be seen that New Zealand was very far ahead in many dimensions.

New Zealand had five times the number of milk cows as Uruguay and the yield in litres per cow was nearly three times more. The differences were even greater in the manufacturing stage, where New Zealand cheese production was 10 times greater than Uruguay's and butter production 172 times greater. The same applied to trade as Uruguay's milk product were negligible in the period.[14] The enormous gap between the two countries in butter production is symptomatic of huge differences in energy use. Butter production requires an effective refrigeration chain from farming through manufacturing, packing and storing, and this process is very energy intensive. In the long run, both economies have been characterized by a clear primary specialization based on the exploitation of natural resources. However, New Zealand advanced

[14] Uruguay even had to import butterfat from Argentina for many years because domestic production was insufficient to meet domestic demand (Bertino & Tajam, 2000).

earlier in the industrialization process and showed signs of structural change at the beginning of the twentieth century (Willebald, 2013).

Table 7
Dairy indicators
ca First War World

		New Zealand		Uruguay	
Milking output					
Milking cows		1917	684,000	1913	125,277
Total litres		1917	1,821,579,117	1913	124,124,374
Yield per cow/day		1917	9.5	1913	3.5
Dairying produce					
Butter					
	Output (tons)	1908	20,099	1908	117
	Factories	1908	196	1908	15
Cheese					
	Output (tons)	1908	15,763	1908	1,738
	Factories	1908	147	1908	124
Dairyng exports					
Butter					
	Output (tons)	1908	11,683	1908	22
Cheese					
	Output (tons)	1908	14,265	1908	50

Source: see Appendix.

On the eve of First World War, industrial branches typically characterized by high energy use such as metal products, engineering, and transport equipment accounted for 15 per cent of total value-added by manufacturing (Rankin, 1991).[15] In contrast, in Uruguay even in the mid-1930s, these branches had not achieved that level (only 12 per cent in 1936). These differences had clear effects on the installed capacity (Table 7).

Table 7
Motive power employed in manufacturing

Country	Year	Number of Works 1/	Number of Engines, &c., driven by: Steam	Water	Gas	Oil	Horse	Hand	Electricity	Total	Amount of Horse-power
New Zealand	1910	3,519	2,218	229	853	231	4	61	1,084	4,680	99,959
New Zealand	1900	3,163	1,359	216	400	31	72	0	15	2,093	39,052
Uruguay	1908	3,435	890	50	138				104	1,182	34,510

		Engines/ establish-ment	HPower/ establish-ment
New Zealand	1910	1.3	28.4
New Zealand	1900	0.7	12.3
Uruguay	1908	0.3	10.0

1/ It refers to the number of establishments.

Source: see Appendix.

[15] Average 1910-15.

With a similar number of works (establishments) –3,519 in New Zealand (1910) and 3,435 in Uruguay (1908)– New Zealand tripled the amount of horsepower. These differences mean that New Zealand manufacturing had 1.3 engines per unit of work against only 0.3 in Uruguay, and 28.4 HP per production unit against 10 in Uruguay. Evidently, much less energy was used in Uruguayan manufacturing.

Table 8
RAILWAY INDICATORS
Data from 1913

	New Zealand	Uruguay	NZ/Uy
Length			
Km	4,593	2,536	1.81
Km/000 pop	4.1	2.2	1.90
Km/Km2	0.017	0.014	1.18
Rolling-stock 1/			
Locomotives	534	179	2.99
Passenger Vehicles	1,363	159	8.60
Trucks and Vans	20,251	3,472	5.83
Goods and livestock traffic			
Tonnes	6,346,066	1,432,590	4.43
Tonnes/km	1,382	565	2.45
Tonnes/Truck	313	413	0.76

1/ Number of vehicles.

New Zealand: 1913; Uruguay: avg. 1912-1913, 1913-1914.

Source: see Appendix.

Finally, New Zealand enjoyed a more developed railway system (Table 8). It had twice as many kilometres of railway line as Uruguay and its infrastructure use was clearly better. In 1913 it had 534 locomotives while Uruguay had only 179, and the differences were even greater in number of wagons and cars. As a consequence New Zealand could move four times as much freight as Uruguay. In addition, it used its railway network more intensively, shifting 1,382 tonnes/km/year against only 565. In contrast, railway wagons in Uruguay had to be used more intensively, which probably led to inefficiency and rolling stock wearing out more quickly.

7. Final remarks and future steps

Settler economies are characterized by abundant of natural resources. However, natural capital is not homogeneous between countries and it can lead to different consequences in terms of growth, income levels and production structure.

There is little literature about the economic development of settler economies that focuses on differences within the "club" in relation to natural resources. New Zealand and Uruguay are similar in many ways such as production structure, the dynamics of production factor flows and their modality of participation in international markets, but in the nineteenth century and the early decades of the twentieth, their levels of income per capita were significantly different. To find new explanations for this state of affairs we need to study other aspects of their economic systems. To explain the two countries' different levels of development we examine differences in their energy natural endowments, basically coal reserves and suitable conditions to produce hydroelectric power.

We discuss the effect of natural resources on economic performance in terms of the debate about the hypothesis of the "curse/blessing" of natural resources. We focus our analysis on two small economies –New Zealand and Uruguay– that are in a group of countries recently settled by Europeans (settler economies) and we consider their energy natural resources. We use concepts derived from the Neo-Schumpeterian and Evolutionist Schools to consider one of the main weak points of that approach, which is its lack of historical specificity. To overcome this weakness we consider the concept of techno-economic paradigm and employ the idea of "key factor" as a main analytical category.

According to our analysis, these differences can be explained by the fact that New Zealand performed better than Uruguay in coal production, and enjoyed better natural conditions to generate low cost electricity, and hence charge lower prices for it. New Zealand's advantage in energy endowments explains, at least partially, the development of its dairy sector, certain energy-intensive manufacturing industries and its more efficient use of railways. Our findings support the hypotheses that to understand the differences in the development of Australasia and the River Plate it is important to consider that the former had a sizeable mining sector, better quality natural resources, and more favourable geographical and climatic conditions, all of which explain why Uruguay has been so energy-dependent.

This study is necessarily partial in nature because we concentrate only on the "key factors" considered in Neo-Schumpterian analysis. In future stages of our research we will supplement our analysis with an examination of some aspects of the institutional arrangements involved in how the energy systems in New Zealand and Uruguay were set up. Two lines of inquiry are particularly important in this respect. First, we will examine State participation in the exploitation and use of energy resources and analyse the characteristics of these systems. Second, we will study how entrepreneurship was organized on the production side in order to evaluate how important different systems of production organization were to achieve scale economies and generate spillover effects. Basically this is the contrast between cooperative and capitalist organization.

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Appendix: statistical sources and methodological decisions

1. Stylized facts

1.1 GDP per capita

GDP per capita expressed in Geary-Khamis 1990 dollars from:

BOLT, Jutta and VAN ZANDEN, Jan Luiten (2013): The First Update of the Maddison Project; Re-Estimating Growth Before 1820. *Maddison Project Working Paper 4*.

1.2 GDP structure

New Zealand

GDP by sector is expressed in current prices according to Linehman (1968).

Agriculture: farm, commercial forestry and fishing.
Manufacturing: factory production.

LINEHMAN, Brent (1968): "New Zealand's Gross Domestic Product, 1918/38". *New Zealand Economic Papers*, Vol. 2: 15-26. Table 1.A: New Zealand Gross Domestic Product. Summary (£000), pp. 16.

Uruguay

GDP by sector is expressed in current prices according to Bonino et al. (2012) based on Bértola (1998) and Bertino and Tajam (1999).

Agriculture: pastoral and crop production.
Manufacturing: factory production.

BONINO, Nicolás, ROMÁN, Carolina and WILLEBALD, Henry (2012): "PIB y estructura productiva en Uruguay (1870-2011): Revisión de series históricas y discusión metodológica". *Documento de Trabajo DT 05/12, Instituto de Economía*, Universidad de la República, May (http://www.iecon.ccee.edu.uy/dt-05-12-pib-y-estructura-productiva-en-uruguay-1870-2011-revision-de-series-historicas-y-discusion-metodologica/publicacion/296/es/).ISSN/ISBN: 1688-5090.

BERTINO, Magdalena and TAJAM, Héctor (1999): *El PBI de Uruguay: 1900-1955*. Instituto de Economía, Facultad de Ciencias Económicas y de Administración, Universidad de la República. Montevideo, Uruguay.

BÉRTOLA, Luis (1998): *El PBI de Uruguay, 1870-1936, y otras estimaciones*. Programa de Historia Económica e Instituciones, Facultad de Ciencias Sociales, Universidad de la República. Montevideo, Uruguay.

1.3 Export structure

New Zealand

Exports by major commodity groups are expressed in current prices.

Mineral: gold, coal, silver, and other minerals.
Fishery: fish, oysters, whale and seal skins, and oil.

Forestry: Kaurí gum, phormium tenax, timber and wood pulp.
Pastoral: animal products of all kinds with very low degree of transformation such as hides and skins (cattle, sheep and rabbit), tallow, wool.
Agricultural: grain, potatoes, seed.
Manufactured: meats (preserved and frozen), butter, cheese, flour, meal, and other manufactured goods.

BLOOMFIELD, G. T. (1984): *New Zealand: A handbook of historical statistics*. Boston Massachusetts: GK Hall & Co.

Uruguay

Exports by major commodity groups are expressed in current prices.

Mineral: sand, stone, gold and other minerals.
Fishery: fresh, canned and dried fish.
Forestry: firewood, posts.
Pastoral: animal products of all kinds with very low degree of transformation such as charqui, bones, hides and skins (cattle and sheep), tallow, wool. It includes live animals.
Agricultural: grain, potatoes, fruits, fodder.
Manufactured: meats (preserved and frozen), butter, cheese, flour, meal, seed paste, and other manufactured goods.

BONINO, Nicolás, TENA-JUNGUITO, Antonio, and WILLEBALD, Henry (2013): "Transit trade vs. the Official prices problem. On the accuracy of Uruguayan export data in the First Globalization", Communication presented in the *2do Congreso Chileno de Historia Económica, Valparaíso, Chile*, September. Data kindly provided by the authors.

2. Endowments

2.1 Coal

New Zealand

Data correspond to the coal consumption within the colony (1879-1911) from NZYB (1914) and coal apparent consumption[16] (1915-40; 5-year periods) from Bloomfield (1984), Table V.24, p. 201 (own estimates).

CENSUS AND STATISTICS OFFICE OF THE DOMINION OF NEW ZEALAND (several years): *The New Zealand Official Year-Book 1914*. Wellington.
BLOOMFIELD, G. T. (1984): *New Zealand: A handbook of historical statistics*. Boston Massachusetts: GK Hall & Co.

Uruguay

Data correspond to apparent coal consumption from Bertoni & Román (2013), Apéndice Cuadro A-1, p. 495-497.

[16] Production+Imports-Exports.

BERTONI, Reto and ROMÁN, Carolina (2013): "Auge y ocaso del carbón mineral en Uruguay. Un análisis histórico desde fines del siglo XIX hasta la actualidad". *Revista de Historia Económica-Journal of Iberian and Latin American Economic History*, 31, pp. 459-497.

2.2 Potential hydropower

Data came from Ogilvie Buchanan (1930) and Oxman (1960) and correspond to author's estimates. The temporal differences between the two works are not important for our purposes because they refer to natural endowments, and technology to generate hydroelectricity did not change significantly.
Source for New Zealand presents data in HP and we transform to KW with the coefficient 1HP=0.746KW.

OGILVIE BUCHANAN, R. (1930): "Hydro-Electric Power Development in New Zealand". *The Geographical Journal*, Vol. 75, No. 5 (May, 1930), pp. 444-457.
OXMAN, Ramón (1961): *Energía, Consumo, Producción y Política Energética*. UDELAR, FCCEEyA, Montevideo.

3. Technological and market indicators

3.1 Capital of hydro-electric power station

Capital expenditure considers investment in land, buildings, machinery, plant, main transmission-lines, interest and amortization expenses and the assistance to local authorities and power-users (included land expropriation) in the year of the beginning of operations estimated for the creation of a complete electrical scheme. The transmission line distance to the nearest city is the average of the corresponding positions of powerhouses weighted by installed capacity (HP).

New Zealand 1918

It corresponds to the estimations by Mr. Evan Parry (NZ Yearbook, 1920) about Mangahao generating-station with a plant capacity of 24,000 HP.

Uruguay 1923

It corresponds to the estimations by the Engineer J. T. Case (Ulem & Co) (Libro del Centenario, 1925, p. 267-268) about Rincón de González generating-station (on Río Negro) with a plant capacity of 32,000 HP.

CENSUS AND STATISTICS OFFICE OF THE DOMINION OF NEW ZEALAND (1920): *The New Zealand Official Year-Book 1920*. Wellington. Section XX. Water-power, Electric Power Supply, Other Works (http://www3.stats.govt.nz/New_Zealand_Official_Yearbooks/1920/NZOYB_1920.html).
EL LIBRO DEL CENTENARIO DEL URUGUAY, 1825-1925 (1925). Montevideo, p. 267.

3.2 Capital of thermal power station

New Zealand 1911

Census 1911 reports on the total capital expenditure (land, buildings, machinery and plant) for electric generation and the total horsepower installed in steam stations. We use the technical coefficient presented in the Appendix to the Journals of the House of Representatives (1904) to estimate the capital corresponding to steam generation. According to this publication, the cost of steam plant would be approximately about half that of the hydraulic plant, therefore we consider that the total capital of the electric system is distributed a third for steam and two thirds for hydro.

Uruguay 1912

Administración de las Usinas Eléctricas del Estado (UEE) is a state enterprise with the monopoly of the generation, transmission and distribution of electricity from 1912 onwards. The activity report (Memoria) corresponding to 1912 informs about capital expenditure of the Usina Eléctrica de Montevideo (Montevideo electrical power station) and the horsepower installed.

ADMINISTRACIÓN DE LAS USINAS ELÉCTRICAS DEL ESTADO (1914): *Memoria. Ejercicios 1911-1912 y 1912-13*. Montevideo, Balance General en 30 de Junio de 1912, p. 9; Información General sobre el Desarrollo de los distintos Servicios, Table, p. 58; Gastos en el Ejercicio 1911-1912, p. 55; K.W.H. producidos, perdidos y consumidos y porcentaje de pérdida, p. 43; Información General sobre el Desarrollo de los distintos Servicios, Table, p. 41.

CENSUS AND STATISTICS OFFICE OF THE DOMINION OF NEW ZEALAND (1911): *Results of Census of Population and Dwellings Dominion of New Zealand*. Wellington, Electric Current, Table XXIX, (http://www3.stats.govt.nz/historic_publications/1911-census/1911-results-census.html#d50e62 1202).

THE JOURNALS OF THE HOUSE OF REPRESENTATIVES (1904): Session I, D-01a, Appendix, p. 35 (http://atojs.natlib.govt.nz/cgi-bin/atojs?a=d&d=AJHR1904-I.2.2.2.2&e=-------10--1-----..-0--)

3.3 Operation costs

Operation costs are for whole electrical system (steam and hydropower) including generation, distribution, management and other expenses (excluding capital expenses such as interest and sinking fund, depreciation and reserve fund).

New Zealand 1911

Census 1911 reports on the total expenditure for this item and the corresponding KWH generated.

Uruguay 1912

The activity report (Memoria) of UEE reports on operation costs corresponding to the Gastos en el Ejercicio 1911-1912 (p. 55) and the KWH generated (p.43).

3.4 Prices

We consider prices corresponding to an individual power station and representative of the price paid by consumers in big population centres (more than 50,000 people served).

New Zealand 1912

NZ Yearbook (1913) reports on retail rates charged for particular lighting and power, heating and tramway purposes corresponding to Dunedin power station.

Uruguay 1912

The activity report (Memoria) of UEE reports on retail rates charged for particular lighting and motive power corresponding to the Usina Eléctrica de Montevideo (Montevideo electrical power station).

CENSUS AND STATISTICS OFFICE OF THE DOMINION OF NEW ZEALAND (1913): *The New Zealand Official Year-Book 1913*. Wellington. Section XIII. Mining, Water-power (http://www3.stats.govt.nz/New_Zealand_Official_Yearbooks/1913/NZOYB_1913.html#idsect1_1_181531).

3.5 Exchange rate

Exchange rate Uruguayan pesos per Sterling Pound from Uruguayan Yearbooks corresponding to Montevideo Stock market.

URUGUAY. DIRECCIÓN GENERAL DE ESTADÍSTICA (several years). *Anuario Estadístico*. Montevideo.

4. Productive structure indicators

4.1 Dairy industry

4.1.1 Milk output

New Zealand 1917

Milk output is expressed in million pounds of butterfat (Bloomfield, Table V.14, p. 185). We transform butterfat into litres according to Eckles & Warren (1916), p. 168, considering cow's milk weights approximately 2.15 pounds per quart and the composition of fat represent around 3.7 per cent.
Number of cows in milk comes from Bloomfield, Table V.12, p. 181.
Milking days per year are deduced from Willoughby (1903), p. 24, considering the minimum and maximum of 267 and 295 days, respectively.

ECKLES, Clarence H. and WARREN, George F. (1916): *Dairy farming*, Ithaca, New York: Cornell University, Mann Library, New York: Macmillan, URL: http://chla.library.cornell.edu/cgi/t/text/text-idx?c=chla;idno=2750834 (Accessed May 15th, 2012).
WILLOUGHBY, Edward F. (1903): *Milk: its production and uses: with chapters on dairy farming, the diseases of cattle, and on the hygiene and control of supplies.* Ithaca, New York: Cornell University, Mann Library, London: C. Griffin & Company, Ltd.. http://chla.library.cornell.edu/cgi/t/text/text-idx?c=chla;idno=2903803 (Accessed May 15th, 2012).

Uruguay 1913

We obtain the number of dairy cows for 1908 and 1916 from Agricultural Census and interpolate the record for 1913. We obtain the ratio "dairy cows in milk to total dairy cows" for 1908 (Agricultural Census) and 1937 (MGA, 1949)[17] and interpolate the ratio for 1913. With both data we get the dairy cows in milk in 1913.

Bauzá (1913) surveys a Dairy Census corresponding to five provinces (San José, Florida, Canelones, Montevideo y Lavalleja) and reports ranges of milk yield per cow/day: 34 per cent produced up to 3 litres per cow/day, 20 per cent produced 3 litres; 13 per cent 5 litres; 6 per cent 6 litres and 27 per cent between 7 and 11 litres.[18] We weight these values and obtain an average of 3.5 litres per cow/day.

We assume the same milking days per year used for New Zealand.

BAUZÁ, Ernesto (1913) "Abastecimiento de leche higiénica a Montevideo", en *Revista del Ministerio de Industrias* No. 5, Octubre.

DIRECCIÓN GENERAL DE ESTADÍSTICA (1911): *Anuario Estadístico de la República Oriental del Uruguay*, Tomo II, Parte III, Censo General de la República en 1908, Imprenta Artística, Montevideo.

MINISTERIO DE INDUSTRIAS (1917): *Estadística Agrícola 1916*, Oficina de Estadísticas Agrícolas, Imprenta Nacional, Montevideo.

MINISTERIO DE GANADERÍA Y AGRICULTURA (1939): *Censo Agropecuario Año 1937*, Primera Parte, Stock Ganadero, Sección de Economía y Estadística Agraria, Dirección de Agronomía, Impresora City, Montevideo.

MINISTERIO DE GANADERÍA Y AGRICULTURA (1939): *Censo Agropecuario Año 1937*, Segunda Parte, Lechería, porcinos, equinos, asnal y mular, cabríos, avicultura, apicultura, Sección de Economía y Estadística Agraria, Dirección de Agronomía, Impresora City, Montevideo.

4.1.2 Dairy produce

Production of butter and cheese of New Zealand and the corresponding factories for 1908 comes from NZYB (1910). Data is expressed in the Imperial system and we transform to the International System of Units with the coefficient 1 ton=1.016 tonne.

Production of butter and cheese in Uruguay for 1908 comes from Agricultural Census (p. 1014) and the factories from Industrial Census (pp. 1153-54, 1179-99).

CENSUS AND STATISTICS OFFICE OF THE DOMINION OF NEW ZEALAND: *The New Zealand Official Year-Book 1910*. Wellington. Chapter 39. Section XIV.—occupation of land; and livestock. http://www3.stats.govt.nz/New_Zealand_Official_Yearbooks/1910/NZOYB_1910.html#idsect2_1_156077 (Access May 15th, 2012).

DIRECCIÓN GENERAL DE ESTADÍSTICA (1911): *Anuario Estadístico de la República Oriental del Uruguay*, Tomo II, Parte III, Censo General de la República en 1908, Imprenta Artística, Montevideo.

4.1.3 Dairy exports

Exports of butter and cheese corresponding to New Zealand come from NZYB (1910). Data is expressed in the Imperial system and we transform to the International System of Units.

Exports of butter and cheese corresponding to Uruguay for 1908 come from Statistical Yearbook (p. 623).

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[17] Corresponding to 8 provinces (Canelones, Colonia, Florida, Maldonado, Montevideo, Paysandú, San José and Soriano) than represent the national milking area. Because these provinces form a specialized region, in fact, we obtain a high ratio.

[18] Data correspond to number of milk cows and we assume that the number of cows is homogenous in the sample.

CENSUS AND STATISTICS OFFICE OF THE DOMINION OF NEW ZEALAND: *The New Zealand Official Year-Book 1910*. Wellington. Chapter 30. Section V.-Exports. http://www3.stats.govt.nz/New_Zealand_Official_Yearbooks/1910/NZOYB_1910.html#idsect1_1_71240 (Access May 15th, 2012).

DIRECCIÓN GENERAL DE ESTADÍSTICA (1911): *Anuario Estadístico de la República Oriental del Uruguay*, Tomo I, Imprenta Artística, Montevideo.

4.2 Motive power in manufacturing

Motive power and number of works (establishments) in manufacturing in New Zealand comes from NZYB (1914) which includes data by districts. In the case of Uruguay, motive power comes from the Statistical Yearbook of 1908 (Industrial Census) (p. 1209) although the source states that, probably, data evidence under declaration. Number of establishments comes from Bértola (1993), p. 80 (we use the item “Manufactura”).

BERTOLA, Luis (1993): *La industria manufacturera uruguaya 1913–1961: un enfoque sectorial de su crecimiento, fluctuaciones y crisis*. Facultad de Ciencias Sociales de la Universidad de la República y Centro Interdisciplinario de Estudios sobre el Desarrollo Uruguay, Montevideo, Uruguay. Cuadro III.2. Número de establecimientos y empleados de la industria y la manufactura, 1908-1930, p. 80.

CENSUS AND STATISTICS OFFICE OF THE DOMINION OF NEW ZEALAND: *The New Zealand Official Year-Book 1914*. Wellington, Chapter 20. Section XX.- Manufactories and works. http://www3.stats.govt.nz/New_Zealand_Official_Yearbooks/1914/NZOYB_1914.html#idsect1_1_209123 (Access May 15th, 2012).

DIRECCIÓN GENERAL DE ESTADÍSTICA (1911): *Anuario Estadístico de la República Oriental del Uruguay*, Tomo I, Imprenta Artística, Montevideo.

4.3 Railways

Length, rolling-stock (number of vehicles) and goods and livestock traffic for New Zealand comes from NZYB (1914) and corresponding to 31 March 1914, including only State-owned lines (95.5 per cent of total system). Data for Uruguay comes from Nahum (2009), pp. 283-297. Territory area is reported in the World Factbook.

CENSUS AND STATISTICS OFFICE OF THE DOMINION OF NEW ZEALAND: *The New Zealand Official Year-Book 1914*. Wellington. http://www3.stats.govt.nz/New_Zealand_Official_Yearbooks/1914/NZOYB_1914.html#idchapter_1_162469; http://www3.stats.govt.nz/New_Zealand_Official_Yearbooks/1919/NZOYB_1919.html#idchapter_1_189377 (Access May 15th, 2012).

NAHUM, Benjamín (Coord.) (2009): *Estadísticas Históricas del Uruguay, 1900-1950*. Tomo IV: Moneda, Bancos, Transportes y Comunicaciones, Servicios. Área de Historia Económica, Facultad de Ciencias Económicas y de Administración, Universidad der la República, Montevideo, pp. 283-297.

WORLD FACTBOOK: Guide to Country Comparisons, *Central Intelligence Agency*, https://www.cia.gov/library/publications/the-world-factbook/rankorder/rankorderguide.html (Accessed May 15th, 2012).