XI Congreso Internacional de la AEHE
4 y 5 de Septiembre 2014
Colegio Universitario de Estudios Financieros (CUNEF)
Madrid

Sesión: "El crecimiento económico en América Latina. Una perspectiva de largo plazo (s. XIX y XX)"

Título de la comunicación: "Capital Stock in Equipment and Energy Consumption Patterns and Divergence between Western Europe and Latin America 1800 - 1970"

Autor/es: Rick Hölsgens (University of Groningen), Cristián Ducoing (Universidad de Valparaíso), Mar Rubio (Universidad Pública de Navarra) and Ben Gales (University of Groningen)

Dirección electrónica de contacto: cristian.ducoingr@uv.cl

Capital Stock in Equipment and Energy Consumption

Patterns and Divergence between Western Europe and Latin America 1800 - 1970

Rick Hölsgens[1], Cristián Ducoing[2], Mar Rubio[3], and Ben Gales[1]

[1]Faculty of Economics and Business, University of Groningen,
h.n.m.holsgens@rug.nl , b.p.a.gales@rug.nl
[2]Economics and Bussines administration, University of Valparaíso ,
cristian.ducoingr@uv.cl
[3]Department of Economics , Public University of Navarra , mar.rubio@unavarra.es

AEHE
XI Congreso Internacional de la Asociación Española de Historia Económica. 4 y 5 de septiembre
Mesa
El crecimiento económico en América Latina. Una perspectiva de largo plazo (s. XIX y XX)

Abstract

The Latin American economies began their independent histories with vast endowments of land and natural resources per person, and were for a while, more prosperous than some European nations. The gap that progressively opened between these promising lands and the Western world remains as one of the central questions of economic history and economic development. We approach the issue of when (and how) Latin America fell behind from a new perspective: energy and capital usage. We use the latest estimations of capital stock (machinery and equipment) and energy consumption for Latin America and compare them with those of Western Europe. The energy capital ratio (how much capital is used per unit of energy) could be a predictor of economic growth, thus providing some answers about the timing and causes

of the different modernisation patterns of these regions.

Keywords: Capital stock, energy, energy efficiency, Latin America, Europe.
JEL Codes:

Contents

1 Introduction

The economic divergence between Latin America and developed countries is one of the big questions in economic history research. In this study we focus on capital-energy ratios in nine European and seven Latin American countries in order to compare changing capital-energy relations between these regions. We argue that the rapid increase in energy-capital ratios in Europe, as compared with Latin America, signal economic progress through investment in more (energy) efficient machinery and equipment; a development that was largely lacking in Latin America

Latin American countries began their independence with vast endowments of land and natural resources, and were for a while, more prosperous than some European nations. Nevertheless, over the course of the nineteenth and twentieth century, Latin America did not manage to maintain its position and a divergence between Europe and Latin America emerged (Bértola and Ocampo, 2012). There have been several studies to measure and explain these differences[1]. Both physical

[1] In the recent years, just for mention some works (Bulmer-Thomas, 2003; Maddison, 2007)

capital stocks[2] and energy consumption have been used as proxies for economic development, and as explanations for the divergence. In this article we look at the ratio between capital and energy. The E/K ratio can signal increasing efficiency (i.e. how efficient did countries use their available energy to develop physical capital), and it shows investment in modern (more energy efficient) capital goods. Divergence and structural breaks in capital-energy ratios for Latin American and European countries might shed some new light on the economic divergence that occurred between these regions in the twentieth century.

The economic divergence between Latin America and developed countries is one of the big questions in economic history research. In this study we focus on capital-energy ratios in nine European and seven Latin American countries in order to compare changing energy efficiencies between these regions. There have been several attempts to measure the differences in output per capita, but the GDP levels, by their own, are not the best measures to understand the divergence process between countries [3]. Our approach, in line with the recent work by Kander et al. (2014), want to measure with new data the efficiency and improvement in energy, complementing the energy indicators with capital equipment. Both physical capital stocks[4] and energy consumption[5] have been used as proxies for economic development in the absence of reliable GDP estimates[6]. Increasing capital-energy ratios, on the other hand, signal increasing efficiency, i.e. how efficient did countries use their available energy to develop physical capital.

Non- residential capital stock estimates can be used a proxy for economic development with a high level of confidence. In the case of capital stock in machinery and equipment, there are an important number of studies that prove the importance of equipment in development Several scholars have done research in this area to provide estimates for Europe[7]. For Latin America, the main research has been elaborated by Hofman (2000); Tafunell and Ducoing (2015). However, the non-residential capital stock could be an empty variable to understand the divergence between developed and developing countries if there are not other parameters to understand the reasons behind capital accumulation. One of these parameters is energy consumption; there have been several publications of energy series in Europe (Gales et al., 2007; Kander et al., 2014) and recently, there are new works with series for Latin America (Rubio et al., 2009; Yáñez et al., 2013). With

[2] (Tafunell and Ducoing, 2015) and

[3] The best attempt to elaborate GDP comparison between Latin American countries and Western Europe is the work by Bolt and van Zanden (2013). We use this work to measures energy intensity.

[4] e.g Tafunell and Ducoing (2015)

[5] e.g. Rubio et al. (2009)

[6] **We must change this sentence**

[7] See the bibliography from Tafunell and Ducoing (2015)

Table 1: GDP per capita in several years

	1850	1870	1913	1950	1973
Belgium	1.847	2.692	4.220	5.462	12.170
France	1.597	1.876	3.485	5.186	12.824
Germany	1.428	1.839	3.648	3.881	11.966
Italy		1.542	2.305	3.172	10.414
Netherlands	2.355	2.755	4.049	5.996	13.081
Portugal	923	975	1.250	2.086	7.063
Spain	1.079	1.207	2.056	2.189	7.661
Sweden	1.076	1.345	2.874	6.739	13.494
UK	2.330	3.190	4.921	6.939	12.025
Argentina		1.417	4.038	5.276	8.077
Brazil		691	694	1.559	3.795
Chile		1.233	2.836	3.741	4.938
Colombia		527	786	2.042	3.351
Mexico		623	1.528	2.308	4.883
Uruguay		1.833	2.694	4.506	5.041
Venezuela		544	1.184	5.201	9.587

Source: Bolt and van Zanden (2013) for Europe and Bértola and Ocampo (2012) for Latin America

these newest available data sets, in this article the authors will present several statistical analyses to answers if the capital - energy patterns are related with the income per capita gap amongst both regions. To do the analysis, the authors have choosen nine European countries and seven countries from Latin America. The countries have been chosen by the data available in both variables, but we also believe them to be representative for their regions. The article will be structured as follows; the second section will present the methods and the data to do the comparisons. The third section contents the descriptive statistics of the analysed countries, looking for the period of the divergence and section four concludes.

2 Capital stock in equipment and Energy as proxies

Energy consumption can be a proxy of (modern) economic activity (Rubio et al., 2009). However, when this energy is used inefficiently a lot of it may be wasted and it may not actually contribute to economic development. While it may sometimes appear that only since the 1970s energy efficiency has become an issue, it was actually rather the period of the post-Second World War boom that was a historical anomaly. During this period, characterized by Pfister with the 1950s syndrome, energy seemed to be available in unprecedented and unlimited supply (Pfister, 2010). During most of the nineteenth and twentieth century attempts to economize on fuel were the norm (Ayres et al., 2003). This can also be seen from the ever decreasing energy intensity levels documented by Gales et al. (2007). They find that according to their new series, "energy intensity tends to decrease, except during the 1950s and 1960s: a period of fast economic growth and very low energy prices" (Gales et al., 2007, p.236). Energy intensity, the most commonly used indicator of a country's energy efficiency is a very crude measure though (Ang, 2006). Energy intensity is the total energy input of an economy divided by the total output of that economy. In other words, it measures the amount of energy needed to produce 1 unit of GDP (usually expressed as the amount of Joule per dollar or euro of GDP) (Gales et al., 2007; Kander et al., 2014). Alternatively, one could reverse this and examine the output produced per input of Joule, named energy productivity (Kander et al., 2014). The energy productivity expresses the output a country produces given its available input of energy. In terms of energy efficiency, this measure is therefore somewhat more intuitive as an increased energy productivity means that a country has been able to produce more, while using (relatively) less energy . One important downside of the use of GDP data as a measure for energy intensity or energy productivity is that changes do not necessarily need to be caused by energy efficiency improvements, but can be the result of structural change (i.e. from an industrial to a service economy) (Kander et al., 2014). By focusing on the relation between physical capital (i.e. machine and equipment capital stock) and energy, we can overcome this to some degree. Obviously, the capital-energy ratio cannot fully circumvent this though. Energy intensive industries (i.e. mining and steel, chemistry) will consume more energy relative to less energy intensive industries without necessarily adding more to the capital stock. Nonetheless the energy-capital relation can determine more accurately the (thermal) efficiency improvements that have taken place since more physical capital has been created/operated using (relatively) less energy. Kander et al. (2014) find that the capital-energy ratio for Sweden, England and Spain increased between 1870 and 2000 (by a factor 10 for Sweden, 4-5 for England and Spain). In this paper we analyze the energy-capital ratio for nine additional European countries, and compare the European trajectory with seven Latin American countries[8].

Capital energy is thus a, albeit still crude, more accurate measure of energy efficiency than energy intensity or energy productivity. However, besides investigating diverging energy efficiencies in their own right, Stern has noted two further important 'stylized facts' related to the capital-energy ratio that make this study worthwhile. First, capital/energy is positively correlated with GDP per capita (Stern and Enflo, 2013) (Stern, 2009, 2011). Hence a higher/increasing K/E ratio is indicative of increasing welfare. Although this says little about the causal relations, it shows that richer countries tend to have higher capital-energy ratios. The second relevant 'stylized fact' is that (at least for the period 1970-2010) the capital-energy ratio of richer countries in-

[8] Trends in seven countries, trends and levels in 4 countries

creased, while in poorer countries (most notably African and Latin American) the capital-energy ratio stayed more or less constant, or even declined (Csereklyei and Stern).

Increasing capital-energy ratios are indicative of efficiency improvements, however, they are also indicative of investment in new, more energy efficient, capital goods. When an investment in physical capital is made, i.e. the machine or infrastructure has been put in place, the energy consumption is more or less determined. In such a so-called putty-clay model, which tends to hold for energy consuming capital , richer countries can be expected to have invested more in higher quality, more energy efficient, capital. Hence a higher capital-energy ratio is indicative of more economic prosperity, while increasing capital-energy ratios over time are indicative of economic development. However, this argument is about capital/energy ratio, but this article will use energy/capital ratio.

There are several reasons to change the study of capital/energy (K/E) ratio by energy/capital ratio (E/K). The K/E ratio has sense if we uses total capital stock (Non-residential and residential). For the majority of the European countries there are problems to get total capital stocks in the long run (Exceptions are found in some countries as Netherlands, United Kingdom, Sweden) and for Latin America, the capital stock estimation are only present (comparable between it) since 1950[9]. If we uses capital stock in machinery & Equipment, we expand the sample and it's possible to research about the energy consumption per unit of capital, another way to understand the development and energy efficiency.

In the next subsections, we firstly present the data sources used (section 3), followed by the energy-capital ratios of our sample countries (section 4). It can be seen that, over the long run, energy/capital decreasing in most/all European countries, while the energy/capital ratios of most/all Latin American countries have been lacking throughout (most of) the twentieth century. The lagging energy/capital ratios we find in Latin America are thus indicative of a lack of investment in energy efficient machinery and equipment in Latin America, and can help to understand the economic divergence between the two continents. Ergo, while Europe invested in more energy efficient, higher quality, capital, Latin America missed out on these developments .

In this study we combine time series data on energy consumption with time series on capital stock in machinery & equipment. The period covered by our analysis includes the nineteenth century and the twentieth century until the emergence of the first Middle East oil crisis in 1973. For those countries for which the data is available, we start in 1800, however, for most countries the available data starts later during the nineteenth century. Our data set includes nine Western

[9] v.Hofman (2000)

European countries and seven Latin American countries (Belgium, France, Germany, Italy, Netherlands, Portugal, Spain, Sweden and the UK (effectively England and Wales) and Argentina, Brazil, Chile, Columbia, Cuba, Mexico and Venezuela). Besides the fact that this combination of countries will provide us with a broad range of countries on both continents, the choice for these specific countries was largely pragmatic as time series for both energy and non-residential capital stocks are available.

2.1 Energy data

Data availability, especially from the side of the Latin American countries, compels us to restrict our analysis to the use of modern energy carriers (i.e. fossils). An obvious downside of this restriction is that especially in the nineteenth century, organic energy sources still made up substantial shares of the total energy consumption for many of our sample countries. Gales et al. (2007) have shown the actual importance of including traditional sources of energy to get a proper view on the historical trajectory of energy intensity. However, if we except the view expressed by Rubio et al. (2009) and Rubio and Folchi (2012) it can be argued that we are looking at a process of modernization, and that in this process modern energy carriers were the main sign of economic development.

A further complication in terms of data selection occurs with the case of peat; one can discuss whether peat should be seen as a traditional or modern energy source. For most countries in our sample, peat, if present at all, never accounted for more than a few percent of the total energy consumption (after 1800); for the Netherlands this is different. During the first half of the nineteenth century, peat provided roughly half of all the thermal energy in the Netherlands (equivalent to about 20% of the total energy consumption). Although, peat was thus rather important for the Dutch economy, we nonetheless exclude it here as a modern energy source. While peat made larger amounts of energy available to the Dutch than would be proportionate to its acreage if it would be dependent on renewable, it could never sustain modern economic growth the way coal has done[10]. Furthermore, despite plentiful exceptions in the North of the country[11], its application in 'modern' industry has been modest.

[10]de Zeeuw (1978) claims that diminishing cheap peat supplies to the economic centers of Holland caused Holland's decline at the end of its Golden Age. His findings have been highly contested though. de Vries and van der Woude (1997) claim that peat was very important for the emergence of 'the first modern economy', but don't believe diminishing supplies were the cause of decline. Although the production of peat remained stable and even increased somewhat during the nineteenth century, it seems unlikely though that securing all thermal energy the Netherlands imported in the form of coal could have been derived and sustained for more than a few decades if this needed to be sourced from domestic peat.

[11]See

Figure 1: Energy Consumption in Peta Joules. Several countries 1850 - 1973

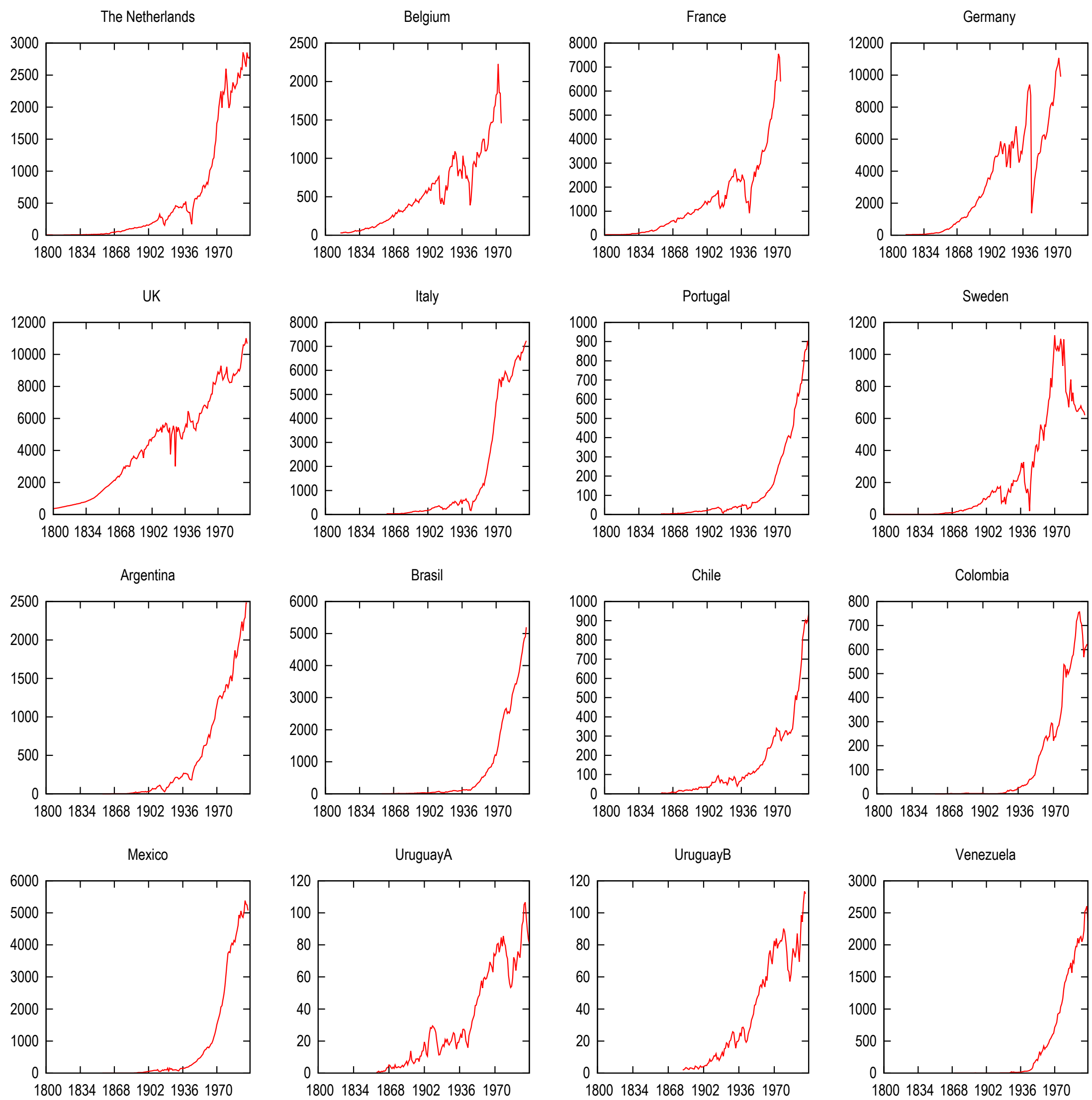


Table 2: Energy consumption (in TJ) per 1000 inhabitants

	1850	1870	1913	1950	1973
Belgium	24,87	57,49	99,76	102,71	190,52
France	5,58	14,25	45,04	57,07	141,54
Germany	4,86	21,33	90,11	61,83	140,20
Italy		1,22	9,87	13,96	102,67
Netherlands	4,62	15,00	53,11	55,95	158,32
Portugal		1,25	6,32	7,33	28,52
Spain	20,18	19,12	25,13	26,63	67,84
Sweden	0,71	3,21	30,73	52,38	129,59
UK	53,32	80,32	122,84	118,40	165,21
Argentina		0,96	14,64	23,79	50,64
Brasil		0,78	2,89	5,02	16,55
Chile		3,49	25,53	19,17	32,37
Colombia		0,19	0,14	5,36	10,87
Mexico			3,41	13,60	32,57
Uruguay		8,74	21,42	16,13	28,72
Venezuela			0,40	32,45	77,31

Source: Gales et al. (2007); Rubio et al. (2009); Rubio and Folchi (2012)

2.2 Capital stock in machinery and equipment

The study of the capital stock in the developed world has been a recurrent research topic. The seminal works of Goldsmith (1951), Kuznets (1961) and Feinstein (1972, 1988) have provided a reference for subsequent studies conducted on many industrialized countries. The most common way to estimate the capital stock is the Perpetual Inventory Method (PIM) which consists of the weighted sum of past investment flows. The gross stock investment is calculated by adding the cumulative year-to-assets and subtracting totally worn (withdrawals).

The formula for calculating the gross stock in year t is thus the followingFeinstein (1988)

1.) $GFCS_{t-1} + GFCF_t - Rtr = GFCS_t$

Where $GFCS_{t-1}$ is the stock of year $t-1$, $GFCF_t$ is fixed capital formation in the current year (t) and Rtr are capital withdrawals produced in the current year. The net stock is obtained by subtracting the gross stock depreciation, which is expressed in mathematical terms as follows:

2.) $NFCS_{t-1} + GFCF_t - \delta - \delta(Rtr) = NFCS_t$

Where $NFCS_{t-1}$ is the net capital stock at the beginning of year t, $GFCF_t$ is the gross fixed capital formation during the year, δ is the depreciation during the period, $\delta(Rtr)$ are depreciated capital goods removed during the year t and $NFCS_t$ is the net capital stock at the end of period t.

The PIM requires two masses of information: historical series of GFCF at constant prices, for each type of asset and the capital stock in the initial year.OECD (2009) The latter can be derived directly from the first mass of information, when you set the initial year in the terminal year of life of the first generation of assets with the greatest longevity. For example, with respect to the nineteenth century, if we attribute a life of 50 years to non-residential buildings and we have investment series dating back to 1850, the initial year of the aggregate capital stock is 1900. This is precisely the option we have chosen. Upon calculation of the capital stock in equipment only the initial year of the stock goes back to 1875, on the assumption that, during that period, the life of these assets was 25 years. In Maddison historical series of productive capital accumulation (non-residential capital) were published for six developed economies: Germany, France, UK, Japan, USA and the Netherlands. The data are estimates are half-year, considering the accumulated investment as the expected life of the relevant assets. For Maddison these are all non-residential structures, machinery, vehicles and equipment, excluding land, natural resources, intangibles (human capital, etc.), precious metals, foreign exchange reserves, foreign assets, etc. In short, we have take the data for United Kingdon, Germany and France from Maddison, and we have used to convert the other European estimations to the same unit.

In the case of Latin America, estimates of capital stock have covered shorter periods and had less geographical scope. The most ambitious by Hofman (2000), covers six countries for the period from 1950. For the period prior to this date, the last available data has been elaborated by Tafunell and Ducoing (2015)[12]. Also, there available series in Tafunell (2009, 2013) to expand the capital stock elaborations to other Latin American countries[13]. In this paper, we have done the capital stock estimation in the same

We can observe in table 3 huge differences in capital stock in machinery & equipment at the end of the period (1973). The most developed country of Latin America, Argentina (US$ G-K 1614), was just the half of the less capitalized European country, Spain (US$ G-K 3052). However, if we observe the long run, this situation was different before the IWW. Chile, as example had US$ G-K 504 in machinery per 1000 inhabitants in 1913 and Sweden has just 1,5 times more. If we jump to 1973 this differences has been changed to a ratio of 17 (to Sweden). More impressive than the European growth, is the Latin American backwardness (the only exception is Mexico, but with lower initial levels), especially in the case of Brasil and Chile.

[12]The core of this work consist of quantitative elaborations on the stock of productive capital.(equipment and non-residential construction) during the long twentieth century (1875-2008) in four major economies in the region (AL-4) Argentina, Brazil, Chile and Mexico.

[13]For an analytical description of the long-term evolution of GFCF in Latin America cf. Tafunell (2013).

Table 3: Capital stock in machinery & equipment per 1000 inhabitants

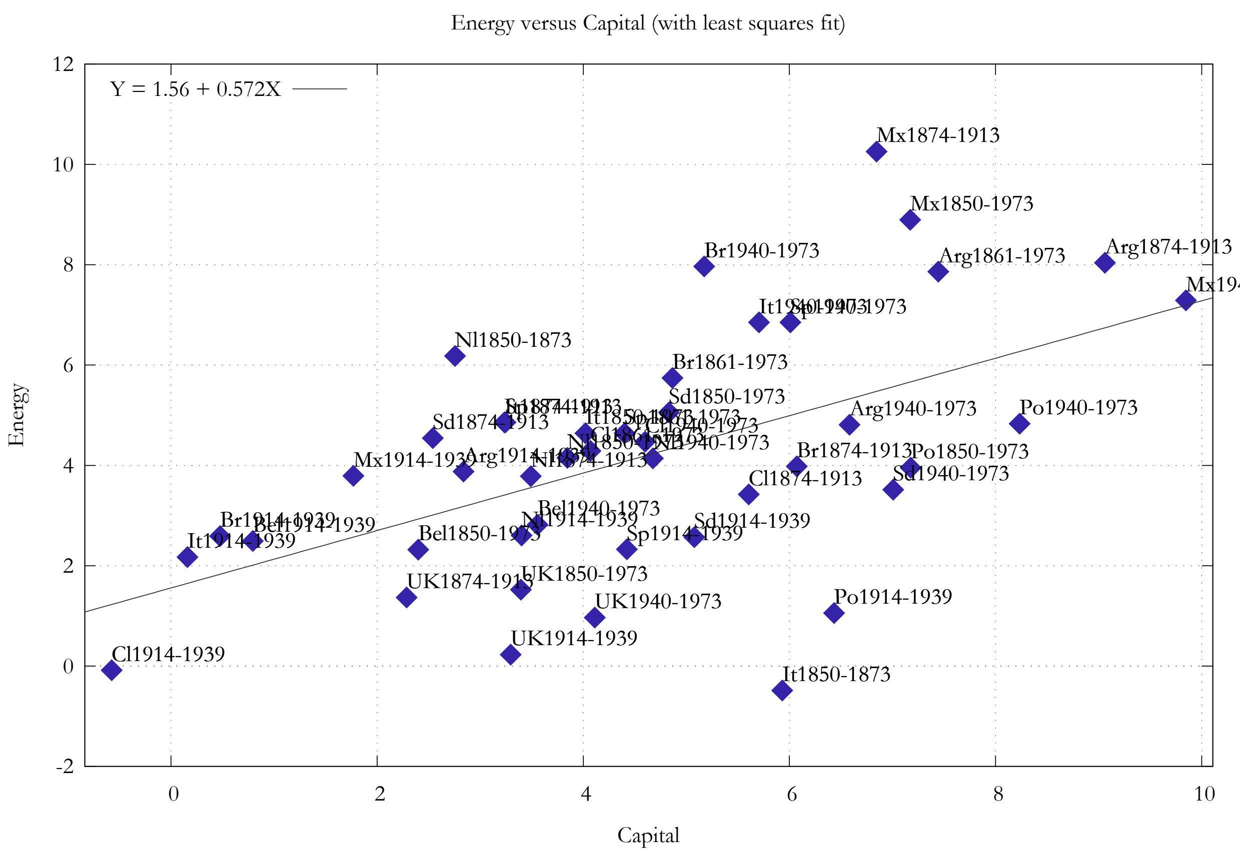
	1850	1870	1913	1929	1950	1973
Belgium				2.328	2.883	6.036
France					1.075	5.009
Germany					1.222	5.335
Italy		237	1.306	702	1.757	5.643
Netherlands	371	525	1.685	2.416	2.216	7.742
Portugal						
Spain			356	650	682	3.052
Sweden	49	136	751	1.188	4.309	12.311
UK			858	1.416	2.132	5.642
Argentina			364	371	639	1.614
Brasil			681	602	571	747
Chile			504	626	479	725
Colombia						
Mexico			180	237	553	1.948

3 How different were Latin America and Europe in the XIX and XX century? An energy intensity approach

With the exception of early coal producers (and consumers) England and Belgium, most (Western) European countries started their industrialization on the basis of coal around the middle of the nineteenth century. In this period, the divergence between Latin America and Europe was still small (see table 1). Even towards the end of the nineteenth century, certain Latin American countries such as Argentina, Uruguay and Chile performed better in terms of GDP per capita than non-core European countries such as Spain, Portugal or even Sweden (Bolt and van Zanden, 2013; Bértola and Ocampo, 2012).

While, overall, the Latin American countries started off at lower levels of per capita GDP in the nineteenth century, their growth rates on average stayed roughly on par with Western Europe until the outbreak of the Second World War. During the war, Latin America seemed to be catching up with Europe, and while after the war especially Venezuela developed quickly, most Latin American countries did not manage to produce the same growth rates as virtually all Western European countries did. Venezuela and Argentina grew rapidly in the 1950s and 1960s, but while the European countries sustained these growth rates, Venezuela and Argentina declined while the other Latin American countries grew at a much slower pace than Western Europe (Bolt and van Zanden, 2013).

Figure 2: Capital Stock in M&E vs Energy Consumption. Growth rates, several periods

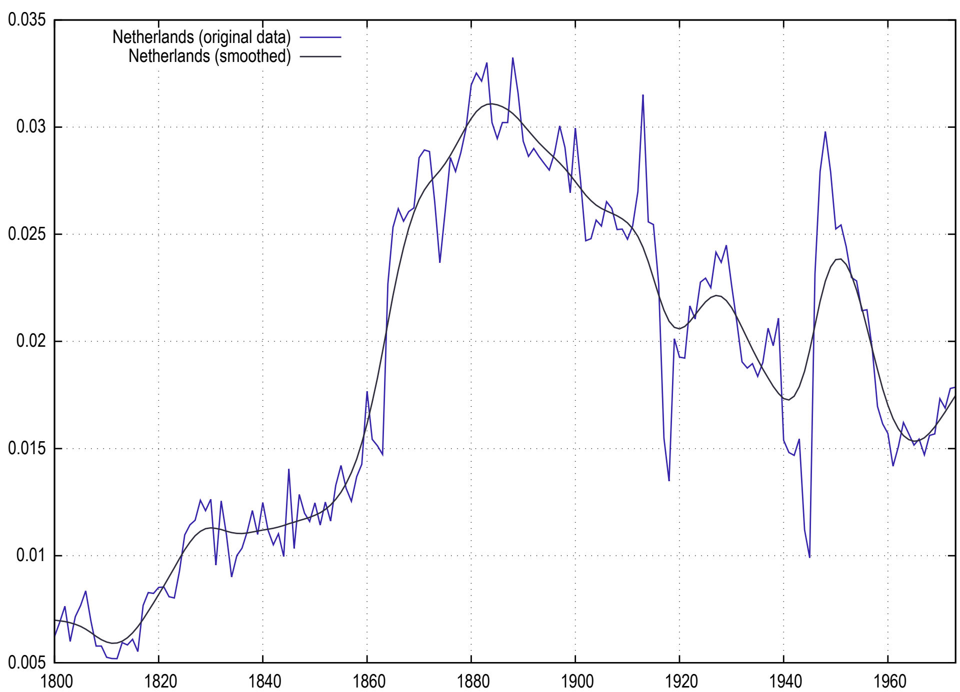


3.1 Trends in E/K ratios

As mentioned above, Kander et al. (2013) found that the K/E ratios in Sweden (10 times) and Spain and Italy (4-5 times) increased markedly between 1870 and 2010. Part of this remarkable increase, especially for the case of Sweden, has to be found in the low initial capital levels, but the growth rate is impressive. In our analysis we find that, overall, in the Western European countries, the K/E ratios for machinery and equipment do indeed increase over the nineteenth and twentieth century.

As ve have explained in the introduction and section two, we will use E/K ratio instead K/E ratio. To introduce to this section, we will present the E/K ratio of the country with longest serie available; Netherlands. As we can see in the figure 3 the energy capital ratio has U inverted shape, with a clear increase in the period 1840 - 1880, that is correlated with the modern industrialization process, and a decline between 1885 to 1960. What is the significance of this decline? the machinery was growing faster than the energy. In a lecture similar to Kander and Schön (2007) when they speak about improvements in K/E ratio, the increases of energy capital ratio

Figure 3: Energy Capital Ratio. TJ per M&E. Netherlands 1800 - 1970.

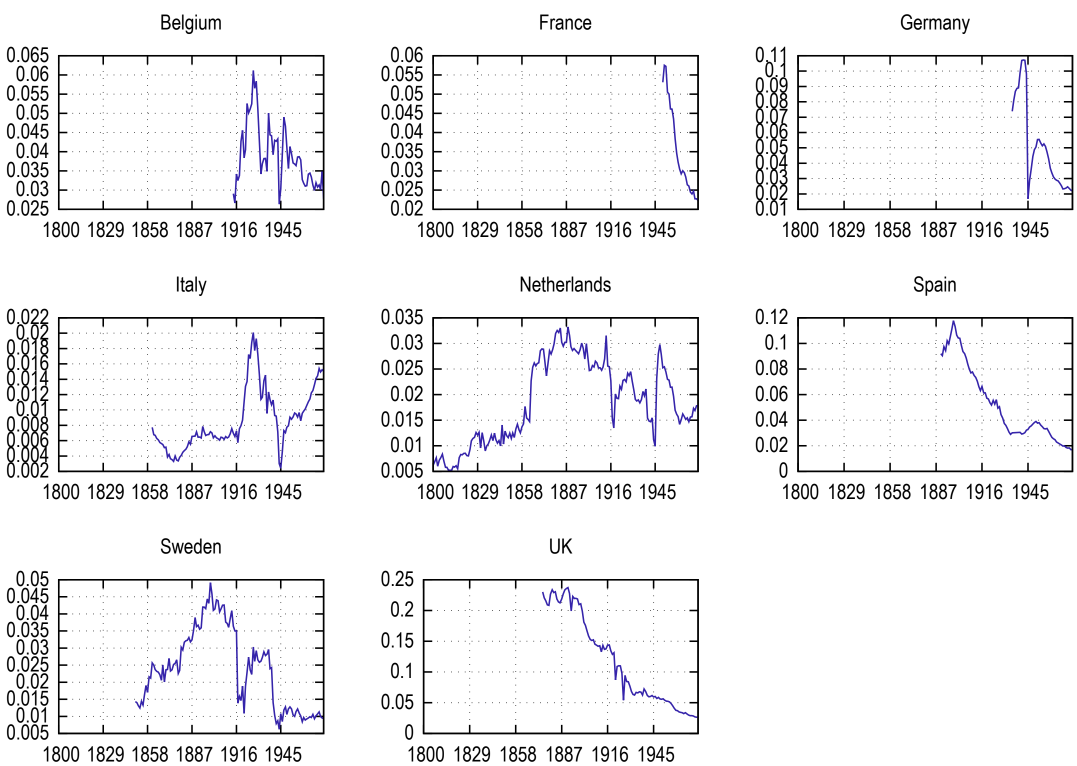


The varying growth rates can in part be explained by the initial position of the countries. Richer countries at the beginning of the nineteenth century such as the United Kingdom, Belgium and the Netherlands, for instance, show much lower growth rates than late industrializing countries such as Sweden (Check this in the data!!!).

Table 4: Energy/Capital Stock in M&E Ratio (TJ per thousands M&E units)

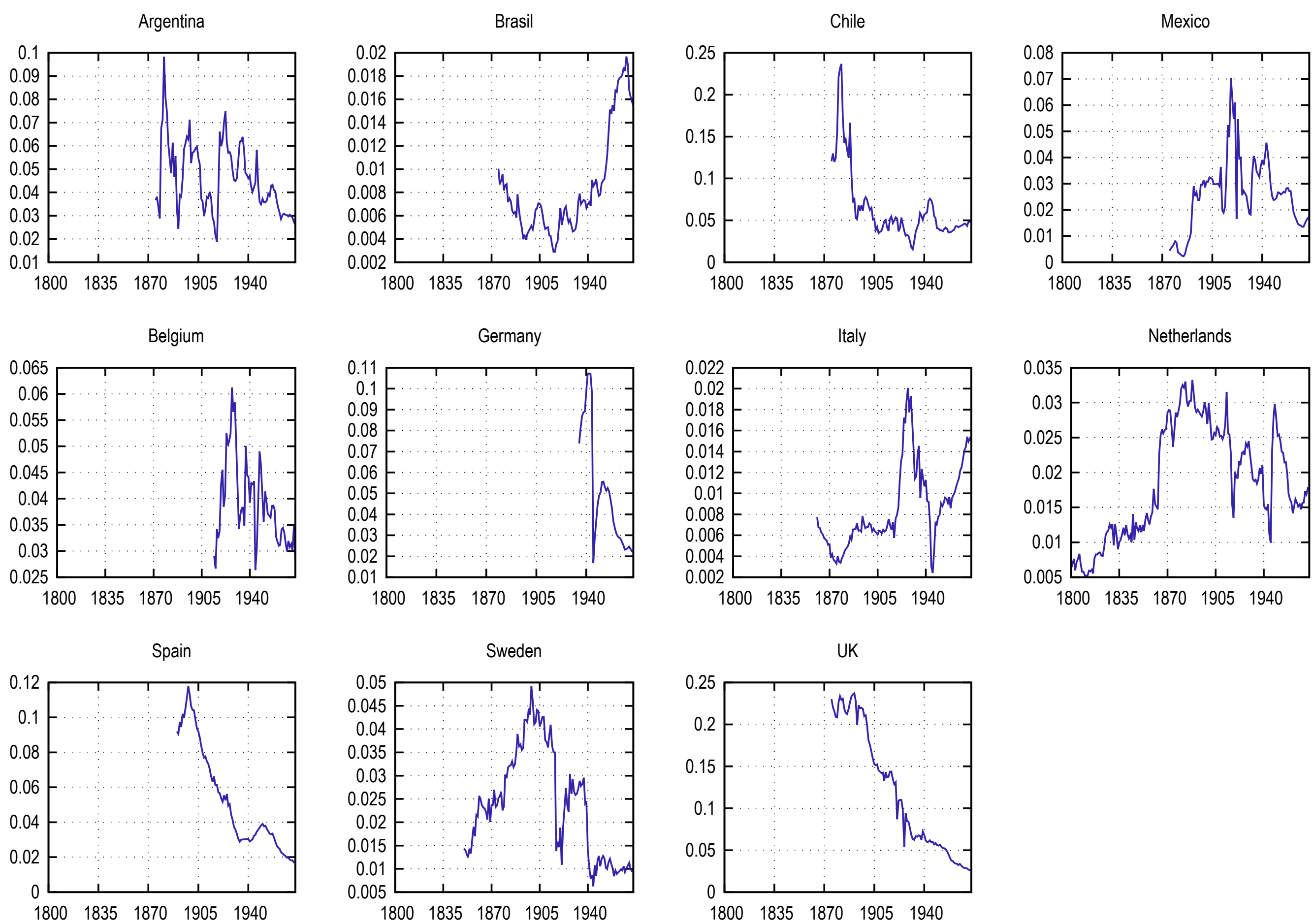
	1850	1875	1913	1929	1950	1970
Belgium			29,1	58,4	35,6	31,3
France					53,1	24,7
Germany					50,6	24,6
Italy		3,3	7,0	19,3	7,9	15,4
Netherlands	12,5	26,1	25,6	24,5	25,2	17,3
Spain			66,2	41,5	39,1	18,2
Sweden	14,3	25,2	36,4	29,2	12,2	11,3
UK		230,2	136,8	84,1	55,5	28,4
Argentina		36,7	37,6	49,6	37,2	29,8
Brasil		10,0	3,5	4,6	8,8	16,7
Chile		120,5	41,7	31,7	40,0	43,3
Mexico		4,4	21,2	25,3	24,6	14,9

Figure 4: Energy Capital ratio. 9 European countries. 1800 - 1970



Remarkably though, the growth rates we find in Western Europe are virtually non-existent in the Latin American countries in our sample. Earlier, we noted already that Csereklyei and Stern found that Latin American countries show stable or even declining capital-energy ratios since the 1970s. Our data proves that the backwardness in modern capital development in Latin America goes further back than the 1970s.

Figure 5: Energy Capital ratio. Tj per capital stock in machinery & equipment in $ Geary -Khemis. Eleven European and Latin American countries. 1800 - 1970



4 Conclusions

In this paper we compared the long trends in energy-capital ratio of nine Western European and seven Latin American countries. We found, following up on Kander et al. (2013) and Csereklyei and Stern, that the E/K ratios in Western European countries, overall, grew steadily over the course of the nineteenth and twentieth century. Latin American countries stayed behind in this development though.

We argue that increasing E/K ratios are a proxy for economic development as increasing E/K ratios signal investment in more energy efficient, i.e. more modern, machinery and equipment. Whereas Western European countries managed to keep investing in new and better machinery, Latin America stayed behind and did not succeed in keeping up with the developments in the Western World.

Bibliography

Ang, B. (2006). Monitoring changes in economy-wide energy efficiency: From energy–gdp ratio to composite efficiency index. *Energy Policy 34*(5), 574 – 582. Hong Kong Editorial Board meeting presentations Hong Kong Editorial Board meeting presentations.

Ayres, R. U., L. W. Ayres, and B. Warr (2003). Exergy, power and work in the US economy, 1900–1998. *Energy 28*(3), 219–273.

Bértola, L. and J. A. Ocampo (2012). *The Economic Development of Latin America Since Independence*. Initiative for Policy Dialogue. (Oxford: Oxford University Press).

Bolt, J. and J. L. van Zanden (2013). The First Update of the Maddison Project; Re-estimating Growth Before 1820. Technical report.

Bulmer-Thomas, V. (2003). *The Economic History of Latin America since Independence*. (Cambridge: Cambridge University Press).

de Vries, J. and A. van der Woude (1997). *The First Modern Economy: Success, Failure, and Perseverance of the Dutch Economy, 1500-1815*.

de Zeeuw, J. W. (1978). *Peat and the Dutch Golden Age: The Historical Meaning of Energy-attainability*.

Feinstein, C. H. (1972). *National income, expenditure and output of the United Kingdom:1855-1965*.

Feinstein, C. H. (1988). *Studies in capital formation in the United Kingdom :1750 -1920*.

Gales, B., a. Kander, P. Malanima, and M. Rubio (2007, August). North versus South: Energy transition and energy intensity in Europe over 200 years. *European Review of Economic History 11*(2), 219–253.

Goldsmith, R. W. (1951). A Perpetual Inventory of National Wealth. In *Studies in Income and Wealth, Volume 14*, NBER Chapters, pp. 5–74. (New York: National Bureau of Economic Research).

Hofman, A. A. (2000). *The Economic development of Latin America in the twentieth century*. Cheltenham, etc.: (Cheltenham: Edward Elgar).

Kander, A., P. Malanima, and P. Warde (2014). *Power to the People: Energy in Europe over the Last Five Centuries(Google eBook)*. Princeton University Press.

Kander, A. and L. Schön (2007, September). The energy-capital relation—Sweden 1870–2000. *Structural Change and Economic Dynamics 18*(3), 291–305.

Kuznets, S. (1961). *Capital in the American Economy: Its Formation and Financing*. Number kuzn61-1 in NBER Books. (National Bureau of Economic Research, Inc).

Maddison, A. (2007). *Contours of the World Economy 1-2030 AD: Essays in Macro-Economic History*. (Oxford: Oxford University Press).

OECD (2009). *Measuring Capital - OECD Manual 2009 Second edition: Second edition*. OECD Publishing.

Pfister, C. (2010). The "1950s Syndrome" and the transition from a slow-going to a rapid loss of global sustainability. Chapter The "1950s. University of Pittsburgh Press.

Rubio, M. and M. Folchi (2012). Will small energy consumers be faster in transition? Evidence from the early shift from coal to oil in Latin America. *Energy Policy 50*, 50–61.

Rubio, M. D. M., C. Yáñez, M. Folchi, and A. Carreras (2009, November). Energy as an indicator of modernization in Latin America, 1890-1925. *The Economic History Review 63*(3), 769–804.

Stern, D. I. and K. Enflo (2013). Causality Between Energy and Output in the Long-Run Lund Papers in Economic History. (126).

Tafunell, X. (2009). Capital Formation in Machinery in Latin America, 1890-1930. *The Journal of Economic History 69*(04), 928.

Tafunell, X. (2013). Capital formation in Latin America: one and a half century of macroeconomic dynamics. *CEPAL Review 109*, 7–28.

Tafunell, X. and C. Ducoing (2015). Non-Residential Capital Stock in Latin America . 1875 – 2008. *Australian Economic History Review* (May 2015), 1–32.

Yáñez, C., M. d. M. Rubio, J. Jofré, and A. Carreras (2013). El consumo aparente de carbón mineral en América Latina, 1841-2000. Una historia de progreso y frustración.