Capital formation in machinery and industrialization.

Chile 1844 – 1938

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Abstract

The present paper revisits an old theme in Latin American and Chilean economic history; the early industrialization in the XIX - XX centuries. The difference with previous approaches is the elaboration of new quantitative series of Chilean machinery investment in the long run and its relative prices and composition, in the period when some authors have sited the beginning of the industrialization in the continent. Initial findings, based on the participation of capital formation in machinery imports and GDP, do not reinforce the idea of early industrialization in Chile.

JEL Classification: E22; L60; N16; N66 and 014

Keywords: industrialization; capital formation; machinery; Chile.

1. Introduction

Since the 1980s many articles have been written arguing for an early industrialization in Latin America (Suzigan 1988;.) before the period known as ISI. This argument has a long discussion about the effects of this industrialization in economic growth and public policy in the last period, because is not feasible industrialization project from scratch, if there was a previous industrial base.

In this paper, the objective is a new quantitative approach to this idea with machinery data base, elaborated from the Chile's foreign trade and statistical yearbook and foreign trade statistics from UK and USA. The importance of this data base is based in three principal characteristics: In first place, is a series in the long run, since 1844 to 1938 (the most common year to set up the beginning of the industrial policy by the state); second, an index of the machinery prices; finally, the third point; disaggregation by productive sector composition (agricultural, mining, industry and transport equipment). With these new series, it's possible to observe the real amount expended in capital formation in industrial machinery (henceforth CFM) by the country and have a new approach to the early industrialization in Latin America. The composition of machinery and its prices are proxies of the degree of industrialization and cost opportunity, respectively. The chosen period 1844 – 1938 have two advantages; in first place, is a period with a great number of unexplored statistical sources, and second, cover all the years before the ISI[1].

The paper is organized as follows; in section 2, a brief resume about early industrialization in Latin America and Chile; section 3 explain the methodology to build data base of capital formation in machinery; section 4 presents the outputs of the new data base, price and investment composition; Section 5 shows an interpretation of the industrialization process towards the share of the capital formation in machinery in imports and GDP. Section 6 concludes.

2. Early industrialization in Latin America and Chile. Actual debates.

If industrialization is defined as the share of industry in GDP, Latin America was far from being an industrialized continent in the middle of the nineteenth century. The main economic activity was agriculture, and the few macroeconomic and social indicators of this century, confirms this assessment. However, several indicators of the early twentieth century created a new perception of the region's economic development. The works of Palma (1979), Bulmer - Thomas (1997), Gómez and Williamson Galvarriato (2009) and Williamson and O'Rourke (2010) generated a new idea of industrialization before the ISI. This idea is linked to Lewis (1954) model two sectors, a sector highly developed and industrialized, as the meat industry in Argentina or the coffee industry in Brazil, but the other sector, rural and primitive, the like the model *Hacienda* in Chile. The first sector has the potential to continue to grow, based on low wages in the sectors of the primitive. This reduces the pressure on wages in the modern sectors and may have continued growth.

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[1] Williamson and Gomez Galvarriato (2009) had done a similar approach, just with the USA and UK foreign exports and without the whole amount of machinery investment. In the case of Tafunell (2009), his comparative work begins in 1890.

About Chile, since the decade of 1970, there is a historic debate about early industrialization, centered in copper foundries and flour mills (García), 1989. Pp. V). In this line, Carmagnani titled his referential book *Industrial development and economic underdevelopment. The Chilean case (1860 – 1920)*[2]. This argue is centered in an unequal development of the Chilean economy, traduced in "one or two" modern sectors, wheat in the decade 1840 – 1850, copper since 1830, and nitrates after the Pacific War against Peru and Bolivia (1879 – 1883). Palma (1979) continues with this argument, and in his doctoral dissertation he proposes an interpretation of the Chile's industrial birth in the XIX century and pre I World War, in opposition to the traditional view of an Industry born in the 1930's.

However, the idea of an industrial boom in Chile during the last years of the nineteenth century and the period before World War I, it is difficult to sustain empirically if there is no industrial GDP to reinforce this hypothesis[3]. There is only one index of the growth (not the amount properly) of the industrial output for the years before to 1913. In this moment, the idea of elaborate a new industrial output is not the best option[4]. It is possible to measures the level of industrialization by another way, in this case a proxy; the share and composition of the machinery investment (in the imports and GDP).

3. Series of capital formation in machinery. Methodology.

In studies about Latin American performance in the long run, there is a lack of quantitative studies mostly because of a lack of data and long run economical series. This work is in the area of quantitative economic history, not with the aim of undermine the traditional periodization of the Chilean economic history, but rather to substantiate this chronological classification with quantitative data.

3.1 Previous series of capital formation in machinery

The road chosen in this article is to research the origins of the industrial development, to understand in a better way the patterns of growth of Chile. There are two series of machinery investment before this work. The first, Hofman (2000), presents machinery investment data for Chile and another five countries from 1900 to 1997 (actually 2005). Between 1900 and 1940 this data base is constructed using statistical yearbook from ECLAC 1949. The second is a new contribution of Tafunell (2009) building of machinery investment data for Latin America countries since 1890 to 1930, the historical period called first globalization. The methodology of this work is using exports of G3 (UK, USA, and Germany) representing nearly 85% of the machinery imports of the above mentioned region. The series presented in this article is part of the PhD. thesis of Ducoing (forthcoming), and is built with the Chilean statistical yearbooks (1830 – 1938), primary sources and others official data.

As is possible to appreciate, the existences of machinery series for Chile is principally for the XX century and not for the XIX, so, there is a problem to measure the real amount and value of industrialization.

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[2] Original in italian; Sviluppo industriale e sottosviluppo economico : Il caso cileno (1860-1920)
[3] The most usual industrial output for the period is the result of a regression that counts the raw material imports and a dummy of tariff protection (Kirsch, 1977); more detail in the section 5 of this article.
[4] Marc Badía – Miro and Cristián Ducoing are working in a new chilean industrial GDP.

3.2 The elaboration of a machinery series

To construct a new machinery series for 1844 – 1938, we use the same methodology in Tafunell (2009), but from the demand, the Chilean customs. In this way, we can get all the countries that are exporting machinery to the country, not just the G3.

The basic equation to construct the series is:

$$(1) \quad Y_t = C_t + GCF_t + Ex_t$$

Yt is the output in the year en t, *Ct* is the consume in the year t, *GCFt* is the Gross Capital Formation in the year t y *Ext* are the net exports.

We take GCF from the equation (1)

$$(2) \quad GCF_t = Str_t + Mch_t$$

When *Strt* are the structures (structures, buildings and dwellings) built or started to build in period t *Mcht* is machinery imported in the period t. therefore, we need a new equation to isolate the *Mcht*.

$$(3) \quad Mch_t = Mim_t + Mn_t - Me_t$$

When *Mim* are the imports machinery, *Mn* are the machinery produced in the national territory and *Me* are the exports or re exports machinery [5]. Mention is made indistinctively of machinery investment and machinery imports, because the principal input of machinery investment in Chile was imports. In the first years of this study (1844 - 1881) capital goods imports are equal to the capital formation in machinery. From 1882 to 1913, national capital goods production is somewhat more important, but the share hardly reached above 2% or 3%. This difficulty is avoided in the analysis taking into account a transition period between 1881 and 1900. The analysis the national production of capital goods does not change the principal results.

Even this supposition, and in concordance with others researchers (Gershenkron, 1962; Lee, 1999), it is possibly that the imports of capital goods are an advantage for the developing countries, because they save all the R+D costs.

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[5] A little number of machinery was (re) exported to Bolivia and Mendoza.

Table Nº1

Example of machinery Imports

Products	1844		1845	
	(weight or measure)	(Value)	(weight or measure)	(Value)
Mining Machinery	3	3100	3	3015
Print Machinery	4	4400	4	4100

Source: Chile`s Foreign Trade Yearbook, 1845.

The above table presents the more traditional shape of the Chilean's trade statistical. This value is the FOB prices, and is not necessary add taxes, because the machinery was tax exempt. The prices are expressed in Chilean pesos of 1913. The relation with pounds is expressed at the appendix D.

Nevertheless, it is necessary to complete the series have a counterpart; in this case, the best way for the period is the G3 + France. We have the aggregate series by tafunell (2009) on the period 1890 - 1930, but we need the results for the previous period, and disaggregate. Between 1830 and 1870 the majority of machinery imports come from UK. Since 1871 the share of USA imports grows steadily and appears the German competition.

Table Nº 2

Share of the machinery imports, by origin country.

	France	Germany	United Kingdom	United States of America	Others	Total
1855	10.93%	5.46%	66.04%	15.29%	2.28%	100%
1871*	-	-	36.97%	40,37%	22.66%	100%
1892	2.63%	15.3%	51.61%	25.37%	5.12%	100%
1909	3.52%	18.35%	32.5%	31,62%	14.03%	100%
1928	1.88%	24.59%	16.99%	48.31%	8.24%	100

*Only information about USA and UK. 1871 reason unknown and 1892, civil war. Sources: 1855, *Anuario de comercio exterior*; 1871 and 1892, UK *Annual statement of the trade* and USA *Annual report of the chief bureau on foreign commerce*, 1909 y 1928 *Anuario estadístico de la República de Chile.*

The named "others" in table 2, is a heterogenetic group, including Belgium, Sweden, and Holland in the main group, and the others countries exporting machinery and equipment to Chile.

Table Nº 3

Index, share and growth rate of Raw Material and industrial capital goods

period	raw material			industrial capital godos		
	Value in pesos (000)	(1910-14 =100)	% of total Imports	Value in Pesos (000)	(1910-14 =100)	% of total Imports
1880-84	46927	37	48,5	2668	17	2,8
1885-89	49831	40	47	4177	26	3,9
1890-94	64061	51	45,8	6908	43	4,9
1895-89	58265	46	45,9	3695	23	2,9
1900-04	67964	54	48,2	6586	41	4,7
1905-09	102946	82	42,9	15261	95	6,4
1910-14	126220	100	41,9	16064	100	5,4
1915-20	142709	113	46,6	10761	67	3,6

Source: Appendix 1

In the above table, we see an increment in the share of industrial capital goods over the total imports. But, this increment it could not consistent with a real industrialization process. Even our suppose that machinery imports are equal to total machinery investment, the imports are not the same with GDP. So, is possible that the best period for the machinery investment (1905 – 09; 6, 4%), the capital formation in machinery didn't reach the 6% of the total GDP (in detail, this point it will be analyze in section 5).

In the graph Nº1, the final machinery series[6] (log). Some of the cycles named above appear. In first place, the vast expansion of machinery investment between 1844 and 1858, due to wheat production. In second place, during 1881 – 1892, a new impulse in machinery due to nitrates and railways, after the war against Peru and Bolivia (1879 – 1884). Finally, the process of modernization – industrialization, the first years of XX century and before I World War. The incidence of the Great War is so big, that the amount of CFM in 1922 is equal to the year 1888. Another feature of the CFM is the slowdown in growth after 1912. During 1844 and 1892, total investment in machinery was multiplied by 10, but, as had been anticipated, the amount of investment in 1932 is lower even than that of 1894.

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[6] To reach this series we have use as deflator, the conversion to pounds of Chilean peso, and then, the deflators used by Díaz et al. (2007)

Graph Nº 1

Capital Formation in Machinery

Chile 1844 – 1938. Gold pesos of 18 (LOG)
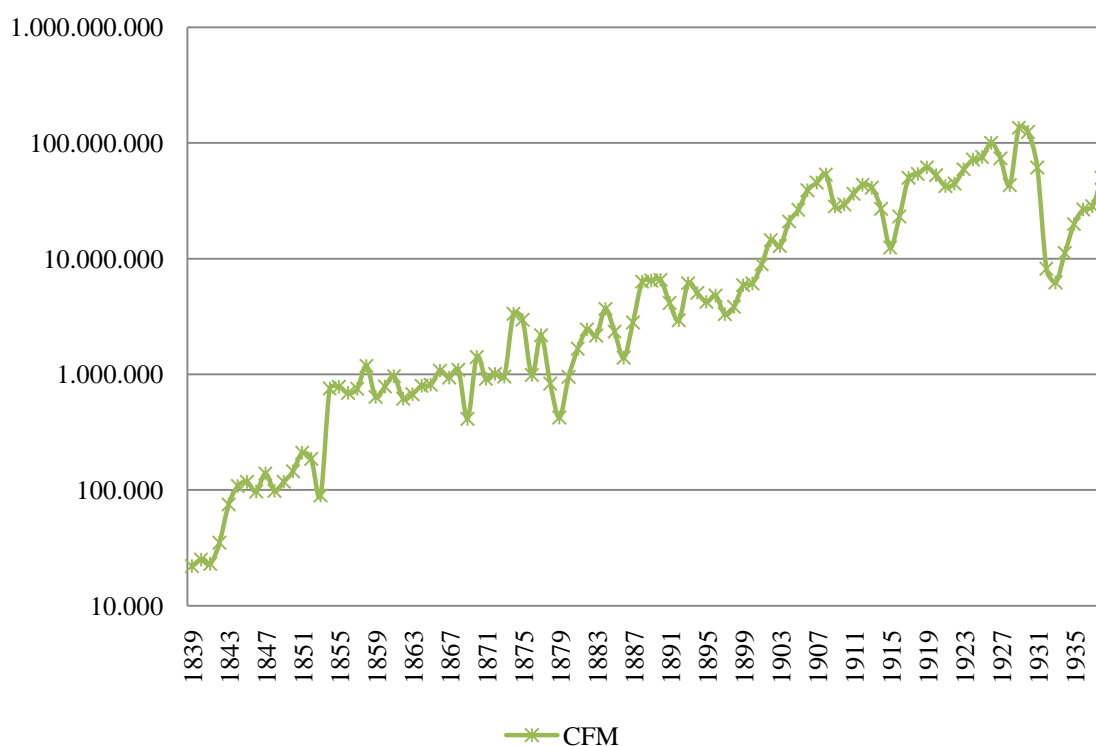
Sources: Appendix 1

4. Relative prices and Composition of CFM

The methodology used to build the new series of machinery investment has two indirect outputs. In first place we get the machinery prices, as we can see in the table Nº1. The prices are nominal, but we use the convertor to the pounds and dollars constructed by Ottone & Cortés (1964) for the Chilean currency.

4.1   Prices

To create a comparison of the different prices components of machinery investment, we defined four kinds of machinery as are classified by OCDE (2009); mining, agricultural, industry and transport equipment. It's impossible (by the moment) take all the different machines that have been imported in this period, but we can choose the most representative by kind. These products are showing in the table Nº4.

Table Nº3

**Kinds of machinery and products of the price sample**

Agricultural	Mining	Industry	Transport
Wheat cleaning machines	Bombs	Machinery for print	Wagons
Windmills and mills	Guides for mines	Machinery for different uses	Locomotives
Plows	Tools for mining machinery	Tools	Tools for Railways

Source: Chilean trade statistics

The machines chosen are part of the structural changes occurring in the Chilean economy over the 94 years covered by this work. In the case of agriculture are represented machinery - used tools for mining guidelines are present throughout the period, like bombs. The industry, the case studied in depth in this work, has the print machinery, an important activity in Chile and Latin America. Finally, wagons and locomotives are the most important elements of the transport sector

Graph Nº 2

Agricultural Machinery prices
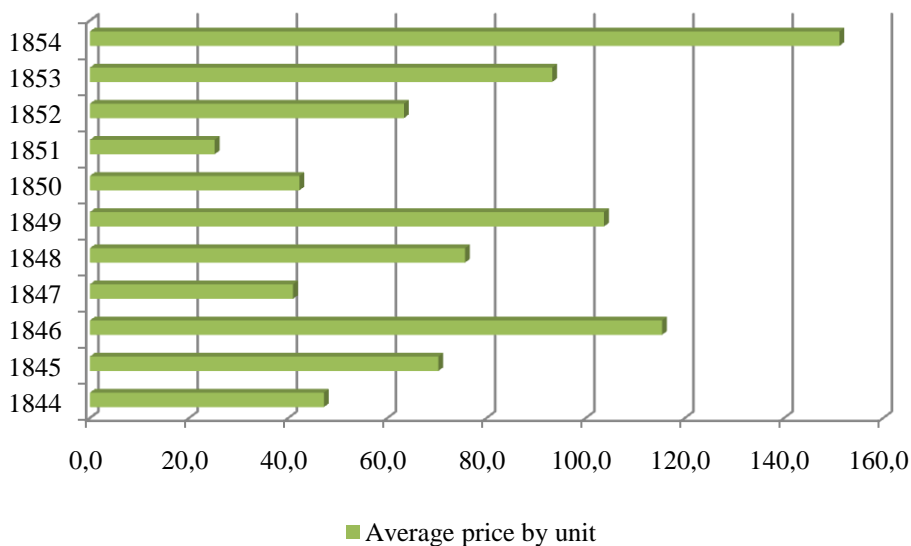
Source. Appendix 1

The Graph Nº 2 shows the average machinery price during the wheat cycle, 1843 – 1855, when the Chileans fields had a important role in the California's *gold rush*. However, the machinery price, more than a performance correlated with the demand[7], shows an important volatility measures in COV.

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[7] One way to measures the demand for agricultural machinery is the wheat output. In this period it`s grows by 6% per year.

4.2 Relative prices and User cost

If the idea is know the real prices or the user cost of machinery, is necessary move on to the relative prices. The index of the relative prices is formed by dividing

(1) $Uc = \dfrac{Pmch}{P}(r + \delta)$

(2) $Uc = \dfrac{Pmch}{P}(r + \delta + \delta rt)$ [8]

When Pmch is the nominal price of machinery, P is the average nominal price of the rest of products related with production, r is the interest rate and δ is depreciation rate. This is the normal way to measures the relatives prices. But the equation is complete when it's introducing the retirement function (*δrt*), because one of the factors that the agents take into account at the moment to do an investment in machinery is the age. The data for the variables are the machinery prices constructed (Ducoing, forthcoming), the economy prices are pool of products related with the production (output of the sector), interest rate is taken from the rate of the national debt, depreciation is geometrical and the retire function are 12 years for mining machinery, 15 for agricultural and industry and finally, 17 for transport.

For some problems with the statistical in several years, it`s impossible to build a complete series of relatives prices, but it`s possible build some averages in the decade or five years. In this case, we present the average relative prices by decade.

Table Nº 4 Relative prices of machinery and user cost.

1844 – 1913 (1844-1854 =100)

	Agricultural	Mining	Industry	Transport
1844 - 1854	100	100	100	100
1855 – 1864	105.2	-	75.6	-
1865 – 1874	107.6	122	70.8	115.1
1875 - 1884	115.2	124	68.5	110.3
1885 – 1894	98.3	-	63.4	112.4
1895 – 1904	94.2	115.6	62.1	103.8
1905 - 1913	94.6	-	69.4	-

Source: Appendix 1

As we can see in the table above, the only one relative price that has a continuous tendency to go down is the industry, and this can explain the composition of CFM at the years 1900 - 1920.

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[8] In the Jorgenson model (Capital Theory), $Uc = (\dfrac{P_k}{P})(i + \delta - \dfrac{\Delta P_k}{P})$ when i denote the nominal interest rate.

4.3 Composition of the investment

The most aggregate way to compare the machinery for industry and the machinery for services or none direct productive, is separate between machinery and transport equipment.

The graph number 3 shows the relation amount of investment in machinery and transport and equipment in the long run, when the industrialist authors claims the existence of a great impulse of industrial output. As we can see, the tendency is clear to a bigger spend on these items, but is transport and equipment the more impressive in numbers, and the relation at the end of the period is 3/5, when at the beginning it was 1/5.
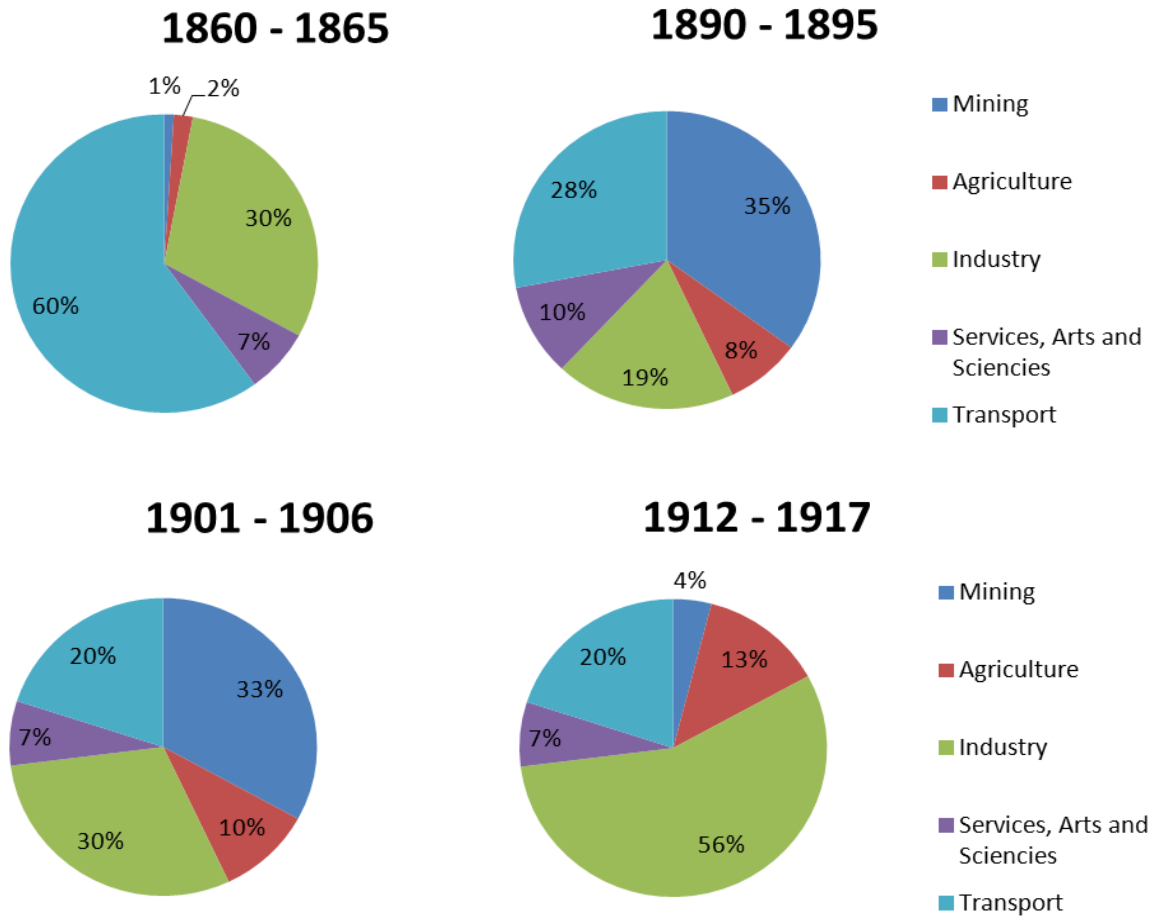
Graph Nº3

Share of Machinery and Transport in CFM
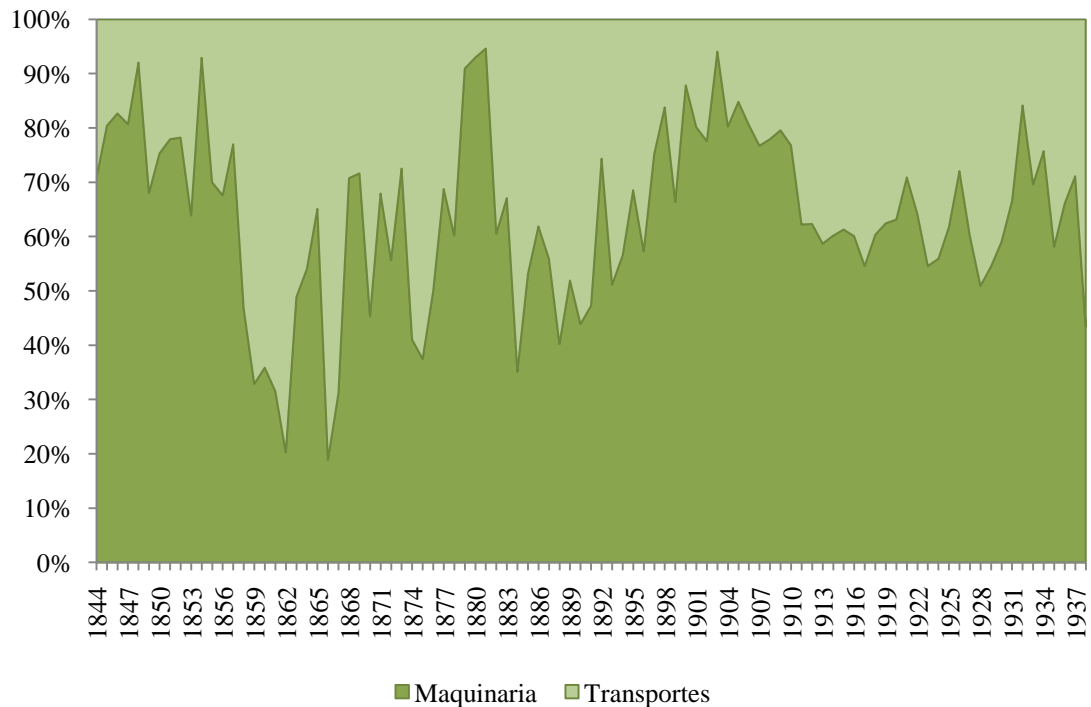
Source: Appendix Nº1

If we see the disaggregated series, in selected years, is possible appreciate a structural change of the CFM composition towards industrial machinery (CFIM henceforth). The problem of these series or numbers, is that the industry growth in the first years of XX century, is too short to affect the structure of the economy in the long run, and the great shock during and after the Great War stopped this process of industrialization. Graph No. 4 shows four-year periods, from 1860 to 1865, from 1890 to 1895, 1901 -06, and 1912-17. In the last five years, you may see a substantial increase in the participation of industry, but as discussed later, in response to a fall in investment in machinery, both in absolute terms, invested less in industrial machinery.

Graph Nº 4

Sectorial Machinery Investment.

Five –year percentage

1860 - 1865

1890 - 1895

1901 - 1906

1912 - 1917

Legend: Mining, Agriculture, Industry, Services, Arts and Sciencies, Transport

Source: Ducoing (2009, 2011)

5. Machinery as a proxy of industrialization

5.1 Measure of industrialization

In the seventies there were some attempts to measure the industrial GDP of Chile in the XIX century. One of these attempts is the PhD Dissertation of Kirsch (1977), who uses the series of Muñoz Gomá and a regression of two variables to measure the industrial GDP within 1880 – 1913. The regression chosen by Kirsch[9] as follows:

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[9] This is a brief presentation of the argues: four equations, and combinations of four variables (Industrial Output, Exports, exports lagged, PT: protectionist tariff legislation and T: time trend variable).

(1) $Log_e Y = log_e a_3 + b_3 (logX_1)$

which relates the rate of change in Y to the rate of change in   . In this case, the north American researcher decided, in function of the results of t-statist, two variables to explain the growth of the Industrial Output; the imports in raw material and the existence or not (dummy) of protective tariff.

(2) $LogRIO = 6.669(12.5) + .428(4.6)\Delta(log\_e\ RIMI) + .143(Protective Tariff\ Dummy\ variable)$

The results, is that the growth of industrial output is explained in a 66% by raw material imports. Improve the industrial output with the CFM series it could lead to circular references. However, it is possible to measure the level of industrialization with the share of machinery in the imports and GDP. The results to fix with the theory of capital accumulation. An increment in the share of machinery in the GDP leads to an increment in the potential output.

Nevertheless, the Industrial production estimated above, has different problems, above all, that does not allow international comparisons. Although you can make interpretations of the level, these estimates of industrial production are primarily intended to measure "the potential or estimated" growth, not the share of GDP. Finally, the estimates are just for the period 1880 – 1912, forgetting nearly 40 years of statistics and economic development. However, there is indirect method to determine the share of machinery in GDP, and at the same time, know the participation of industrial machinery. As is known, the share of machinery in the product in the periods after 1938, you may make a comparison between the period studied in this work and the period of ISI (1939 to 1975, when the share of industrial production in GDP achieved higher rates).This estimate of the assumptions made by other authors on the share of imports in the product (Mamalakis, 1976, 74-84) for the period in which there is no national accounts (or estimates is determined by a few variables). Therefore, we set for the period 1844-1913 as follows:

(1) $\dfrac{IM}{O} = 0.5 - 0.7$ Relation between Imports and Output

(2) $\dfrac{IM}{GDP} = 0.25 - 0.35$ Then, relation between Imports and GDP (estimated)

(3) $\dfrac{CG}{GDP} = 0.1 - 0.12$ The relation between capital goods and GDP

(4) $\dfrac{Mch}{GDP} = X$ Finally, the share of the CFM on the GDP

IM= Imports, GDP = Gross Domestic Product, CG = Capital Goods, and Mch = Machinery and Equipment.

To compare the share of CFM on Imports and GDP, it used the series of Hofman, for Chile, Argentina and Brazil, for the period 1900 – 1976. As has been mentioned before, this CFM series are based in the 1949, ECLAC Statistical Yearbook;

During the years 1880 - 1913, a period during which early industrialization lays Chile, the share average of the CFM in the GDP was 5.2%, while the same measure for CFIM was 1.7%. In the case of the ISI process, these figures reached 10.6% and 4.4%, respectively. The gap between

CFM share in imports and CFM share in GDP since 1940 it is explained by the less importance of the imports in the total output.

For comparisons with Brazil and Argentina, the results are very mixed. On the one hand, Chile is far behind compared to Brazil, but advance with respect to Argentina. It is necessary to make certain clarifications. It is likely that these results are determined by changes in measurements of machinery Argentina deteriorated appears in this comparison since one of its main imports, agricultural implements and machinery is not considered (situation has been corrected in Tafunell 2011) Moreover, per capita GDP of Brazil, is lower than Chile and Argentina, which can raise the numbers.

However, although Gomez Galvarriato and Williamson (2009) had included Chile in the group of emerging industrial countries, they had been warned that their numbers were lower than those of Argentina, Brazil and Mexico. The results shows in the Graph Nº5 about share of the CFM and CFIM confirmed.

Graph Nº 5

CFM and CFIM. Shares in Imports and GDP

1844 - 1976
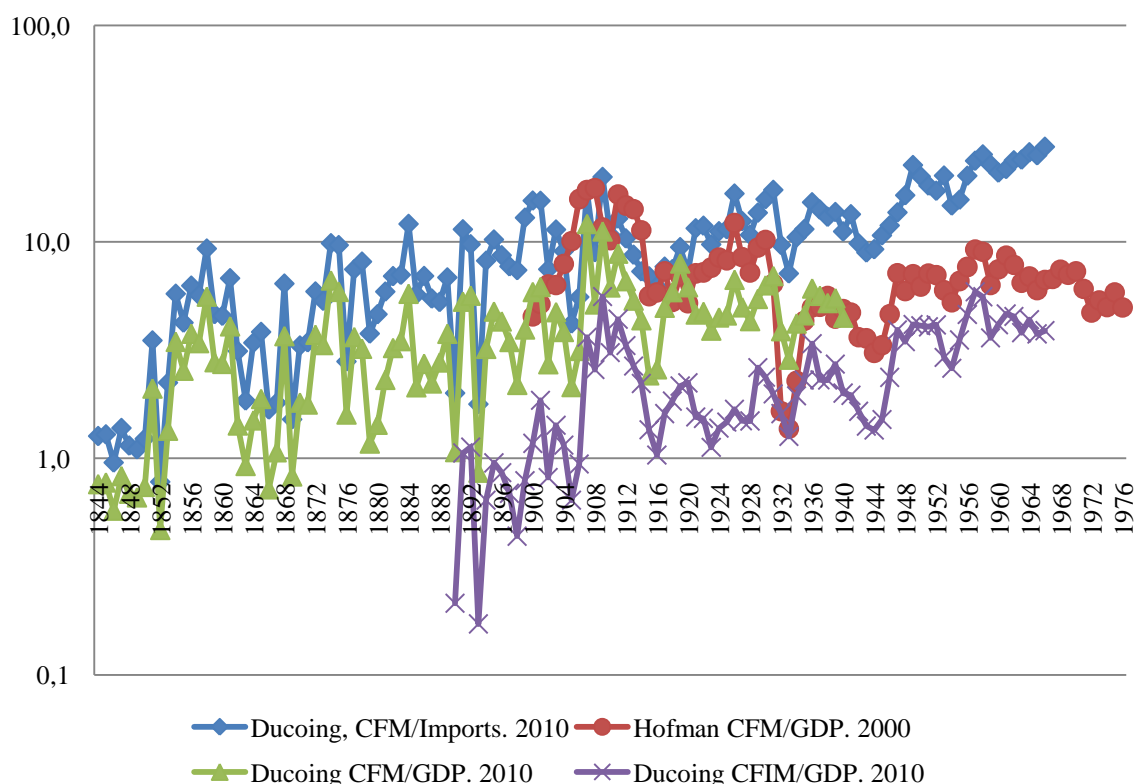
Source: Appendix 1.

6. Conclusions

The early industrialization that some authors argue for Chile before the I World War, is not really an industrialization process. The most probably name for this economic process is modernization. Three are the principal reasons to change the denomination:

1. The share of the machinery in the imports and GDP and total imports is not growing an accelerated rhythm in the majority of the years studied, and shows a continues volatility. For the final period is bigger than in 1844, but the level in this year is too low. If we use the machinery investment as proxy of industrialization, there are other indicators that are growing in most accelerated path.

2. The most important component of the machinery investment is the transport equipment, so, is not feasible that the principal or one of the principal activities of the country is the industry. Just in the 1907 - 1920 years, we can see a more important share of industry in the machinery investment. The reason for the primacy of transport & equipment investment, is the existence of a great saltpeter activity during 1880 – 1929, that requires locomotives rather industry machinery.

3. Despite the undeniable industrial growth in the years 1844 - 1938, compared the rate of share of machinery in the product, this hardly reaches, on average, the half of the ISI numbers.

The main theme presented in this paper, it will be completed with the study of the capital productivity and the measures of the capital services in machinery (Ducoing, PhD Dissertation, forthcoming).

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Appendix 1

Sources for capital goods imports and machinery investment:

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