

The impact of tin on the economic growth of Bolivia

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Abstract

The tin industry has been the backbone of the Bolivian economy for most of the last century. This paper attempts to quantify the impact of the industry on Bolivia's economic growth. Specifically, it analyzes whether the tin industry had any discernible effect on the level of economic activity, as measured by Gross Domestic Product (GDP). Ordinary Least Squares estimations are made on the impact of the tin industry on GDP. Additionally, and to reinforce the OLS exercise, Cointegration Analysis is carried out between GDP-per-capita and the price of tin in order to determine whether a long-term trend exists between these two variables.

Resumen

La industria del estaño ha sido la columna vertebral de la economía boliviana durante la mayor parte del siglo pasado. Este artículo intenta cuantificar el impacto de esta industria sobre el crecimiento económico en Bolivia. Específicamente, analiza si la industria de estaño tiene algún efecto sobre el nivel de actividad económica, medida por el Producto Interno Bruto (PIB) a través de estimaciones de mínimos cuadrados ordinarios. Adicionalmente, se realiza un análisis de cointegración entre el PIB per cápita y el precio del estaño para determinar si existe una relación de largo plazo entre estas dos variables.

Key Words: Bolivia, Mining Industry, Tin Industry, Tin Barons, Economic Growth.

Palabras claves: Bolivia, Industrial minera, Industria de estaño, Barones del estaño, Crecimiento económico.

Clasificación JEL: N16, N56, O40, 054, Q39.

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I. Introducción

The history of Bolivia is inexorably linked with its mining industry. Until recently, it provided the financial sustenance for the proper functioning of government and also the human resources that were required to lead it. This dependency between the public sector and one industry has been the topic of innumerable debates, and will probably continue to be as Bolivia remains an economy dominated by few sectors and hence a small group of individuals who control them.

This article analyzes the role of tin on Bolivia's economic growth. Specifically, it analyzes whether the tin industry had any discernible effect on the level of economic activity, as measured by Gross Domestic Product (GDP). In order to build the proper context, following this brief introduction, section two describes the tin industry since the beginning of the twentieth century, with special emphasis given to the changes that Bolivia experienced as it became a tin-exporting country. The third section describes the role of the so-called Tin Barons and the contributions, in tax revenue, that they made during their most lucrative period. In section four, Ordinary Least Squares estimations are made on the impact of the tin industry on GDP. Additionally, and to reinforce the OLS exercise, Cointegration Analysis is carried out between GDP-per-capita and the price of tin to determine whether a long-term trend exists between these two variables. Section five concludes.

2 Bolivia is divided into nine departments, or provinces.

II. The tin industry from 1900 to the present

The mining industry in Bolivia was dominated by silver until around 1900. From that year onwards it has been dominated by the tin industry, particularly due to a depletion of silver sources in the Southwestern region of the country. The provinces² of Potosí and Chuquisaca were the bastions of silver, whereas La Paz and Oruro have been the main centers for tin production. Regardless of the metal or the location of production, the mining elites have always wanted stable, civilian governments whose financial resources could be devoted to massive railroad -and later, road- construction, so as to minimize the most expensive element in the mining process: transportation costs (Klein, 1992).

Though the similarities between silver and tin miners are many, it is important to point out that the rise and fall of silver laid the groundwork for the eventual establishment of the tin era. Thanks to the development of the silver industry, Bolivia had been able to obtain the latest in mining technology, including the utilization of electricity, modern power tools and the employment of the latest engineering techniques and the people able to use them. Additionally, Bolivia was already connected to the Pacific coast through a train network, courtesy of the silver-backed regimes that had made modern transportation their primary task. Hence, when silver finally collapsed, it was possible to easily transfer the technology and transportation networks to tin.

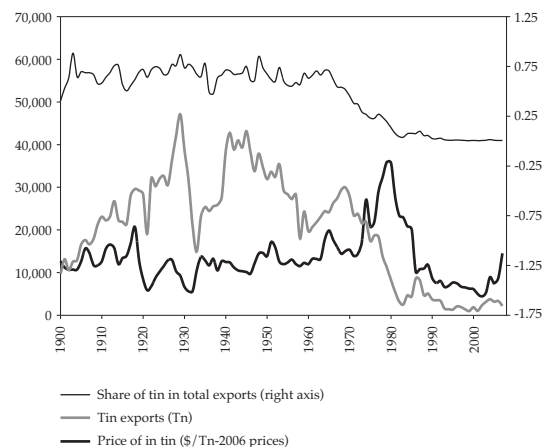
As the new industry started to establish itself during the latter years of the nineteenth century and the first decade of the twentieth century, an unanticipated expansion of world demand for tin in canning and in other industrial uses began to take place. This, along with an exhaustion in European production, allowed Bolivia to capitalize quickly and effectively, filling in the gap that had been created by this increased demand and reduced output from the traditional sources of production.

Though transition from silver to tin was relatively smooth for Bolivian society as a whole, it was less so for the traditional, silver-producing elite. For a variety of reasons, they did not easily change from one metal to the other, and hence they inadvertently helped create the conditions for a new group of Bolivian entrepreneurs to emerge, particularly in La Paz and Oruro. Eventually, this shift in economic power was reflected in politics too, when in 1899 the city of La Paz won the right -through a civil revolt- to be the seat of government, at the expense of the constitutional capital of the country, the city of Sucre, in the Province of Chuquisaca. This revolt was actively promoted and directed by the new tin-producing mining elite, demonstrating the long-standing belief that in Bolivia political power resides in the hands of those with economic might.

From the very beginning, the importance of tin in the Bolivian economy cannot be overstated. It

was the main export product by far, representing in some years more than 80 percent³ of the dollar value of total exports. Between 1900 and 1969, an average of 66 percent of total exports were tin exports, and its importance only began to diminish in the 1970s, as the Bolivian economy began to diversify somewhat and domestic production of the metal started to decrease. Figure 1 shows the evolution of the price of tin -in 2006 prices- and the level of exports -in tons of concentrate (ore)- of the metal between 1900 and 2007. The figure also shows the share of tin exports to total exports for this time period.

Figure 1
PRICE OF TIN (2006 PRICES), LEVEL OF TIN EXPORTS, AND SHARE OF TIN IN TOTAL EXPORTS, 1900-2009



Source: Author's calculations based on data from the Historical Archives of the Central Bank of Bolivia, the International Tin Council, and ITRI Innovation Ltd.

³ Most of the raw data for this document was obtained from the Historical Archives (Boletines Mensuales) of the Bolivian Central Bank. The rest of the data was obtained from the International Tin Council and from ITRI Innovation Ltd. All data manipulation is the author's; complete responsibility of the results presented here rests with the author.

As can be observed, price and exports are closely correlated, generally reflecting the expected inverse relationship between the two variables. In 1929 Bolivia exported a record of 47,079 tons of the metal but soon after suffered one of its biggest falls -to 14,957 tons- in 1933. During the Second World War tin exports averaged around 40,000 tons, and thereafter a downward trend settled in, with occasional hikes that never amounted to what had been experienced during the 1930s and 1940s. In the first decade of the twenty first century, the level of exports hovered around 2,500 tons per year.

In 2006 prices, 1979 was the year in which the metal reached its highest price quotation: \$35,870 per ton. For most of the period analyzed, the price of the metal fell below \$20,000 per ton, but in recent years it has experienced a comeback of sorts, with an almost 100 percent increase between 2005 and 2007. It is worth noticing that tin evolved from being the preeminent export product during the first seventy years of the 1900s to being a barely noticeable commodity, particularly in the last 20-odd years, when its relative importance diminished to single -even less than single figures for most years after 1980- digits. The year 1980 was the last year in which tin represented 13 percent of total exports. From that year onwards, the share of tin has continually diminished, and in 2007 it only represented 0.67 percent of total exports.

III. The tin barons

The so-called tin barons are Simón Patiño, Carlos Victor Aramayo and Mauricio Hochschild. The latter one is the only non-Bolivian of the three. Much has been written about them, but as some authors correctly argue, the moralistic tone of most of the literature on them does not necessarily do justice to their actual contribution to the Bolivian tin industry and to the Bolivian economy and society as a whole (Hillman, 1984).

To understand these very controversial figures, a glimpse into the political climate of Bolivia during the 1930s and 1940s is necessary. In March of 1937, President David Toro announced the formal confiscation of the Standard Oil Company in Bolivia. This was a historic move, as it was the first such confiscation of a major North American company in Latin America, preceding the larger and better known Mexican nationalizations by a whole year. The move propelled the government into an active role in the economy, making it a major producer of primary products, and breaking with its previous, more traditional *laissez-faire* position, of letting private agents be the main providers of most goods and services. The next year a new President, German Busch, called on a constitutional assembly to draft a new constitution that would replace the one enacted in 1880⁴. The new constitution approved in 1938 reflected the conventional wisdom of the times, and though it rejected the

⁴ The constitution of 1880 is widely regarded as a liberal document, in which the rights of the individual were enshrined and the state's intervention powers were strictly limited.

more radical proposals of agrarian reform and outright nationalization of the mines, it severely limited individual property rights. With this new constitution, property was now a social right and its legitimacy was defined by its social utility.

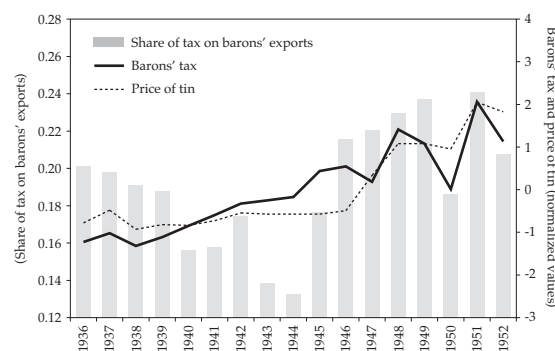
The antipathy⁵ that is spread throughout much of what has been written about these three miners can be explained by the political realities of the times. The prevailing political class felt that they were symbols of a liberal past that the new Bolivia had to overcome. Their activities produced wealth, but it was individual, not social wealth. They were becoming rich, but the country -it was alleged- was not sharing on this wealth. The social utility of their very existence was questioned, and so it is no wonder that they were regulated and taxed heavily in order to fit in with the more interventionist mold that was spelled out in the new constitution.

One such regulation concerned the obligatory handover of foreign earnings to the Central Bank. By law, all private miners were required to turn over their foreign earnings to the Central Bank to be converted at special exchange rates into Bolivian currency. The exchange rates that were utilized fell below the market rates, thus the government was able to extract significant rents from the big miners, in addition to other taxes established by law. Some authors estimate that as much as 25 percent of the total value of tin exports was extracted from private miners through a combination of direct and indirect

taxes (Ayub, 1985), though the estimates that are presented here fall below this figure. These data should be analyzed in light of the fact that the share of the barons' exports on total exports between 1929 and 1952 averaged 60 percent. In 1929, its relative importance was 76 percent, and in 1952, the lowest year, 43 percent. As can be immediately appreciated, the significance of the barons as a major source of export earnings and as a principal source of tax revenues was always considerable.

The obligatory turnover of foreign earnings lasted from 1936 to 1952. Figure 2 below shows the share of the tax on the baron's total exports, and the (normalized) evolution of the barons' tax and of the price of tin between the years 1936-1952.

Figure 2
BARONS' TAX, SHARE OF TAX BARONS' EXPORTS AND PRICE OF TIN, 1936-1952



Source: Author's calculations based on data from the Historical Archives of the Central Bank of Bolivia, the International Tin Council, and ITRI Innovation Ltd.

⁵ Good representations of how most Bolivian writers felt (and feel) about the tin barons can be found in Almaraz Paz (1967) and Mesa *et al.* (2007).

The discounted exchange rate utilized by the government changed several times during the period analyzed, but fluctuated around the 20 percent devaluation mark⁶. By subtracting what the barons would have received if the foreign earnings had been exchanged at the market rate of bolivianos per US dollar and the discounted rate, it is estimated that the government was able to extract an average of 19 percent of the total value of the barons' exports during the 1936-1952 period. For instance, in 1938, when the level of exports of the barons reached \$17.8 million, the government collected \$3.4 million through this mechanism (19.01 percent tax on foreign earnings that year). In 1949, when exports reached \$52.9 million, the tax was \$12.5 million, or 23.63 percent tax on foreign earnings for the year. In all, for the 17-year period in which this program was implemented, the government extracted \$143.4 million from the barons, out of a total value for their exports of \$743 million⁷. The share of the tax on the barons' total exports reached a peak in 1951, when the figure reached 24 percent. The year 1944 was the year in which this variable reached its lowest level, 13.26 percent. Figure 2 also shows that the baron's tax and the price of tin tend to follow each other closely, a finding that should not be surprising as the price of tin would give

government an idea of when to tax more heavily and when this tax -reflected in the discounted exchange rate- should come down.

It is difficult to provide an unequivocal judgment on the merits of these persons on Bolivia's development as a country. What can be stated is that they made a lot of money, but they also contributed greatly to the government's coffers, thereby making an invaluable contribution to the country's economic development. Notwithstanding these facts, the interventionist and populist nature of the new Bolivian state won the day, and on October 31, 1952, the three groups were nationalized.

IV. Impact on GDP

Some estimates on the main variables that determine Bolivia's export demand for tin have been presented before (Bojanic *et al.* 1992). Little research has been done, however, on the impact of the industry on the country's level of economic activity⁸. This article presents the first such estimates of the tin industry's impact on Bolivia's GDP.

Annual data from 1950 to 2007⁹ has been collected, and the logarithm of GDP -expressed in current

⁶ Source: Statistical Reports, Central Bank of Bolivia.

⁷ All figures presented here are in current US dollars, unless stated otherwise.

⁸ A. Doraisami (1996) presents evidence of the impact of tin exports on Malaysia's economic growth. As a producer of tin and important member of the tin cartel, the experience of Malaysia with tin should hold relevant lessons for Bolivia.

⁹ The econometric exercise begins in 1950 due to the fact that GDP data only commences to be collected by all relevant institutions (Bolivian Central Bank, National Statistics Institute) from that year onwards. No reliable estimates for this variable exist for any years prior to 1950.

dollars- is regressed on five independent variables. These are the logarithm of the *price of tin* in current dollar values, the *share of tin exports to total exports*, the logarithm of the official *exchange rate (bolivianos/US\$)*¹⁰, the logarithm of *world consumption*, in metric tons of tin, and the logarithm of *Bolivia's level of production*, also in metric tons. This specification was run for three different time periods to account for the fact that the tin cartel -Bolivia was an integral part of this organization- ceased to exist in 1985¹¹. The exchange rate has been included in the model due to its effects on the domestic costs of production. As the Bolivian currency depreciates, for a time it lowers costs of production, thereby making the industry more competitive and better able to increase its level of production, which, as a commodity market, is likely to be completely sold at current world prices. The described effects of a depreciation hold as long as domestic prices do not rise in step with the depreciating boliviano¹².

The model is estimated by Ordinary Least Squares. It is expected that all variables have a positive sign except the *share of tin on total exports*. It is predicted that as this variable decreases, the lessening importance of the tin industry will have a dampening effect on GDP. On the other hand, increases in *world consumption* of the metal and in *domestic production* should produce a positive

impact on GDP, as the consumption of the metal and the domestic capacity to placate this demand increase. A depreciation of the domestic currency, which is reflected in an increase of the variable *bolivianos/US\$*, should also have the expected positive impact on the level of exports as lower costs of production increase the country's capacity to produce more of the metal. This, in turn, should boost GDP. Finally, and due to consistent increases in world demand for the metal, increases in the price of tin should increase the value of exports, which in turn should cause a positive effect on GDP. The results are presented in Table 1.

As Table 1 shows, estimations are presented for three different periods: 1950-2007, 1950-1985 and 1986-2007. For the regression covering the period 1950-2007 and shown in the first column, all coefficients have the expected signs and all are statistically significant, except world consumption of tin. The variable Bolivia's level of production of tin is only marginally significant. To account for serial correlation, this regression and the others shown in Table 1 have been estimated with an AR(1) error specification. The model shows that there is a direct, positive relationship between the level of economic activity as measured by GDP and the price of tin. Positive signs on world consumption of tin and on Bolivia's level of pro-

¹⁰ The exchange rate is a yearly average of the official spot rates set by the Bolivian Central Bank.

¹¹ On October 24, 1985, due to an oversupply of tin in the international markets, the Tin Council (composed of Bolivia, Malaysia and other major tin-producing countries) collapsed and it discontinued its efforts to prop up the price of the metal.

¹² Additionally, the depreciation of the boliviano, which is reflected in the real exchange rate, should persist overtime to allow for adjustments in the level of production of tin.

Table 1
ECONOMIC GROWTH AND TIN
DEPENDENT VARIABLE: LOG (GDP)
ORDINARY LEAST SQUARE ESTIMATES

	1950-2007	1950-1985	1986-2007
Intercept	7.825 * (2.53)	0.856 (0.20)	8.934 * (5.15)
Price of tin (log)	0.706 * (7.35)	0.874 * (8.98)	0.444 * (4.35)
Share of tin exports in total exports	-1.819 * (-5.21)	-1.240 * (-3.54)	-2.229 (-1.31)
Yearly average Bs / \$ (log)	0.053 (3.35)	0.093 * (3.48)	0.442 (2.23)
World consumption of tin (log)	0.348 (1.62)	0.480 (1.61)	0.235 (2.23)
Bolivia's production of tin (log)	0.302 (2.06)	0.628 * (2.45)	-0.320 (-2.86)
AR(1)	0.610 * (5.15)	0.143 (0.59)	0.082 (1.03)
Number of observations	57	35	22
R ²	0.989	0.985	0.955
Adjusted R ²	0.988	0.982	0.937
Durbin-Watson Statistic	2.104	1.872	1.482

T-scores are in parentheses

* Significant at the 5% confidence level

Source: Author's calculations.

duction show that increased world consumption and increased domestic production do have a positive, though marginal, effect on GDP. By lowering domestic costs of production, a depreciation of the Bolivian currency tends to favor exports, including that of tin, which the model proves to be a significant factor in boosting GDP. Finally, the diminished relative importance of the tin industry has had a negative impact on the country's level of economic activity.

When the same model is run for the period 1950-1985 - 1985 being the year when the Tin Cartel collapses - the results are generally the same, though the impact of *Bolivia's level of production of tin* increases dramatically. It becomes significant at the 5 percent confidence level and its coefficient becomes bigger. One possible explanation is that before 1985, when the mining industry in general and the tin industry in particular were the main breadwinners for the Bolivian economy, the capa-

city of the industry to produce the metal counted more to Bolivia's well being than the situation after 1985, when the importance of the industry dwindled away and the country's dependence on the metal disappeared. Tellingly, when the same model is run for the period 1986-2007, the variable *share of tin exports in total exports* becomes insignificant, proving that once Bolivia diversified away from tin, its impact on GDP diminished substantially. In all, the three regressions generally show the same pattern of results, though the last model -covering the period 1986-2007- shows, predictably, that the impact of tin on GDP decreases substantially as other industries of the Bolivian economy replaced the once prevalent position of the mining sector in general and of the tin industry in particular¹³.

In order to complement the results described above, Cointegration Analysis has been carried out to determine whether a long-term relationship can be observed between GDP-per-capita and the price of tin, both variables in current US dollars. The results of this exercise are presented in Table 2.

As Table 2 shows, the Trace Test indicates the existence of cointegration equations at the 5 percent and 1 percent levels of significance, hence

proving the positive relation that exists between these variables for the period 1950-2007¹⁴. Table 2 also presents Vector Error Correction estimates for the cointegration equation, including estimates for the same cointegrating relation expressed in log form. As the VEC estimates demonstrate, there is a long-run equilibrium relationship between GDP-per-capita and the price of tin, confirming their positive association over the period of interest. The negative sign on the coefficient of the variable *Price of Tin* may reflect the fact that since the year 1980 the price of tin has shown a persistent downward trend - with occasional hikes during the 1980s and a more permanent hike during the early part of the twenty first century - hence causing GDP-per-capita to (generally) move along the path taken by the price of the metal.

Figure 3 below shows the relation between GDP-per-capita and the price of tin over the period analyzed.

As can be observed, the direct, long-term relation between these two variables becomes even more evident when analyzed graphically, and confirms the findings of the cointegration exercise presented before.

¹³ These regressions were also done utilizing end-of-period exchange rates in order to account for the volatility of this variable. The results do not diverge much from those observed in Table 1, but for the period 1950-2007, the variable 'world consumption' of tin becomes significant and the variable 'domestic production' of tin becomes insignificant. Both variables maintain the positive signs found when the yearly average for the exchange rate was utilized. The regressions for the subperiods 1950-1985 and 1986-2007 show an almost identical pattern of behavior as those observed with average exchange rates.

¹⁴ The Max-Eigen value test also indicates the existence of cointegration between the series analyzed at the 5% and 1% levels of significance.

Table 2
JOHANSEN COINTEGRATION TESTS AND VECTOR CORRECTION ESTIMATES, 1950-2007

Sample(adjusted): 1952 to 2007

Included observations: 56 after adjusting endpoints

Trend assumption: Quadratic deterministic trend

Series¹: GDP per Capita, Price of Tin

Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test				
Hypothesized no. of CE(s)	Eigenvalue	Trace statistic	5 percent critical value	1 percent critical value
None**	0.36	31.56	18.17	23.46
At most 1**	0.12	6.85	3.74	6.40

** Denotes rejection of the null hypothesis at the 1% confidence level.

Trace test indicates 2 cointegrating equation(s) at both 5% and 1% levels.

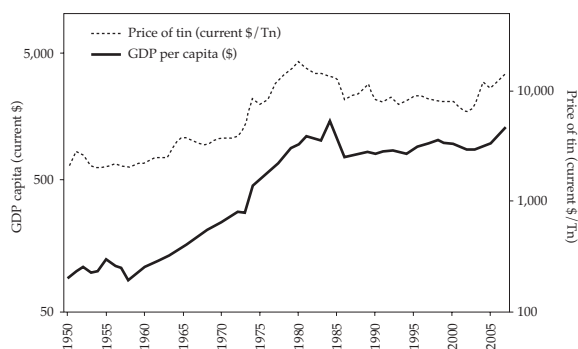
¹ The Augmented Dickey-Fuller test for a unit root shows that both series are integrated of order 1 at standard levels of significance.

Vector Error Correction Estimates			
			In log form
Cointegration Equation (CE)	GDP per Capita	1.00	1.00
	Price of Tin	-0.12 (0.02) [-6.14]	-1.37 (0.13) [-10.52]
	Constant	272.82	5.89

Note: Standard errors in parentheses and t-statistics in brackets.

Source: Author's calculations.

Figure 3
GDP PER CAPITA AND PRICE OF TIN,
1950-2007



Source: Author's calculations based on data from the Historical Archives of the Central Bank of Bolivia, the International Tin Council, and ITRI Innovation Ltd.

V. Conclusions

The tin industry has been the most significant industry of the Bolivian economy in the last century. Though its impact has diminished over time, the contributions of this industry to Bolivia's development have been substantial, and the metal may still play a role as it has begun a comeback of sorts in the last few years.

The industry has always been controversial, particularly when its most important representati-

ves were the so-called Tin Barons. Despite anecdotal evidence to the contrary, the contributions made by these barons to the industry and to Bolivian society as a whole are significant, and they should be remembered in this light.

Ordinary least square analysis and cointegration analysis confirm that tin has indeed played a significant role in the country's economic performance over the period 1950-2007. Consistently, the price of tin and the share of exports of the metal on the country's total level of exports proved to be significant to Bolivia's economic activity. Moreover, cointegration analysis also showed that there is a positive, long-term relationship between GDP-per-capita and the price of tin, evidence of the direct, significant impact the industry has had on the well being of Bolivia's citizens. This relationship was significant at standard levels of confidence.

Finally, and particularly due to recent developments, further research should be encouraged to analyze the parallelisms between Bolivia today and the country in the late 1930s and 1940s, when -as today- the merits of an imperfect but democratic, liberal society were questioned. The lessons learned more than a half a century ago may still be useful today, even though the set of characters -including the industry analyzed- is completely different.

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