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The impact of metals' prices on the capital structure of mining and metallurgic firms in Latin America (2004-2014)

Impacto de los precios de los metales en la estructura de capital de las empresas minero-metalúrgicas en América Latina (2004-2014)

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Abstract

This work examines the short and medium-term effects of the international prices of several mineral (gold, silver copper, zinc) and metallurgic (aluminum, steel) products, on the capital structure of mining and metallurgic firms listed in the stock markets of Argentina, Brazil, Mexico and Peru. The study uses quarterly data for the period 2000-2014. Consistent with the Dynamic Pecking Order theory, the findings confirm that profitability and the price of the products they sell, relate negatively with the firms' financial leverage.

JEL classification: G13, G32, G33.
Keywords: Mineral products' prices; Capital Structure; Corporate Performance.

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Resumen

Este trabajo examina los efectos de corto y mediano plazo de las fluctuaciones de los precios internacionales de varios productos minerales (oro, plata, cobre, zinc) y metalúrgicos (aluminio, acero) sobre la estructura de capital de las empresas de la industria minera y metalúrgica listadas en los mercados bursátiles de Argentina, Brasil, México y Perú. Se utilizan datos trimestrales para el periodo 2000-2014. Consistente con la teoría del Orden Selectivo de Preferencia Dinámico "*Dynamic Pecking Order*", los resultados del análisis econométrico confirman que la rentabilidad y los precios de los productos que venden, se relacionan negativamente con en el apalancamiento financiero de las empresas.

Códigos JEL: G13, G32, G33.
Palabras clave: Precio de productos minerales; Estructura de capital; Desempeño corporativo.

Introduction

The capital structure of a firm is the ratio between debt and equity (common and preferred stock) it uses to finance its investments. The theory of Capital Structure determination is responsible for analyzing the way in which a firm makes this decision and, consequently, divides the cash flows from its normal operations into: a) a fixed component, to pay its obligations to creditors; and, b) a residual component that belongs to the shareholders (common and preferred). This decision has a strategic connotation of the greatest importance, as leverage determines the sensitivity of free cash flow and, therefore, of the value of the firm. For this reason, this topic receives great attention in financial research.

The objective of this study is to determine what is the relationship between the fluctuations of the main precious and industrial metals (gold, silver, aluminum, copper, zinc and steel) prices, and the profitability and capital structure of a sample of mining and metallurgic producers that publicly trade their stock in the of the Argentinian, Brazilian, Mexican and Peruvian markets stock markets.

Initially, we use the Factor Analysis methodology to reduce the dimensionality of the explanatory variables (price of the different commodities) of the model, followed by a Regression Analysis with cross-section and time-series data combined (pooled data). The necessary tests to determine whether fixed or random effects are advised in the estimation lead to the conclusion that the pooled regression is good enough for the data. The output evidence suggests that risk management measures for firms in the mining and metallurgic industry are advised, as supports the recommendation that managers of stock and bond portfolios issued by the firms in these industries consider the dynamics observed in their capital structure.

The above results corroborate the predictions of the Dynamic Pecking Order theory in the sense that the leverage of firms is sensitive to their capacity to generate internal resources. In the second section, the Capital Structure Theory is reviewed. In the third, the evidence provided by different studies on the determinants of the Capital Structure are reviewed. In the fourth part, works on capital structure in Latin America and, particularly, in the mining-metallurgic sector are reviewed. In the fifth section, the recent evolution of the prices of the products studied is analyzed, and the sample of mining-metallurgic firms listed in the indices of Argentina, Brazil, Mexico and Peru is presented. In the sixth part, the methodological aspects of the analysis are addressed, presenting the results and interpreting their meaning. Finally, we conclude with a couple of reflections and recommendations.

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The classical theory of capital structure

The seminal work of Miller and Modigliani (1958) represents a starting point of great importance for the development of the modern theory of capital structure in firms.

The seminal contribution of these authors to the theory of how the Capital Structure is determined leads to various conclusions of great importance. In its first version, where the inexistence of taxes and the costs of bankruptcy are assumed, it is impossible to determine an ideal financial strategy given that, regardless of the proportions corresponding to debt and capital, the weighted average capital cost remains constant. However, by recognizing the existence of taxes, but still making the assumption that costs of bankruptcy do not exist, a financial strategy that maximizes the benefits of the fiscal shield, and enhances profitability[2], would lead to a 100% indebtedness[3]; of course, this is far from reality (Miller and Modigliani, 1963).

These ideas quickly evolved during the following years and, in 1973, Litzenberg (1973) proposed for the first time the "Trade-Off Theory" in which he states that a firm follows a financing strategy based on the cost-benefit analysis of comparing the benefits of debt with the cost related to the possibility of bankruptcy.

To put the above proposal into perspective, other works need to be mentioned. One of the most important contributions for the development of the theory was the work by Jensen and Meckling (1976), who posed that the incentives of the managers in a firm are aligned with the objective to maximize the value of the equity, instead of the total value of the firm. According to this logic, when the managers have exceeding resources available, they get involved in strategies that transfer risks to the bondholders. By favoring risky projects that benefit the shareholders in case of success–no matter how unlikely this may be[4]–but that could potentially result in significant losses for the bondholders in case of failure, the firm carries out a strategy known as "over investment". Thus, the bond investors, aware of the "agency problem" that results from the behavior of the managers, would demand an additional reward for the risk when the firm intends to issue additional debt.

Myers (1977) developed a similar argument to explain the problem known as "under investment". His argument is that the managers have an incentive for not investing in new projects, even when their present net value is positive, if the expected gains would mainly benefit the bondholders and only marginally benefit the shareholders.

Myers (1984) challenged that the optimal capital structure can be explained solely through the analysis of the costs and benefits of using debt[5] in a context of information asymmetry between the shareholders and the managers of the firm, suggesting that the Pecking Order Theory must not be conceived as something static. In case of there being no adjustment costs, the capital structure observed in the firms ought to be optimal at all times. Nevertheless, due to the fact that they do exist, there are normally remnants in the adjustment of the leverage towards the optimal level. Firms cannot immediately compensate for the effects of events that divert

[2] A sensible manager would use debt only when the cost of the same is less than the expected profitability of the investments being financed. Therefore, the excess above the cost of the debt accumulates to the benefit obtained by the shareholders.

[3] Under this scenario, a leverage level of 99.99% could be assumed, so that there is at least an "owner" to receive the entirety of the benefits.

[4] The managers invested even on those projects in which it was not expected to obtain a present net positive value, unless there were extraordinary conditions at play.

[5] Theory of Capital Structure Selection Based on the Cost of Opportunity or Trade-Off Theory.

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the optimal level, thus, it is expected (as it happens in real life) for there to be a transversal dispersion between the effective reason of leverage in a sample of firms that have the same objective reason of financial leverage. This approach is known as the Dynamic Pecking Order Theory.

Myers and Majluff (1984) developed a different proposal on the determinants of the capital structure in firms. These authors argued that there is asymmetry in the information available to the employees of the firm (insiders), and also in that available to the economic agents external to the firm (outsiders, which includes investors and market analysts). Some of the theoretical implications are that: a) the managers–holders of superior information on the real value of the firm–will not issue new shares when they consider that the firm is undervalued because doing so would lead to the dilution of the shares of the current shareholders; b) the managers shall issue shares only when they consider that the shares are overvalued in the market and, in this sense, the announcement of a new issuance acts as a sign that is interpreted by the market as the shares being too expensive, thus causing the lowering of the price.

In this manner, the best financing strategy consists on using the funds generated internally–provided that they are available–which prevents problems of information asymmetry. If the funds generated by the operation are not enough to cover the needs of operation, investment, and growth, the firms shall issue debt because by being a contractual commitment constant in its value (at least from the perspective of the investors who maintain it until maturity), it is less affected by the information asymmetry than the value of the shares.

From the previous arguments, we can conclude that the determination of the optimal financing structure of a firm requires carefully evaluating the costs of agency associated with the use of external financing (risk transfer and sub-investment), weighing them against the costs of agency related to the excess cash and absence of financial compromises (the free cash flow problem). However, once the optimal proportion of debt has been determined regarding the capital, the firm will have no other alternative other than the consistent search for that level.

Factors that determine capital structure

The literature that empirically contrasts the capital structure determinants of the firms is rather broad. Nevertheless, there is still ambiguity over which of the different existing theoretical positions best explains the phenomenon and, therefore, it is a field that still requires further investigation. The outstanding literature review works carried out by Harris and Raviv (1991) or Graham and Lear (2013) discuss multiple works on the subject, but hardly comprise most of the theoretical proposals and do not give account of the results of all the empirical contrast studies pertinent to the subject. However, although the works identified by these authors (and many others) are undoubtedly growing more abundant and varied, the theory on the determinants of the capital structure remains in a defining state, and a greater effort is required on this line of research.

Harris and Raviv (1991) present a broad review of the existing literature on the theories that explain the capital structure. The review includes academic articles that explain the phenomenon in terms of agency costs, information asymmetry, the interactions between market products and/or market inputs, as well as other aspects related to corporate control. Its most important contribution is the identification of a set of variables, whose relation to the capital

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structure makes them ideal candidates to carry out the contrast of the theory with reality, and the regularities or stylized facts that have been broadly documented.

Graham and Lear (2013) present a detailed review of the empirical research on capital structure published since 2005 and until the early years of the second decade of the XXI century. To establish an order in the analysis, the works are classified as belonging to one of three perspectives that explain the variations in the capital structure: a) between firms; b) between industries; and, c) of a single firm throughout time. They also evaluate the explanatory capacity of the approaches of the Trade-Off Theory and the Dynamic Pecking Order Theory, highlighting their limitations. The authors analyze works on how the offer of capital affects the leverage level, as well as some specific aspects of the credit contracts that had not been previously researched in detail, focusing on: understanding why the changes in the capital structure of the firms have little influence on their value in a broad range of leverage levels; why the estimations of the speed with which the changes in capital structure take place are biased; and other aspects on the capital structure of the firms that had not been taken into consideration previously.

Other two works worth mentioning in this section are those by Frank and Goyal (2009) and by Bessler, Drobetz and Kazemieh (2011), because they support the reference framework of this investigation and, specifically, serve to justify the selection of commodity prices as an explanatory variable of the leverage levels of the firms.

According to Frank and Goyal (2009), the Pecking Order Theory is one of the most influential on the capital structure. Due to the adverse selection problem, firms prefer internal financing; however, when external financing is required they prefer debt above the owed capital at the lowest costs of information associated with the issuance of bonds (Myers, 1984). Therefore, if a firm determines its capital structure according to the provisions of the Pecking Order Theory, in a regression of the leverage level against the financial deficit, a slope coefficient equal to one ought to be observed. For example, Shyam-Sunder and Myers (1999) find a favorable result for this prediction in a sample of 157 firms, between 1971 and 1989. That is, the evidence statistically supports the validity of the Dynamic Pecking Order Theory.

In contrast, Bessler, Drobetz and Kazemieh (2011) state that both the variables that represent the leverage in the firms, as well as those that are frequently assumed as their determinants, must be related to the theories that explain the nature and operation of the capital structure. This is relevant because it is assumed that said variables are indirect measurements of the economic forces described in the theory, such as the costs associated to the financial stress or information asymmetry. Nevertheless, the expected indication of the relation is sometimes ambiguous, thus the importance of clarifying in which cases there is consensus regarding the indication of these relations. Said definition is indispensable, for example, to anticipate the leverage levels based on other characteristics or environmental factors of the firms (such as the prices of their products).

A preliminary conclusion of the discussion on the determinants of the capital structure is that it still is an uncompleted chapter in Financial Economics, and that the new evidence continuously presented in the literature regarding the main postures—which are briefly outlined here—contributes to establishing the bases for a future categorical definition in favor of one or another theoretical position.

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Capital structure studies in Latin America

The study of firms' capital structure in emerging markets has produced notable results, so we mention two of the most outstanding works as reference for the interested readers; but we do not, however, develop the subject with greater detail for space limitation reasons. The two recommended studies on this subject are those by Booth, Aivazian, Demirguc-Kunt and Maksimovic (2001) and Jõeveer (2006).

In the Latin American context, the tendency for research on the determinants of the capital structure of firms has risen in recent years and, as in the case of the literature on emerging markets, we must limit our review of the same to the mention of those that we consider more representative.

The work by Medina, Salinas, Ochoa and Molina (2012) presents a review of empirical studies on the capital structure of Colombian firms (among others), and corroborates the empirical validity of the Dynamic Pecking Order Theory for Colombian firms. Mongrut *et al*. (2010) study how the corporate exchange firms of Argentina, Brazil, Chile, Mexico, and Peru determine their indebtedness policy for the period of 1995-2007. Based on the results of a panel analysis, they find evidence to reject the hypothesis of the Dynamic Pecking Order Theory. Maqueira, Olavarrieta and Zutta (2007) analyze the determinants of the capital structure for a sample of 113 Chilean firms for the period of 1990 to 1998. These authors contrast the results of a Lisrel model (Linear Structural Relations) with regard to the results obtained by ordinary least squares (OLS) and find significant differences. The list of works on capital structure in Latin America is continuously growing and contributes each time with more results of interest for theoretical discussion.

Given that this work studies capital structure in a sample of Latin American mining-metallurgic firms, it is worth highlighting two works whose focus lies precisely on firms of this sector in the region. Two works were identified that comply with the previous criteria; namely, that by Paredes, Ángeles and Flores (2015) and that by Paredes and Flores (2012).

Paredes, Ángeles and Flores (2015) utilize static and dynamic panel analyses to explore the determinants of the leverage of 14 mining firms in Mexico, Columbia, Chile, Brazil and Peru, between the first quarter of 2004 and the third quarter of 2014, contrasting their results with the relevant theories. In their work, they report that the more tangible the shares, the greater level of leverage observed; whereas the growth rate of the sales and size of the firm do not have a significant effect on said variable. Another finding is that profitability reduces leverage, which is consistent with the Dynamic Pecking Order Theory, and that the lagging values of the leverage are more robust to explain the current leverage value than the other explanatory variables.

Paredes and Flores (2012) propose a panel analysis to study the behavior of the capital structure of ten firms of the Mexican steel sector during the period of 2001-2011. The objective of the research consists on determining the significance of the factors that influence the leverage level, based on the concepts of the capital structure theory. These authors use the financial information of the firms and a macroeconomic variable as control variable. The financial variables include the leverage level, the cash flow relative to the value of the shares, the growth rate of the revenue, the ratio of productive assets, and the size of the firm. The macroeconomic variable is the annual growth rate of the Gross Domestic Product. The results of the study indicate that, on the one hand, there is a significant relation between the growth of the firm and

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the cash flows allocated to investments, and on the other, the leverage level. By increasing the profitability of the firm, the cash flow and the excesses can be invested into productive assets, all the while decreasing the leverage level. The fixed effects model utilized allows to conclude that the relation between the selected variables and the leverage level is different for each firm. The results are consistent with the Pecking Order Theory.

It is highly probable that both the Trade-Off Theory and the Pecking Order Theory are, even combined, partial explanations of a more complex phenomenon. The incidence of agency conflicts, industry volatility, product differentiation, and other factors make it clear that, though the traditional theory explains a good part of the stylized facts, as established by Frank and Goyal (2003), there are still many variables that can influence the leverage levels of the firms.

The price of mining and metallurgic metals, and the Latin American firms that produce them

Given that under normal conditions the technological changes in mining are only gradual and, therefore, the operating costs of firms in the industry are rather stable through time, it is possible to assume that the fluctuations in the price of minerals, subject to frequent ups and downs, are generally linked to the economic cycle. However, at times, geopolitical situations and even strategic decisions made by the large global producers are rather important factors in the determination of the levels of profitability and the generation of operative cash flow of the mining firms. In this sense, confirming if the price of the minerals influences the capital structure of the mining firms is framed within the Pecking Order Theory. When the prices of minerals are high, the greater utility and generation of operating flow reduce the needs for external financing, and its effect shall be reflected in the capital structure.

The financial theory suggests that the leverage level of the firms should be measured as the debt to capital ratio, both expressed at their market value. However, the difficulty in obtaining information of the market value of the total liability, forces it to be calculated using the book value of the liability, combined with the market value of the capital. Thus, the numerator of this ratio is a book value resulting from the general balance, which is only gradually modified throughout time. However, the denominator continuously changes according to the change in the price of the shares.

In this work, leverage levels of the sample firms are measured in terms of the book value of debt in the numerator and the capitalization value (market value) of its shares in the denominator, given that this measurement of leverage level responds dynamically to the fluctuations of the prices of minerals produced by the sample firms.

In the review of the literature regarding the determinants of the capital structure of the firms presented above, it is said that there is a broad number of works that explore which are the factors that influence the leverage levels of the firm. Thus, the Trade-Off Theory states that the main determinants of the capital structure are the benefits derived from the fiscal shield of the debt versus the potential costs of bankruptcy; or rather, the Pecking Order Theory proposes that the relative quantity of each of the financing sources utilized by the firms depends on the information asymmetry level that exists between the investors regarding the set of information handled by the managers. However, beyond these fundamental explanations of the determinants of the capital structure of the firms, it is possible to identify diverse factors such as the degree

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of differentiation of the products, the intensity of the expenses in publicity or in research and development, and many others. In particular, this work proposes modelling the ratio sensibility of the Total Debt / Capitalization Value of the Shares to the variations of the international prices of the minerals for a sample of Latin American mining firms.

Evolution of the price of mining products and steel between 2004 and 2014

During the eleven years from January 2004 to December 2014, the prices of most commodities experienced significant variations. Since the start of the century and up to 2007, a significant growth of the same had taken place, driven by the strong demand for raw materials generated as consequence of the elevated growth rate of the Chinese economy and other emerging countries, in conjunction with the macroeconomic global stability that allowed a constant, though slow, growth of most of the industrialized countries.

However, in light of the turbulence provoked by the Financial Crisis of 2007-2009 this scenario changed radically. The economic agents sought safe refuge, traditionally precious metals and hard currency, and thus there was a significant push towards the rise of the price of gold (and, to a lesser extent, silver), in addition to the appreciation of the American dollar towards the rest of the currencies.

Even though during the first couple of years of the century the tendency in the prices of the metals were consistent towards a rise–which was consistent with the high positive correlation historically observed between their prices (see Table 1 and Figures 1 and 2)–only gold and silver were considered a safe refuge in the face of uncertainty. Therefore, as consequence of the grave repercussions of the global financial collapse on the economic activity, the prices of the metals used mainly in industries followed a clearly differentiated behavior regarding precious metals. Nevertheless, the correlation between the prices of the six metals was extremely high throughout the period, always above 0.40 and in some cases above 0.90.

Table 1. Correlations between the prices of the selected minerals.

	Gold	Silver	Copper	Steel	Aluminum	Zinc
Gold	1.000	0.959	0.844	0.885	0.402	0.462
Silver	0.959	1.000	0.864	0.875	0.494	0.500
Copper	0.844	0.864	1.000	0.915	0.795	0.798
Steel	0.885	0.875	0.915	1.000	0.667	0.587
Aluminum	0.402	0.494	0.795	0.667	1.000	0.849
Zinc	0.462	0.500	0.798	0.587	0.849	1.000

Source: Own calculations with data from Standard & Poors' Capital Markets Database.

Gold increased from a price close to 400 dollars per ounce in January 2004, to a maximum of 1,772 in September 2012, that is, an increase of 343%, to then register a significant adjustment regarding its maximum level, and looking for a new level of around 1,200 dollars towards the end of the analyzed period. For its part, the price of silver went from a little more than 7 dollars per ounce to almost 38 dollars between January 2004 and March 2011, that is an increase of 442%. From this moment, a pattern of erratic adjustment was observed, to finally begin a pronounced decreasing tendency in September 2012, and reaching a minimum level of a little

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more than fifteen dollars towards the end of 2014. Although up to 2012 the price of silver had a strong correlation with the price of gold, which appeared to have decreased after November 2012, though the general tendency has been very similar.

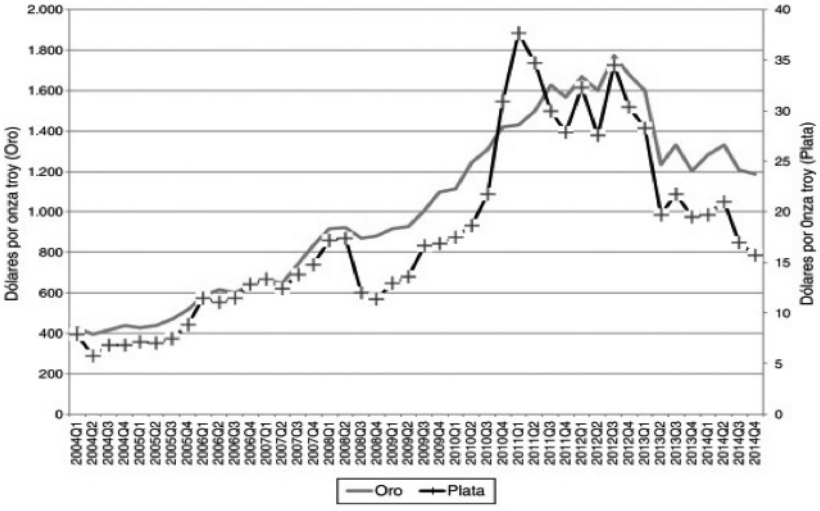

Figure 1: Quarterly price of gold and silver march 2004 – december 2014
Source: Bloomberg.

As a whole, both the minerals that serve as input in industrial processes and steel observe a behavior influenced mainly by the economic cycle, though in each case there are specificities and differences due to the different degree of industrial concentration, the technological change, the particular conditions of different producing regions, etc. Even when aluminum and steel require a certain degree of industrial transformation, in reality we are dealing with commodity products, whose price continues to be very close to the rest of the industrial minerals.

Copper is an industrial raw material, whose price was mainly pushed upward during the first half of the analyzed period due to the significant demand of the Chinese economy and that of other southeast Asian countries. But with the Financial Crisis and the subsequent economic deceleration, it registered a significant drop and reached its lowest level in December 2008, as can be observed on Figure 2. Once the global economy and the demand for copper began to recover, its price reached levels higher than the maximum of 2003, but before November 2012 its downward trend began once more, consistent with the deceleration of the Chinese economy, which remains until the end of our sample.

The price of zinc saw a different behavior regarding the rest of the precious metals (or copper), which was more in accordance with its use in the industry. The price remained at reasonably stable levels during the first three years of the century, but starting in 2004 it began to increase and by the end of 2006 it reached its maximum. From that moment onward, a sharp decrease began and continued until the end of 2008. With the subsequent gradual recovery of the economy, the price recovered and stabilized around the levels of 2,000 dollars per unit of measure.

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Aluminum also followed a trend related to the cycle of the global economy, but with less extreme movements. Between 2000 and 2008 it registered a growth of approximately 100%, to then collapse within a couple of months below the initial price. In this sense, it followed a very similar pattern to the rest of the industrial raw materials in response to the sharp deceleration of the global economy associated to the Financial Crisis. With the growth of the global economy, it had a sharp recovery but never reaching the levels prior to the crisis and had a slight drop in the last couple of years.

The price of steel for the sample had a significant increase of 400%, between its initial level at the start of the period and the maximum level reached during the same, it was the same as all the other raw materials, which in this case was of 500%. However, at the start of the global crisis there is a drop that reaches the levels it had in 2004. The recovery was pronounced and it was of almost 100% until before 2010, but it never reached the levels of 2008; at the end of the period it showed a constant decrease due to the drop in the global demand.

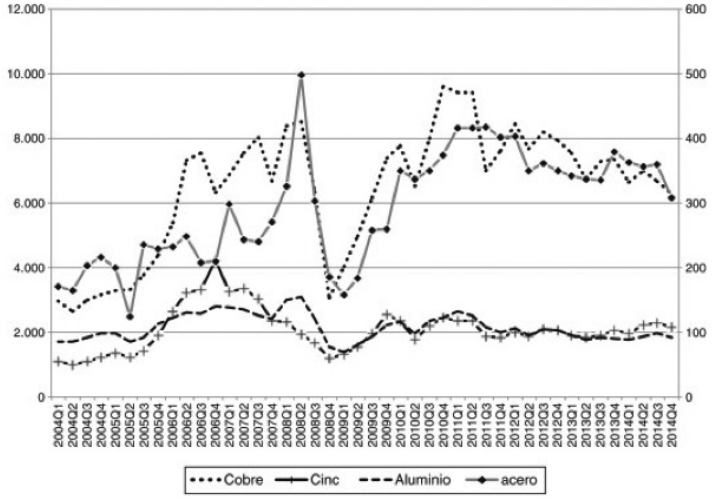

Figure 2. Quarterly price of steel, aluminum, copper and zinc march 2000 – december 2014
Source: Bloomberg.

Due to the differences of the units of measure used to provide the quotes of the different commodities, it is difficult to directly compare their prices, but it is possible to use the coefficient of variation of their behavior during the period of study to establish which prices experienced greater volatility during said period. Table 2 shows that aluminum experienced the greatest volatility relative to its average price, whereas silver, gold and copper had a significantly more stable behavior.

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Table 2: Descriptive Statistic of the Prices of the Mining Products

	Silver	Copper	Zinc	Aluminum	Gold	Steel
Average	14.33	5193.47	1777.34	1963.77	827.91	241.94
Standard Deviation	9.35	2677.18	784.19	468.52	474.68	114.99
Coefficient of Variation	1.532838	1.939901	2.266464	4.191441	1.744125	2.104094

Source: Own calculations with data from Standard & Poors' Capital Markets Database.

The mining and metallurgic firms of the sample

The sample of mining and metallurgic firms included in this study represent a rather limited fraction of the universe of firms of the same sector in Latin America. The mining activity in the region is rather important and the number of firms dedicated to this activity is quite large, but most of them are not exchange firms, thus it is very difficult to obtain their financial information. In total, fourteen mining and metallurgic firms were studied quoting their assets in the stock exchanges of Argentina, Brazil, Mexico and Peru, during the period beginning on the first quarter of 2004 and up to the fourth quarter of 2014. The information extracted from the financial statements included the total liability, total sales, and net utility. Similarly, the price of the assets in the market at the closing of each quarter and the number of assets in circulation were used to determine the capitalization value. The leverage ratio was calculated as the quotient between the total liability and the capitalization value of the assets in the market, while the net utility to sales ratio allowed having a measurement of profitability in accordance with the capital structure theory. The data corresponding to the financial statements of the firms were obtained from the Capital IQ database, while the prices at the closing of the quarter for each asset came from Bloomberg. Of the fourteen firms in the sample (see Table 3), one produces aluminum, five produce steel, and the rest are mainly extractive. Regarding their geographical distribution, one is located in Argentina, three in Brazil, two in Mexico, and seven in Peru.

Table 3. Mining firms included in the sample

Ticker	Nombre	Producto	País	Índice
ALUA	Aluar Aluminio Argentino S.A.I.C.	Aluminio	Argentina	MERVAL
ERAR	Ternium Sidecar	Acero	Argentina	MERVAL
CSNA3	Companhia Siderúrgica Nacional	Acero	Brasil	BOVESPA
GGBR4	Gerdau S.A.	Acero	Brasil	BOVESPA
GOAU4	Metalúrgica Gerdau S.A.	Acero	Brasil	BOVESPA
GMEXICO B	Grupo México	Metales diversos y minería	México	IPC
PE&OLES	Industrias Peñoles	Metales preciosos y otros minerales	México	IPC
BVN	Compañía de Minas Buenaventura	Oro	Perú	IGBVL
ATACOBC1	Compañía Minera Atacocha	Metales diversos y minería	Perú	IGBVL
MILPOC1	Compañía Minera Milpo	Metales diversos y minería	Perú	IGBVL
CORAREI1	Corporación Aceros Arequipa	Acero	Perú	IGBVL
SIDERC1	Empresa Siderúrgica del Perú	Acero	Perú	IGBVL
MINSURI1	Minsur	Metales diversos y minería	Perú	IGBVL
VOLCABC1	Volcán Compañía Minera	Metales diversos y minería	Perú	IGBVL

Source: Capital IQ

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Description of the methodology and the results

The objective of this work is to determine if the international price of the minerals influences the financial leverage levels. Therefore, the analytical approach chosen to model the relation was a Longitudinal Regression Analysis (time series combined with cross-section observations), given that the database consists of forty quarters of observations for fourteen firms.

A time series analysis for each firm would have faced the challenge of having very few observations per firm to achieve a satisfactory adjustment. Given that the information of the financial statements is quarterly, even when the prices of the metals can be obtained daily (or even intraday), the financial information of the firms is only available with the aforementioned frequency. By combining the information of all the firms in a Panel Data Analysis, it is possible to rectify the problem of the sample size, given that the complete database is used, thus having greater degrees of freedom for the estimations.

During the first stage of the analysis, high correlations were detected between the prices of four mineral and two metallurgic products considered to be possible explanatory variables of the capital structure during the analyzed period. It is not difficult to explain this phenomenon, given that the sensibility of the prices of the same to the global economic cycle is known. Although there are indeed differences in their nature (two are precious metals, another two are industrial metals, and the last two are metallurgic products), the global demand is closely related to the rise and fall of the economic activity, while the offer is basically stable, and with very gradual variations in time[6].

Factor Analysis

If the prices of each of the metals included in this analysis as explanatory variables had been included, a multicollinearity problem would have been generated. Because of this, it was decided to use the Factor Analysis method through Principal Components to combine the information contained in the original series of the prices of the minerals into factor scores.

The Factor Analysis can be described as a statistical technique used to: (1) reduce the number of variables and (2) detect the structure of the relations between original variables; with which it is possible to classify them.

To better understand the way this technique functions, the key steps to follow for its estimation are described below. First of all, we depart from a *P* set of random, observable variables $\boldsymbol{X}=(X_1,\ldots, X_p)$ with averages $\boldsymbol{\mu}=(\mu_1, \ldots, \mu_p)$. Thus, we have:

$$\boldsymbol{X}_i - \mu_i = \mathrm{L}_i\mathrm{F} + \varepsilon_i, \; i=1,2,\ldots,p \qquad (1)$$

It is convenient to introduce a $\boldsymbol{\mu}$ vector of a *p x 1* dimension, which contains the averages of the original values, **L** is a coefficient matrix of p x m dimension, $\mathbf{F}=(F_1,\ldots,F_m)$ is a factor of unobservable standardized variables of m x 1 dimension, known as "common factors", and $\boldsymbol{\varepsilon}=(\boldsymbol{\varepsilon}_{1,\ldots,}\boldsymbol{\varepsilon}_p)$ is a vector of errors.

[6] The technological changes and the incorporation of new producers to the global market are phenomena that present themselves in a very deliberate manner in the mining-metallurgic industry.

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The model expresses the observable p variables $\boldsymbol{X-\mu}$ in terms of *m* common unobservable **F** factors, and *p* unique unobservable $\boldsymbol{\varepsilon}_i$ variables. The loadings of the factors or **L** pattern matrix links the unobservable common factors to the observed data. Thus, the *j* row of L represents the loadings of the j-th variable of the common factors. Alternatively, the line can be considered to be the coefficients of the common factors of the *j*-th variable.

There are some necessary additional restrictions so that $E(F_i) = 0$, $Var(F_i) = 1$, $E(\boldsymbol{\varepsilon}) = 0$, $Cov(\boldsymbol{\varepsilon}_i\boldsymbol{\varepsilon}_j) = 0$, $E(\mathbf{FF}') = \boldsymbol{\Phi}$, and $E(\boldsymbol{\varepsilon\varepsilon}') = \boldsymbol{\Psi}$, where $\boldsymbol{\Psi}$ is a diagonal matrix of unique variances. Given the previous assumptions, it is possible to derive the basic relation of the variances of the Factor Analysis. The variance matrix of the observed variables is expressed as:

$$\mathbf{E}[(\boldsymbol{X-\mu})(\boldsymbol{X-\mu})'] = [(\mathbf{LF}+\boldsymbol{\varepsilon})(\mathbf{LF}+\boldsymbol{\varepsilon})'] = \mathbf{L\Phi L}'+\boldsymbol{\Psi}. \qquad (2)$$

The main objective of the factor analysis (or factorial analysis) is to model the observed $p(p+1)/2$ variances and the covariances of $\boldsymbol{X}$ as functions of the *pm* weight of factors in **L** and *p* specific variances in $\boldsymbol{\Psi}$.[7]

Table 4 shows the results of the Factor Analysis for the prices of the metals studied in this work. In a first output, the weight of the two extracted factors are shown, as well as the "communality" levels (the proportion of the variance of the original variables explained through the extracted variables) and "unicity" (the proportion of the variance not explained). Communality allows corroborating that the Factor technique is capable of capturing a high proportion of the original total variance, close to or greater than 80%, except in the case of zinc (which explains only 69%).

The algorithm used for the extraction of the factors was the Principal Component Analysis. The extraction of the weights of the factors was very interesting when assigning a high weighing to steel, copper, gold and silver in the first factor, while the weights corresponding to zing and aluminum were relatively low. However, in the second factor, the weights corresponding to these last two increased significantly. The portion of the variance explained by the model reaches 69% for the first factor and 31% for the second factor. Based on the loadings of the non-rotated factors, the values of the Factor Scores were estimated in order to reduce the dimensionality of the model from six original variables to only two. The values of the factors are used in the next stage of the analysis as input.

In order to achieve a clearer interpretation of the results of the factor analysis, a factor rotation[8] was carried out using the Varimax method. This time, the weights of the first factor clearly indicate a strong relation, greater than or equal to 95%, with gold and silver, and to a lesser extent with copper and steel at 76% and 85%, respectively. Due to the rotation, a greater decanting in the first factor with regard to aluminum and zinc is achieved; in the second factor, the weighing of aluminum and zinc clearly stands out. Table 4 shows the outputs of both estimation methods.

[7] Chapter 39, Factor Analysis, EViews 7 User Guide II, pp. 736-737, based on Johnston and Wichtern (1992).

8 The "rotation of factors" is a technique that is designed to modify the coordinates of the original axis to achieve a more intuitive interpretation of the outputs of the Factors Analysis (see, for example, Chapter 39, Factor Analysis, EViews 7 User Guide II.

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Table 4. Loadings of the original factors and of the rotated factors using the varimax method

Principal Component Method

Covariance Analysis: Ordinary Correlation

Sample: 2004Q1 2014Q4 Included Observations: 616

Previous Communalities: Multiple square correlation

1. Non-Rotated Factors

	F1	F2	Communality	Unicity
STEEL	0.867068	-0.165475	0.77919	0.22081
ALUMINUM	0.456403	0.794907	0.840181	0.159819
COPPER	0.950428	0.209137	0.947052	0.052948
SILVER	0.892262	-0.337623	0.91012	0.08988
GOLD	0.840133	-0.505347	0.961199	0.038801
ZINC	0.432049	0.712229	0.693936	0.306064

Factor	**Variance**	**Accumulated**	**Difference**	**Ratio**	**Accumulated**
F1	3.552046	3.552046	1.972414	0.69218	0.69218
F2	1.579632	5.131679	---	0.30782	1.00000
Total	5.131679	5.131679		1.00000	

2. Rotated Factors

	F1	**F2**
STEEL	0.849893	0.238478
ALUMINUM	0.054106	0.915016
COPPER	0.757483	0.61096
SILVER	0.949198	0.09562
GOLD	0.97732	-0.077751
ZINC	0.06917	0.830152

Correlation of Rotated Factors

	F1	F2
F1	1	-1.67E-16
F2	-1.67E-16	1

Source: Own calculations using EViews 9

Cross-sectional regression analysis

In the second part of the empirical analysis, we depart from the assumption that the capital structure of the mining-metallurgic firms of the sample–estimated as the Total Debt / Capitalization Value ratio–is a dynamic variable that responds to the variations of the price

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of the corresponding assets. As such, even though it is unrealistic to assume that the financial managers modify the composition of the financing sources in the general balance as a response to the behavior of the prices of the products they sell immediately (this effectively causes the prices to rise or fall in a, more or less, prolonged manner, but will be reflected several quarters after the start of the trend), due to the fact that the price of the assets reflects the relevant information for its valuation in an immediate and unbiased manner, it is safe to say that the capitalization value does respond in a dynamic manner to the fluctuations of the prices.

To determine the sensibility regarding the magnitude and direction of the influence of the prices of the metals on the capital structure of the firm, the latter is defined as the variable to be explained. The values of the two factors estimated using the Factor Analysis, which represent the behavior of the prices of the six mineral and metallurgic products, in conjunction with the net utility to quarter sales ratio, are included as explanatory variables.

It is to be expected that the rise of the price of the products of these firms increase their level of income and utility, given that the cost structure resulting from a physical plant and little changing technological processes do not affect the result. Therefore, the indication of the corresponding coefficients to the factors that represent the prices of the six studied products is negative. Similarly, the relation of the net utility to sales reflects the mid-term profitability of the firm, as it depends mainly on its efficiency, though given the relative stability of the production and management costs, it is also sensitive to the fluctuations of the prices of the product.

The proposed model to evaluate the relation between the explanatory variables and the capital structure of the firms can be expressed as follows:

$$(\text{Total Debt / Market Capitalization})_{it} = \alpha + \beta_1(\text{Factor 1})_{it} + \beta_2(\text{Factor 2})_{it} + \varepsilon \quad (3)$$

The results of the model are shown below in Table 5.Both the indication of the three explanatory variables, as well as the statistical significance of the variables confirm that the model has a solid empirical support. In addition to the simple Cross-Section Regression, the possibility of carrying out a Panel Data Analysis with fixed or random events, or both, was considered for the model to have the capability to recognize the natural differences between firms, products, and geographical regions in which they operate. It is interesting that both the fixed effects model, as well as the random effects model were rejected given that they do not improve the explicative capability of the model sufficiently to replace it. To this end, the corresponding estimations, the Redundant Fixed Effects Test, and the Hausman test were carried out for the random effects model. The results of the estimation and of the corresponding tests are omitted from this work for reasons of space.[9]

[9] However, they are available at the explicit request of the interested party from the contact authors.

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Table 5: Cross-Section Regression for the Financial Leverage as Function of the Price Factors of the Metals and the Profitability of the Firms

Dependent Variable: D(Total Debt / Market Capitalization)				
Method: Least Squares Panel				
Sample (adjusted): 2004Q2 2014Q4				
Periods included: 43				
Cross-Section Units Included: 14				
Total Observations in the Panel: 600				
Variable	Coefficient	Standard Error	t-statistic	Prob.
C	0.015433	0.004575	3.372894	0.0008
D(F1)	-0.030876	0.016294	-1.894931	0.0586
D(F2)	-0.038047	0.00699	-5.443414	0
PROFITABILITY	-0.047098	0.014585	-3.229232	0.0013
R-square	0.101230	Variance of the Dependent Average		0.006231
Adjusted R-square	0.096713	E.S. of the Dependent Variable		0.101652
Regression E,S	0.096612	Akaike Criteria		-1.829603
Sum squares of the residuals	5.572275	Schwarz Criteria		-1.800328
Authenticity Log	553.7958	Hannan-Quinn Criteria		-1.818208
F-statistic	22.41368	Durbin-Watson		1.806666
Prob(F-statistic)	0.00000			

Source: Own calculations using EViews 9

Conclusions

The econometric results suggest that the profitability of the mining firms and the behavior of the price of their products (metallurgic commodities) are variables that negatively affect the capital structure of the firms, due to the impact that these have on the cash flows of the same. Consequently, the main contribution of our analysis consists on providing evidence in favor of the Dynamic Pecking Order Theory in the context of the sample of mining firms of the studied Latin American countries.

However, the evidence can also be useful in the design of coverage strategies against market risks by the firms of the sector, in order to minimize the potential impact that the fluctuations of the prices of their products have on their capital structure up to now. An unplanned increase of the leverage of a firm, affected by the drop of the prices of its products, puts at risk their credit score and raises the cost of their financing sources. The results are also of interest for the portfolio managers, who are interested in minimizing the volatility of their bond portfolios (affected by changes in the credit score) and on the level of exposure to the market risk of the assets incorporated in their portfolios.

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