YIELD AND COMMODITY PRICES:
A VIEW FROM MINING BOND MARKETS

TESIS PARA OPTAR AL GRADO DE
MAGÍSTER EN FINANZAS

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Santiago, julio 2016

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June - 2016

SUMMARY

Linking the economic sector of bond mining issuers to commodity price indices published by the IMF a database at bond-year-commodity level was built to measure the funding cost elasticity to commodity price changes. The main results of this process show that commodity price variation are negatively related with bond yields, increasing this relation when the effect is separated in increases and price reductions. A 10% fall in the annual price of a mining commodity (for example copper, oil or iron ore) adds about 70bp - 40bp to the bond yields of incumbent firms, while an increase of similar magnitude has no statistically effect on these last. Also, this effect is greatest in lower maturity bonds, smaller companies and firms whith higher leverage. All these results are robust to the inclusion of variables at bond, firm, year and country level, and to different financing cost specifications. This nobel evidence is in line with the recent episodes of financial stress experienced by mining companies and the consequent credit rating cuts by rating agencies.

Keywords: Financing costs, Mining companies, Commodity prices.

JEL Classification: Q12, Q02, L71-72.

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1. Introduction

The rapid growth of commodity prices experienced from 2000, reaching its peak in 2008, it has been reversed since 2011. In this context, energy and metal markets are among the most affected by these fluctuations. Starting in 2000 the price of crude oil (WTI) was 28 dollars per barrel, reached it historic peak in June 2008, where this commodity was quoted at the extraordinary sum of 134$. The crises experienced during 2008 resulted in a sharp decline in this price to 39$ per barrel in February 2009, a drop close to 70% of its value in less than a year. Since then, the black ore price recovered to 110$ in April 2011, losing all this progress in the last years closing at 37 dollars to December 2015, value close to those recorded 15 years ago. A similar behavior was evidenced by the copper price during the same period: start at 0.8$ per pound in December 2000, reached its peaks at 3.9$ and 4.5$ in April 2008 and February 2011, respectively, and closed at 2.1$ in December 2015.

Agents of the global economy have been affected by these large fluctuations in the commodity markets, especially commodity producing countries linked to the mining sector during the last period of falling prices. The recent World Economic Outlook titled "Adjusting to Lower Commodity Prices" (IMF, October 2015) showed that both actual and potential output move together with commodity terms of trade in energy and metal producing countries. For example, in the case of metal exporting countries, the average annual GDP growth of Australia and Chile fell to 2.4% and 2.6% in 2012 - 2015 respect to 3.1% and 4.4% registered in the period 2000 - 2012[1], respectively. At a micreconomic level, many commodity producing firms have experienced risk rating cuts and others are being putting on review for downgrade due to the weakening of their main source of income, especially metal and oil mining companies. The big drop in the price of metals in 2015 motive the credit rating cut of BHP Billiton from A3 to A1 by the rating agency Moodys in March 2016 arguing that the company decreased their profits and increase its cash flow deficit. The same happened with Codelco,

[1] Values calculated based in GDP at constant prices reported in the World Economic Outlook Database, IMF April 2016.

the largest copper producer worldwide, that saw its credit rating cut from AA- to A + by S&P the agency in early February. At the same time, these agencies have putting on review for downgrade 120 oil companies and 55 mining companies projecting a declining demand and oversupply in mining commodities for the following years[2]. Other companies have failted to incorporate this new negative scenario in their finances, deferring payments its to creditors and falling into default status. According to Standard & Poor's, 112 companies worldwide defaulted on their obligations in 2015, where 46 of these belong to the oil - metals sector (41% of total defaults, in 2014 the total defaults were 60)[3]. In December 2015, the second largets coal miner in USA, Arch Coal, chose not to pay 90M$ in interest to its bond holders. Following this, the price of its bonds fell to such an extent that closed its trading on the secondary markets. Similarly, the oil campany Afren plc defaulted on its 2016 bonds after refusing to make a $15 million interest payment, falling on the same day its shares to historic lows.

The scenario described in the preceding paragraphs evidence that financial agents and markets have reacted in different ways to the experienced negative events in the commodity markets, and especially those affecting the oil and metal mining sector. To better illustrate the channels through the changes in commodity prices operates suppose the following scheme for the profits of incumbent firms:

$$\pi = p \cdot q - c \cdot q - r \cdot D \tag{1}$$

; where π are profits, p is the commodity realted price, q is the quantity sold - produced, c is the unit cost of production, r is the funding cost and D is the total debt of the company. The direct effect of prices is through total revenues, where $\pi'(p) = q > 0$ reflects the change in the company's liquidity. An unexplored indirect channel is through the funding cost, where the sign of $r'(p)$ defines the impact of price variations on the debt service and the company's solvency. The theorical explanation for the direction of this elasticity lies in the relationship between commodity prices and the expected payoff of the risky debt. Assuming that

[2] https://www.moodys.com/research/Moodys-places-energy-and-metals-mining-issuers-on-review-for--PR_342773

[3] http://www.mondaq.com/unitedstates/x/469552/Insolvency+Bankruptcy/The+Year+in+Bankruptcy+2015

commodity prices are positively related to debt services, then commodity price changes would be negatively related with yields through its effect on the present value of debt only if contemporary commodity price variations reflect changes in future price expectations. In an efficient market (Fama, 1965), due to actions of many competing market participating, the intrinsic values of goods will be reflected immediately in their actual prices. Due to disagreements among market participants concerning fundamental values of securities, prices start to walk randomly in an unpredictable manner from their intrinsic value. So, if a commodity prices exhibits random walk behavior, the expected future price of the commodity will be equal to its current price.

The main goal of this paper is to explore the effect of commodity price variations in primary mining industry on the funding costs of incumbent firms, measured as the yield to maturity of bonds issued by these (i.e measure $r'(p)$). Linking the economic sector of issuers to commodity price indices published by the IMF, a database at bond-year-commodity level was built. The main results of this process show that commodity price variation are negatively related with bond yields, increasing this relation when the effect is separated in increases and price reductions. A 10% fall in the annual price of a mining commodity (for example copper, oil or iron ore) adds about 70bp - 40bp to the bond yields of incumbent firms, while an increase of similar magnitude has no statistically effect on these last. Also, this effect is greatest in lower maturity bonds, smaller companies and firms whith higher leverage. All these results are robust to the inclusion of variables at bond, firm, year and country level, and to different financing cost specifications. This nobel evidence is in line with the recent episodes of financial stress experienced by mining companies and the consequent credit rating cuts by rating agencies.

The remainder of the paper is organized as follows. Section 2 provides a brief overview of the related literature. Section 3 describes the data and summary statistics. Section 4 presents the econometric framework and basline results. Section 5 explores some specific channels through which commodity price variations affect corporate bond yields. Section 6 presents a set of robustness checks. Section 7 concludes.

2. Literature review

The increase of capital investment in commodity markets over the last 15 years it has generated considerable academia debate about how the experienced "financialisation" distorts the price of raw materials. During the past decade there has been a substantial increase in volatility and the level of raw material prices largely explained by the increase in the demand for this resources by emerging economies, however, parallel has seen a rapid increase in commodity derivatives trading and financial investors activity in commodity markets (Domanski and Heath, 2007). Since 2001 the value of open positions and the turnover in major commodity futures contracts have increased substantially, which is attributed in part to technological changes and the entry of a new class of participants in the long side of the market, like the introduction of full electronic trading on commodity futures exchanges and capital investments made by commodity index traders (Dwyer et al., 2011; Cheng and Xiong, 2014). In this context whether the choices of financial speculators reflect an informed perspective on fundamental market factors, financialisation process can play a beneficial price discovery role. However, if financial speculators based their decisions on future price expectations in the absence of fundamental reasons – for example "noise" or "momentum" trading behaviour - speculation can be destabilizing (De Long et al., 1990; Reichsfeld and Roache, 2011).

Financial investors are more active in future markets compared to the spot market, because they do not want to have to take responsibility for physical delivery of materials because it is expensive storage. This is the opportunity cost of buying and holding a good or financial instrument versus purchasing a futures contract for delivery in the future. The theoretical relationship between futures prices and spot prices is based on a no-arbitrage condition. Assuming that the commodity is storable and that participants are able to freely access both the spot and futures markets then an unexpected increase in the futures price would, all else equal, allow agents to profit from buying the commodity today at the spot price, and selling it in the future at the futures price. This would then place upward pressure on the spot price

and/or downward pressure on the futures price until the no-arbitrage condition was restored (Dwyer, 2012). In Frankel & Rose (2010) it is argued that increases in interest rates lowers prices of raw materials through two channels: 1) increase the costs of maintaining inventories, decreasing the demand for these and the total demand for the commodity; 2) and make bonds a more attractive financial instrument to invest, reducing investment demand for commodities. On the other hand, Calvo (2008) argues that the increase in raw material prices are accompanied by low interest rates, rising sovereign funds, and consequently low demand for liquid assets, however, it is a temporary relationship corrects over the long term.

The empirical evidence that tests the hypothesis of financialisation has focused mainly on the analysis of time series based on the theory of cointegration and cross correlation between different financial markets. A recent study by Cheng and Xiong (2014) analyzed the cross correlation between different commodity price indices showing that these rose from a range of -0.2 to 0.2 prior 2004 to 0.7 in the mdiddle of 2008. Also in this cross correlations between commodity prices and other financial markets such as bond and equity markets are reported, showing that correlations trended upward from 2004 to 2008 and have increased significantly since the collapse of Lehman Brothers in 2008. Buyuksahin et al. (2010) cannot find any cointegrating vector between the S&P 500 and Goldman Sachs Commodity Index (GSCI) sub-indices during 1991–2008, although some unstable cointegration between the benchmark commodity and equity indices can be found during the sub-period 1997 to 1999. They conclude that there is little evidence of a common long-term trend between investable commodity and equity índices. Chevallier and Ielpo (2014) test crossmarket linkages between commodities, bonds, industrial production and inflation in USA. They show that one cointegration relationship exists between these variables during 1993–2011 taking into account a structural break in August 2008. Grisse (2010) using a VAR model finds that fluctuations in interest rates largely explain the variations in oil prices in the long term.

Although "financialisation" theory has vast theorical and empirical support, certain facts discredit its validity. In Dwyer et al. (2011) are given 5 reasons to dismiss the "financialisation of commodities": 1) Increases in commodity prices have been seen in commodities with

developed futures markets and commodities with undveloped futures market (for example the market for coal and iron ore, which doesn't have large financial derivatives markets, increased prices as others who); 2) There exists heterogeneity in price variation within markets with developed financial markets (e.g. oil and gas , both with developed financial markets showed different behaviors since 2009, due to the high growth in the supply of natural gas in the US due to technological developments); 3) The increase in the correlation between commodities and other financial prices, which is usually cited as evidence of financial speculation, is not unusual in the historical context. Episodes with increases in the correlation of commodities and actions have occurred in the past when financial investments did not play such an important role in this market; 4) non-energy commodities in and out of indexes showed similar correlations regarding oil; 5) and non significant changes in inventories they posed speculative activity.

Fundamental factors, such as growth of Asian countries, have been studied as determinants of prices of raw materials and also as a complementary hypothesis to "financialisation". A combination of rapid industrialization, stronger per capita income growth, higher commodity intensity of growth, and rapid population growth in some countries (notably China, India, and the Middle East) have contributed to the strong pace of commodity demand growth in the last decade (Helbling et al., 2008). Cevik and Sedik (2011) show that both supply factors, such as physical production, and demand factors, such as consumption of emerging and advanced economies, are positively correlated with the price of raw materials, with the correlation stronger on the consumption of emerging countries. These results are especially important in energy markets, where emerging economies made the greatest contribution to the upsurge in global crude oil demand, accounting for 69% of the increase in world oil consumption between 1990 and 2008 as oil consumption in OECD countries declined during that period. Similarly, Arbatli and Vasishta (2012) evidenced that an increase by 1% in growth expectations of India and China increase by 5.5% the price of copper and 3.6% aluminum prices, while growth expectations of USA and the interest rate explain the variation in the oil prices.

The use of fundamental analysis approach has been vastly applied on financial asset valuation. For example, in "housing" literature there are two streams to relate the house prices with their fundamentals, one that takes aggregated data and another based on the regionality of these. In the first category of studies, McCarthy and Peach (2004) suggested that there was no bubble in the U.S. housing market and that changes in house prices reflected movements in personal income and nominal mortgage rates. Another example of this approach is Shiller (2006) or Gallin (2006) who used aggregate data on home prices, personal income, building costs, population, user costs of housing and interest rates. They showed that changes in fundamentals did not explain the rapid growth of U.S. house prices after 2000. In the second stream, Himmelberg et al. (2005) used their own calculations of owning costs of housing for 46 Metropolitan Statistical Areas (MSA) to argue that the high price-to-income and price-to-rent ratios observed between 1995 - 2004 were explained by shifts in real long-term interest rates and therefore there was no bubble in the U.S. housing market. Fender & Scheicher, 2009 analyzes fundamental factors for ABX prices (CDS price indeces for MBS at different tranches) finding that those instruments backed with senior exposure are more sensitive to the financial market environment respect to real state activity.

In bond markets, a pionner research by Collin - Dufresne et al. (2001) study the determinant of credit spread changes from a contingent-claims or no-arbitrage view (Black & Scholes, 1973). Based on the premise that holders of risky coporate bonds can be thought of as owners of riskless bonds who have issued put options to the holders of the firm's equity (Merton, 1974), they found that variables that should in theory determine credit spread have rather limited explanatory power (leverage, yield curve, assets, etc.). Under a similar framework Campbell & Taksler, 2003 using data from 1995 to 1999 show that firm level volatility and credit ratings can explain equally well the cross - sectional variation in coporate bond yields, results that are consistent with theorical models, specifically because firm's volatility is a key input in the Black - Scholes option - pricing formula. Chen et al. (2007) studied the yield spread dynamics for over 4,000 corporate bonds finding that more iliquidid bonds earn higher yield spreads and an improvement in liquidity causes a significant reduction in yield spreads, wich is in line with

the notion that investors demand a liquidity premium for illiquid securities (Amihud & Mendelson, 1986; Lo, Mamaysky & Wang, 2004). Andreasen et al. (2015) found that restrictions on capital inflows produce a substantial and economically meaningful increase in coporate bond spreads, not concluding the same for capital outflows. This finding was strong for short - term maturity bonds, issued by small firms and in countries with underdeveloped financial markets.

The relationship between the price of raw materials and microeconomic variables is scarce, however empirical studies have been conducted on the subject at a macroeconomic level. De Gregorio (2012) analyzes the effect of rising prices of raw materials in the inflation rates of Chile, finding that inflation in food prices has a greater impact on headline inflation regarding energy inflation. In Cespedes and Velaso (2012) is studied the macroeconomic response of a set of commodity-producing nations to episodes of boom and bust in commodity prices. The results indicate that boom episodes are correlated with increases in countries outputgap and investment rates, effects that are softened by flexible exchange rate regimes and developed financial markets. More recently, a similar exercise was conducted in the last World Economic Outlook (IMF, 2015) using a commodity terms of trade index for net exporting economies finding that both actual and potential output move together with the commodity terms of trade but the actual ouput commoves twice as strongly as potential output. Also, in this study it is reported the recent increase in sovereign spread of commodity exporting countries. Dauvin (2016) analyze 22 emerging markets sovereign spreads showing that commodity prices are relevant for exporters, as they help relaxing the credit constraint in periods of increasing prices, however, they are less important when assessing sovereign risk of poor countries. Combining sovereign bond markets and commodity prices Powell and Gilbert (1988) analyze the debt interest payments of major copper producing LDCs (Chile, Zambia, Peru, Papua New Guinea and Zambia) showing that debt services and commodity revenues move together. The autors proposes different commodity linked bonds contracts based on variable coupon rates which are procyclical to copper price, eliminating the uncertainty of future payments to bondholders.

3. Data description

3.1 Data Sources

The main goal of this paper is to explore the effect of commodity price variations in primary mining industry on the cost of incumbent firms funding, so a connection between the productive sectors and different types of raw materials must be defined in a first instance. After analyzing the SIC codes to 4 digits list it were selected those representing better the primary mining industry joining these to 7 indices of commodity prices published by the IMF: Coal, Aluminum, Copper, Gold, Iron Ore, Energy Index and Metal Index. The latter was spliced to a primary economic sector that represents mining companies that sell a set of metal commodities. The motivation of this segmentation emerge from the "housing" literature that allows heterogeneity in the analysis which if not taken into account can reach wrong conclusions. For example, in Mikhed and Zemcik (2009) cointegration test on housing prices and fundamental variables is performed in aggregate way resulting in a long-term relationship between the series, but when this test is performed by segmenting homes geographically the conclusions are different. This can be extrapolated to the commodity industry, where the aggregate analysis would be assigning a single price index for all sectors and the segmented analysis is grouping the primary sector with their respective commodity. In this context, it is understood by primary sector to the one that its core business is the exploitation of its own reserves and the marketing of the respective raw materials to processing companies, not taking into account external contractors running tasks extraction, firms that lease the territories of exploitation or companies providing ancillary services to the industry (eg machinery leasing). This process is designed to keep only primary productive enterprises, avoiding contamination in the subsequent analysis of intermediate transactions by companies in the middle (or around nearby) of the industrial chain. Table 9 in Appendix 1 details the union between the different mining sectors and commodities based on the sectoral definition of their SIC code to 4 digits and price indices published in the IMF Primary Commodity Data, respectively.

To control for all variables that could directly affect the financing costs, specifically the cost of borrowing capital in the bond market, standard determinants of yield to maturity according to structural credit risk models and the empirical literature on the determinants of corporate bonds are considered (Merton, 1974; Collin-Dufresne et al., 2001; Campbell and Taksler, 2003; Chen et al., 2007). The sample that is used in this study contains firms that issue their bonds in both international and domestic markets, in different type of currencies and for listed and unlisted companies. Also, given that only certain types of firms choose, and are able to access to financing via bond markets, the results of this study cannot be extrapolated to the entire universe of firms.

The first step of the data construction process is to obtain a comprehensive sample of all the available bond-level issuance information at December 2015 from Thomson Reuters Eikon (indeed outstanding bonds). This platform allows to identify several features of bonds issuances like issue and maturity date, currency, coupon rate, historical yield-to-maturity (YTM), bid and ask bond prices, issuer name, industry, country, among other data fields. Then only bonds of industries defined in the preliminary step were retained. As a preliminary filter, following Datta et al. (1999) and Elton et al. (2001), they were deleted all bonds with special features, like bonds with options (convertible, callable or sinking fund bonds), floating rate bonds, coupon zero bonds, zero then fixed bonds and zero then floating bonds.

On a second level, historical financial statements of issuers were obtained from Capital IQ, obtaining information such as assets, sales and liabilities. Also, this financial platform provides historical credit rating of issuers based on Standard & Poor's long-term ratings scale and helped to refine the economic sector obtained in the preceding stage (this source assigns the economic sector to companies based on the relevance of the income of the different products is sold in its total revenue). Also, a serie of country-level controls used in Andreasen et al. (2015), such as GDP growth, global financial volatility and country credit ratings are considered. As a measure of economic growth the annual change in real GDP is used and the volatility of financial markets is approximated by the CBOE VIX index that captures the expected 30-day risk neutral volatility, as implied by S&P 500 option prices. Country credit

ratings are obtained from Capital IQ based on Standard & Poor's long-term ratings scale in foreign currency. Finally, yield to maturities of sovereign bonds with similar currency and maturity are included in the analysis.

To reduce the potential for errors in the coding of the data, the database was clean in three ways. First, the top and bottom 1% of yield to maturities were eliminated form the analysis. Second, all observations in the accounting variables that exceed the simple mean by more than five standard deviations were dropped. Third, bonds issued in countries were the total number of observations is fewer than 25 were not considered. The resulting sample consists of 3,593 observations at bond – year level, representing 655 individual bonds and 140 issuer companies between 2002 and 2015. The bonds are mainly from companies that are located in USA, linked to the oil and gas mining and perform their bond issues in US dollar. To view the data distribution at country, year and issue currency level, see Appendix 2 (also the sources and variables used in this study are described). In the next subsection a brief descriptive statistics of the main variables are presented.

3.2 Descriptive Statistics

Table 1 shows descriptive statistics at year - bond level for variables to be used in the empirical section. This presents the averages and standar deviations of a serie of selected variables segmenting by economic sector and by periods in which commodity prices fell (rose). In aggregate terms, during episodes of falling prices are observed higher yield to maturities respect to episodes of increasing prices. The sectors that saw increased their cost of financing in greater magnitude during the decline were the Coal and Metal sector, which recored yield to maturities above 4% compared to those evidenced in boom periods. On the other hand, the less affected sectors by a fall in prices were the Aluminum and Copper sector, where the same differentials in yields doesn't exceed 1%. Another interesting fact is that the volatility of yields is higher when price declines are experienced, for example the aggregate standard deviation of yields is 3 times higher in adverse periods respect to booms. Similar conclusions are obtained when the liquidity of the bonds, operating margins and issuer credit rating are analyzed: bearish price

Table 1: Descriptive statistics at bond-year level for falls and increases episodes in commodity prices, selected variables

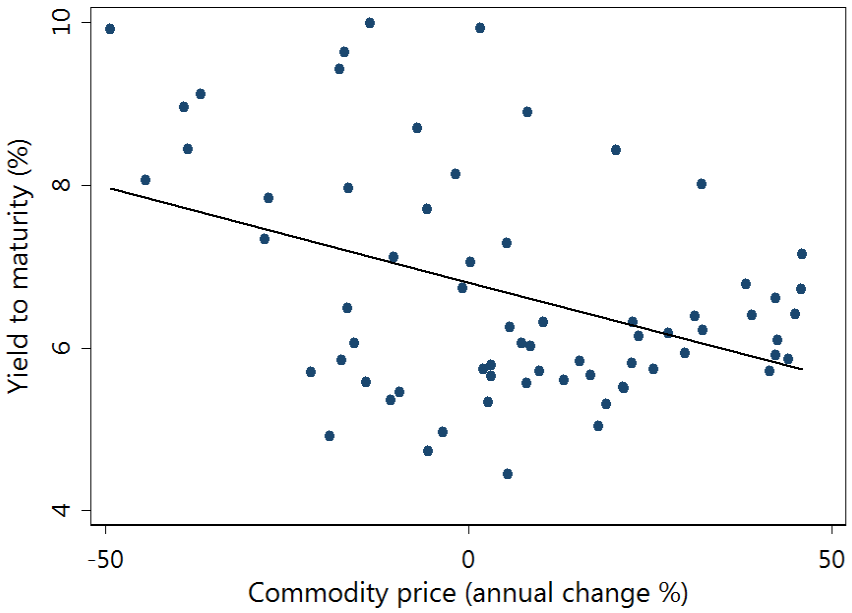
	Obs.		Commodity price (%)		YTM (%)		Bid - Ask spread		Issuer credit rating		Operating margin (%)		Liabilities to assets (%)	
Mining sector	Fall	Increase	Fall	Increase	Fall	Increase	Fall	Increase	Fall	Increase	Fall	Increase	Fall	Increase
Gold	216	100	-13.31	16.09	8.21	6.18	0.19	0.09	11.07	13.76	10.37	26.01	47.01	39.81
			(10.73)	(11.58)	(6.47)	(2.38)	(0.51)	(0.06)	(1.96)	(2.31)	(28.23)	(15.81)	(14.03)	(8.36)
Aluminum	173	171	-19.68	13.21	6.35	5.77	0.26	0.12	12.09	12.25	5.84	4.44	60.56	60.79
			(6.36)	(12.93)	(2.21)	(1.59)	(0.87)	(0.11)	(1.48)	(1.39)	(5.66)	(5.79)	(9.23)	(7.44)
Coal	260	16	-16.03	38.25	11.84	6.21	0.71	0.65	6.31	10.38	5.45	15.12	65.72	66.05
			(7.11)	(23.67)	(12.18)	(1.41)	(1.66)	(0.81)	(3.47)	(0.89)	(12.04)	(4.68)	(11.79)	(6.37)
Copper	320	136	-17.37	38.53	6.48	6.26	0.12	0.08	11.87	11.12	28.89	38.72	52.09	54.96
			(12.18)	(37.51)	(2.91)	(1.69)	(0.17)	(0.11)	(1.85)	(2.11)	(19.98)	(15.79)	(8.88)	(16.23)
Irone ore	101	47	-37.87	14.49	10.72	6.95	0.26	0.17	9.82	12.66	11.63	32.72	51.51	45.89
			(15.35)	(20.62)	(9.31)	(2.77)	(0.53)	(0.21)	(2.73)	(1.01)	(49.84)	(17.25)	(15.89)	(16.21)
Metal	168	44	-18.18	17.01	11.34	7.21	0.71	0.43	7.79	9.86	8.07	23.06	53.01	43.56
			(9.19)	(23.05)	(9.18)	(2.39)	(1.77)	(1.22)	(2.75)	(2.93)	(31.67)	(12.43)	(11.96)	(9.99)
Oil and Gas	831	1,010	-31.26	21.64	7.54	5.77	0.43	0.38	10.97	12.72	20.01	22.25	56.49	57.53
			(15.38)	(16.98)	(7.49)	(2.76)	(1.16)	(1.05)	(3.83)	(2.59)	(23.39)	(19.05)	(11.22)	(10.04)
Total	2,069	1,524	-23.46	21.63	8.35	5.92	0.39	0.31	10.22	12.51	15.58	22.36	56.23	55.75
			(14.68)	(20.31)	(7.86)	(2.55)	(1.14)	(0.91)	(3.64)	(2.51)	(25.34)	(18.97)	(12.54)	(11.93)

Notes: This table shows the averages and standard deviations (in parentheses) of the main features of bonds - issuers by commodity index - economic sector. Firms fundamentals were collected from S&P Capital IQ and bond features were obtained from Thomson Reuters Eikon. Commodity price (%) is the annual change in the index of commodity prices for the corresponding economic sector. Bid - Ask spread is the annual average of monthly differences between the bond bid prices and ask prices. Operating Margin is the operating income to net sales, Issuer credit rating take values between 1 and 21 according to the credit rating scale for foreign currency issues used by Standar & Poors (being 21 the best score, AAA, and 1 the worst, D) and Liabilities to Assets represents the total liabilities over total assets. All bonds with special features that could biased the results, as "zero coupon", "zero and then Fixed" and "zero then floating", were deleted. Top and bottom 1% of yield to maturity (YTM) and bid - ask spread were eliminated. All observations in the accounting variables that exceed the simple mean by more than five standard deviations were drop.

cycles are related to less liquid bonds, worse credit ratings and bad operating margins, also, these escenarios are related to higher volatility in these financial variables. The only exceptions to these conclusions are the operating margin in Aluminum sector and the issuer credit rating in copper sector, where the relationships described are reversed. In terms of leverage no significant differences between decline and boom periods are evidenced. The only sectors that increased their leverage to price falls were the Gold, Iron ore and Metal sector.

The negative relationship between commodity price changes and financing costs evidenced in Table 1 is best illustred in Figure 1. In this it's shown the annual commodity price variation and average yield to maturity per economic sector - year. The β regression coeficient between price changes and yield to maturity (left variable) is near to -0.02, indicating that an increase in 1% in commodity prices is related with a decrease in 2 basis points in the average yield to maturity. Using the EMBI Glonal index a similar relationship was reported at country level in the IMF World Economic Outlook (2015). In Appendix 3 the correlation matrix of these variables is shown.

Figure 1: Annual commodity price variation and average yield to maturity



Notes: This figure plot the linear relation between annual commodity price variation and the average yield to maturity per economic sector - year. The β regression coefficient for this relationship is -0.021.

4 Results

4.1 Econometric specification

This section estimates an empirical model aiming to measure the effect of commodity price variation on the yield to maturity at wich related firms (commodity index – economic sector) get bond funding in global markets. The main estimated equation goes as follows:

$$y_{bfit} = \beta^{\Delta Price} \cdot \Delta Price_{it} + \gamma X_{bft} + \delta \mathrm{W}_{ct} + \mu_b + \epsilon_{it} \tag{2}$$

; where on the left hand side y_{bfit} is the yield to maturity of a bond b, issued by firm f from commodity index – economic sector i in year t; on the right hand side we have $\Delta Price_{it}$, which is the annual variation from commodity index – economic sector $\boldsymbol{i}$ in year t . Additional controls included in the regression are X_{bft}, representing bond-year level variables as Years to Maturity - Bid ask spread and firm-year level variables as Log(Assets), Liabilities to Assets, Operating Margin (these variables are used with 1 year lag) and Credit ratings of issuers - Default status; and W_{ct}, representing country - year and year level variables as GDP growth, Country credit ratings, Financial volatility and Sovereign yields. The specification will be estimated with panel data regressions using bond fixed effects, μ_b, and clustering the standard errors at commodity index –year level, ϵ_{it}. Also specifications with year and country - year fixed effects are estimated.

The main parameter of interest is $\beta^{\Delta Price}$, which represents the yield to maturity elasticity relative to changes in the related commodity price index. The theorical explanation for the direction of this coefficient lies in the relationship between commodity prices and the expected payoff of the risky debt. Assuming that commodity prices are positively related to debt services, as found at country level for commodity producing countries in Powell and Gilbert (1988), and the present value of risky debt is determined by computing its expected future cash flows discounted at the risk - free rate, then commodity price changes would be negatively related with bond prices (or positively related with bond yields) through its effect on the

present value of these only if contemporary commodity price variations reflect changes in future price expectations. According to Fama (1965) in an efficient market, due to actions of many competing market participating individuals, the intrinsic values of goods will be reflected immediately in their actual prices. Due to disagreements among market participants concerning fundamental values of stocks or commodities, prices start to wander or walk randomly in an unpredictable manner from their intrinsic value. If a commodity exhibits random walk behavior, the present price of the commodity will be equal to its previous value plus a stochastic term, so the future price expectation is equal to the current price. The existence evidence corroborates this random nature in commodity prices (Musunuru & Patton, 2012) at least over short periods of time (Dixit and Pindyck, 1994)[4].

The theorical sign of Years to Maturity coefficient is determined by the term structure of interest rates or better known as "yield curve". This reflects the future interest rates expectations at different maturities, wich in normal economic times (non financial stress or recessions situations) they tend to rise with increasing the maturity of fixed income instruments, therefore the sign of this coefficient ought to be positive. For bid - ask spread coefficients a positive sign is expected in line with the notion that investors demand a liquidity premium for illiquid securities[5] (Amihud & Mendelson, 1986; Lo, Mamaysky & Wang, 2004).

The signs of coefficients at firm level variables obey the theorical framework defined in so-called structural models of default (Black and Scholes, 1973; Merton, 1974). These models assume that default is triggered when the firm value falls below some threshold, where this threshold is a function of the the amount of outstanding debt. Then, as the size of assets and operating margin are postively related to firm value, it is expected that their coefficients be negative, on the other hand, the leverage ratio affects the threshold increasing probability of default, and therefore the coefficient of this variable ought to be positive. For controls at country and year level are expected the signs found in previous studies (Bekaert et al., 2011; Andreasen et al., 2015). In the next section basline estimation for equation (2) are presented.

[4] Appendix 3 contains unit root test for all commodity price series at level used in this study.
[5] In this context an illiquid asset is defined as one with a large differential between bid and ask price.

4.2 Baseline Results

Table 2 presents the results from estimation of equation (1) by Ordinary Least Squares (OLS) clustering standar errors at commodity index –year level. In column (1) it's controlled for commodity price variation, years to maturity and bid - ask spread; in (2) firm's features such as liabilities to assets and total assets are included; year and country - year level controls like sovereign close yield, annual change in real GDP, financial volatility and country credit ratings are present in (3); and in (4) it is controlled by firm level variables that are more endougenous to the cost of funding, like issuer credit ratings and operating margins. From (5) to (8) and (9) to (12) the dynamic is the same adding fixed effects per year and country - year, respectively.

Most of the coefficients for control variables have the expected signs, and many of them have a statistically significant effect on yield to maturity. The positive effect of years to maturity reinforces the idea of a yield curve with positive slope, however, this effect disappears when it controlled by sovereign close yield, the other statistically significant representative of the yield curve; for bid - ask spread coefficients the results corroborate the theorical premium for illiquid assets (Chent et al., 2007). The evidenced positive sign for Liabilities to Assets is consistent with structural models of default and the empirical evidence previously found (Hotchkiss and Ronen, 2002). For the case of Log(Assets) there is no statistical significance in its coefficient, the same is true for real GDP growth. Financial volatility have a positive effect on yield to maturities, consistent with the theorical context posed by Merton (1974), where increases in equity volatility, both idiosyncratic and systematic volatiliy, increases the risk of bankruptcy and financing costs (Campbell and Taksler, 2002), however this effect has no statistical significance. The country credit ratings appear to be reflected in the cost of financing local firms. Countries with better credit quality have on average yield to maturities lower in their outstanding bonds respect their peers with worse. The resulting coefficients from the inclusion of issuer credit ratings and operating margins have the expected predicted sign by the theory, i.e, issuers with better credit quality and operating margins have lower cost of

funding. Also, the few companies that are in a state of default have on average yields 14% higher than the rest with better credit status.

For the main coefficient in this work the results suggest that annual commodity price variations have statistically significant negative effect on yield to maturity of bonds issued by linked commodity companies: for example a decrease (increase) of 10% annualy in the commodity price increased (decreased) by approximately 32 - 38 basis points the yield to maturity controlling only for fixed effects at bond level (1 to 4), 21 - 25 bp adding fixed effects at year level (5 to 8) and 13 - 19 bp with country year fixed effects (9 to 12). These results are robust to the inclusion of controls at bond, firm, country and global level. An interesting result is that the magnitude of the effect of commodity price variation and its statistical significance remains after controlling for more endogenous variables as are the issuer credit rating and operating margin, showing that the effect of commodity price variation on yields doesn't reflect changes in firm's liquidity, as it does the operating margin, or changes in the overall business climate, as it does issuer credit ratings. The negative effect of this coefficient may be reflecting the change in the present value of outstanding debt through its effect on the expected payment of the debt service. Also, this elasticity has economic relevance respect to the other evidenced sensitivies. Based on the specification (4) a increase (decrease) of 1.1% annually in commodity prices has an approximately equivalent effect on yield to maturities like and increase (decrease) of 1% in operating margin and a increase (decrease) of 22% has an equivalent effect on yields like and increase (decrease) of one step in issuer credit rating scale. These values rise to 1.3% - 24% and 2.1% - 40% when this excersise is performed based on the specification (8) and (12), respectively.

A relevant point that is not incorporated in this analysis is the possibility that companies hedge commodity prices by buying - selling future contracts. In this line, in a classic Modigliani and Miller (M&M) world with perfect capital markets, risk management should be irrelevant. When there are no information asymetries, taxes, or transaction costs, hedging financial risk should not add value to the firm because shareholders can undo any risk management activites implemented by the firm at the same cost. Another view claims that hedging stems from the

Table 2: Regressions for yield to maturity and commodity price changes

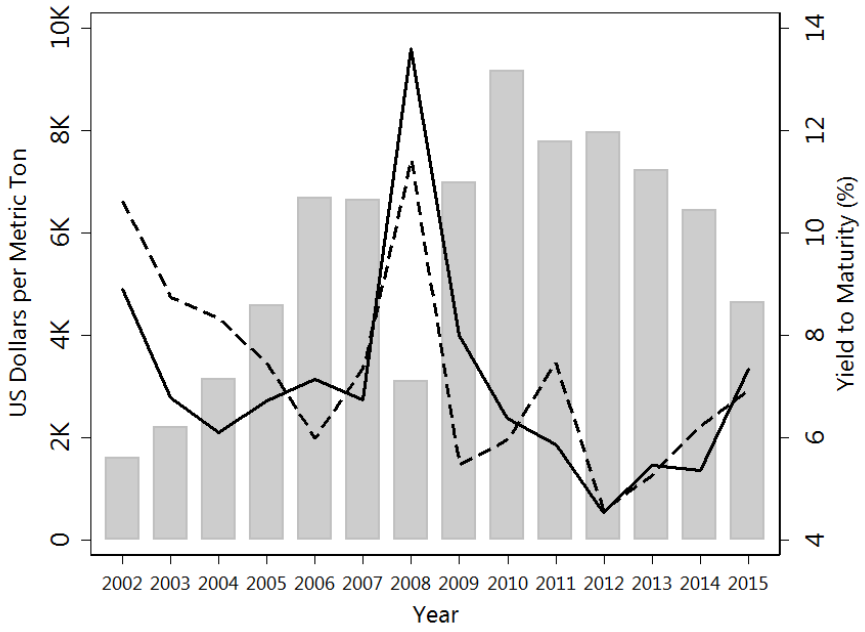
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Δ% Commodity price	-0.038***	-0.035***	-0.034***	-0.032***	-0.021**	-0.023***	-0.023***	-0.025***	-0.013*	-0.016*	-0.016*	-0.019**
	(0.012)	(0.012)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.010)	(0.009)	(0.009)	(0.008)
Years to Maturity	0.154**	0.145*	-0.186	0.017	-3.215*	-2.867*	-3.247**	-3.055**	-0.913	-1.021	-1.426	-1.535
	(0.070)	(0.102)	(0.131)	(0.127)	(1.654)	(1.540)	(1.573)	(1.388)	(1.171)	(1.088)	(1.164)	(0.952)
Bid - ask spread	0.120	0.098	0.085	0.093	0.121**	0.106*	0.097*	0.111*	0.120**	0.109**	0.113**	0.150**
	(0.073)	(0.065)	(0.067)	(0.070)	(0.058)	(0.056)	(0.055)	(0.059)	(0.058)	(0.055)	(0.055)	(0.063)
Liabilities to Assets		0.068***	0.072***	0.012		0.038**	0.040**	-0.000		0.049**	0.047**	-0.007
		(0.017)	(0.017)	(0.017)		(0.015)	(0.016)	(0.014)		(0.021)	(0.021)	(0.015)
Log(Assets)		-0.098	-0.548	-0.217		-0.160	-0.192	-0.077		0.121	0.121	0.588
		(0.558)	(0.494)	(0.578)		(0.487)	(0.488)	(0.562)		(0.480)	(0.489)	(0.538)
Sovereign close yield			0.653**	0.595***			0.659*	0.586**			0.929**	0.942***
			(0.263)	(0.220)			(0.354)	(0.238)			(0.414)	(0.285)
GDP growth			0.230	0.170			0.531***	0.507***				
			(0.178)	(0.175)			(0.165)	(0.174)				
CBOE VIX			0.077	0.051								
			(0.049)	(0.038)								
Country credit rating			-2.391**	-2.492**			-0.192	-0.251				
			(1.059)	(1.126)			(0.750)	(0.842)				
Operating Margin				-0.036**				-0.032*				-0.040**
				(0.015)				(0.017)				(0.019)
Issuer credit rating				-0.703***				-0.601***				-0.768***
				(0.197)				(0.179)				(0.208)
Default				14.633***				14.973***				14.537***
				(3.602)				(3.431)				(3.340)
Constant	5.181***	2.352	8.438	15.773**	77.622**	69.322**	72.777**	78.634**	26.787	25.123	28.647	40.009**
	(0.988)	(6.112)	(5.378)	(5.993)	(35.323)	(33.448)	(33.594)	(30.647)	(23.381)	(22.541)	(22.810)	(19.784)
Observations	3,593	3,463	3,463	3,463	3,593	3,463	3,463	3,463	3,593	3,463	3,463	3,463
R-squared	0.616	0.644	0.659	0.707	0.662	0.680	0.683	0.722	0.680	0.697	0.699	0.742
Bond FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	NO	NO	NO	NO	YES	YES	YES	YES	NO	NO	NO	NO
Country - Year FE	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES

Notes: This table provides estimated coefficients from panel regression defined in equation (1). Δ% Commodity price is the annual change in the index of commodity prices for the corresponding economic sector, Years to Maturity is the year of maturity minus year *t*, Bid - ask spread is the annual average of monthly differences between the bond bid prices and ask prices, Liabilities to Assets represents the total liabilities over total assets, Log(Assets) is natural logarithm of total assets, Sovereign close yield is the yield to maturity of government bond with similar maturity and currency, GDP growth is the annual change in real GDP (%), CBOE VIX is the Chicago Board Options Exchange volatility index (%), Country credit rating take the value of 1 if the country credit rating is above or equal to AA+ and 0 otherwise, Operating Margin is the operating income to net sales, Issuer credit rating take values between 1 and 21 according to the credit rating scale for foreign currency issues used by Standard & Poors (being 21 the best score, AAA, and 1 the worst, D) and Default take the value of 1 if the firm it's found in default and 0 otherwise. Firm level variables are used with 1 year lag. Regression are performed clustering standar errors at commodity index –year level. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.01

incentive of managers to maximize their personal utility. Risk averse managers engage in hedging if their wealth is concentrated in the firm they manage and if they find the cost of hedging on their own account is higher than the cost of hedging at the firm level (Smith & Stultz, 1985). Empirically, Jin and Jorion (2006) studied 119 U.S. oil and gas producers finding that hedging activites not affect firm's values, consistent with the theory described above.

In Figure 2 it shows the average yield to maturity for the copper industry, the predicted yield to maturity based on linear prediction model presented in column (4) of Table 2 and the copper price per year. A first evidence is that the proposed bond pricing model seems to fit in a good way to historical values of yield to maturities, showing some divergence during the first commodity price boom between 2002 and 2006. Also a negative relationship is evident between commodity prices and yield to maturities, decreasing the latter during 2002 - 2006 and 2008 - 2012, and increasing during 2006 - 2008 and 2012 - 2015, periods in which there was a boom and a slump in commodity prices, respectively.

Figure 2: Predicted yield to maturity and commoditie prices, the case of Copper



Notes: This figure shows the average predicted yield to maturity for the copper industry based on linear prediction model presented in column (4) of Table 2. On the left axis are the average effective yield to maturity (Continuous line) and predicted yield to maturity in (%) (Dash line). On the right axis is the copper price in thousand of dollars per Metric Ton (Bars; K abbreviation refers to thousand of dollars).

5 Heterogeneity

5.1 Sectoral and control variables heterogeneity

To asses the flexibility of the main effect found in the previous section regressions of the baseline model controlling for sectoral and other controls heterogeneity were estimated. Panel A of Table 3 shows the results of sectoral heterogeneity, which indicate that for the most sectors there is no a statistically significant difference in the effect of change in commodity prices on yield to maturities. Only for the Coal sector this effect appears to reach 12bp by percentage of variation in the price of the respective commodity, while for the Diversified metals sector this value is close to 11bp, however the latter effect is not statistically significant.

In Panel B of Table 3 estimates of heterogeneity from other controls are performed. Continuous variables were centralized in its mean for a relative interpretation in the coefficients. Most of the controls used in the main estimate appear to be heterogeneity channels for the principal effect in study. Companies with higher leverage are more affected to changes in the price of their main source of income. On the other hand, bonds of longer maturity, firms with better operating margins, larger in assets and better credit quality, tend to mitigate de adverse effects of commodity price variations. Also, less liquid bond are more sensitive to the effects of price variations. These results seem quite intuitive: First, companies facing financial complications (high leverage or poor results) are more vulnerable to other adverse effects; Second, larger companies with better credit quality have the backing and financial reputation to circumvent negative scenarios; and third, long-term obligations should not be influenced in large magnitude by changes in the expected value of its payments, since the variation in long - term flows are weighted to a lesser extent in the debt present value and payments of these instruments are focused in that evaluation horizon. An interesting result of this heterogeneity exercise is shown in column 8 of Panel B, where it is simultaneously controlled by all channels of heterogeneity. In this specification the commodity price coefficient represents and elasticity of 5.5 bp per percentage point of variation, representing the “average bond” sensitivity.

Table 3: Regressions for yield to maturity, sectoral and controls heterogeneity

	Panel A: Sectoral heterogeneity							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ% Commodity price	-0.043***	-0.030***	-0.033***	-0.031***	-0.033***	-0.033***	-0.031***	-0.027***
	(0.014)	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)	(0.007)	(0.008)
Δ% Commodity price*Oil and Gas	0.018							
	(0.016)							
Δ% Commodity price*Coal		-0.089**						-0.093**
		(0.043)						(0.044)
Δ% Commodity price*Aluminum			0.014					0.008
			(0.013)					(0.013)
Δ% Commodity price*Copper				-0.007				-0.011
				(0.020)				(0.020)
Δ% Commodity price*Gold					0.008			0.000
					(0.014)			(0.013)
Δ% Commodity price*Iron ore						0.013		0.003
						(0.032)		(0.032)
Δ% Commodity price*Metals							-0.081	-0.085
							(0.053)	(0.054)
Constant	18.350***	15.262**	15.855***	16.544***	15.678**	15.566***	16.416***	17.160***
	(6.114)	(5.881)	(5.990)	(5.692)	(6.022)	(5.854)	(6.000)	(5.524)
Observations	3,463	3,463	3,463	3,463	3,463	3,463	3,463	3,463
R-squared	0.709	0.711	0.708	0.708	0.707	0.708	0.711	0.715
Bond FE	YES	YES	YES	YES	YES	YES	YES	YES
Control variables	YES	YES	YES	YES	YES	YES	YES	YES

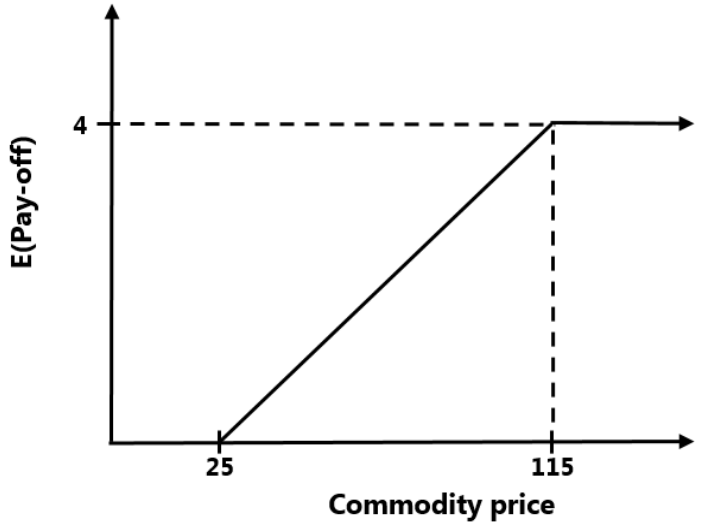
	Panel B: Control variables heterogeneity							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ% Commodity price	-0.037***	-0.032***	-0.033***	-0.039***	-0.036***	-0.039***	-0.051***	-0.055***
	(0.007)	(0.008)	(0.008)	(0.009)	(0.007)	(0.008)	(0.006)	(0.006)
Δ% Commodity price* Years to Mat.	0.001*							-0.000
	(0.001)							(0.001)
Δ% Commodity price* Bid - ask spr.		-0.004						-0.004*
		(0.003)						(0.003)
Δ% Commodity price*Liab. to Assets			-0.001**					-0.000
			(0.001)					(0.000)
Δ% Commodity price*Log(Assets)				0.021***				0.003
				(0.008)				(0.005)
Δ% Commodity price*GDP growth					-0.002			-0.000
					(0.002)			(0.002)
Δ% Commodity price*Op. Margin						0.001***		0.001*
						(0.000)		(0.000)
Δ% Commodity price*Issuer cred. rat.							0.021***	0.019***
							(0.003)	(0.003)
Constant	13.384***	14.353***	14.518***	14.574***	14.213***	13.666***	10.801***	10.809***
	(2.754)	(2.667)	(2.697)	(2.684)	(2.639)	(2.540)	(2.124)	(2.101)
Observations	3,463	3,463	3,463	3,463	3,463	3,463	3,463	3,463
R-squared	0.710	0.708	0.712	0.718	0.708	0.715	0.755	0.758
Bond FE	YES	YES	YES	YES	YES	YES	YES	YES
Control variables	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Control variables refers to those used in column (4) of Table 2. Δ% Commodity price is the annual change in the index of commodity prices for the corresponding economic sector, Years to Maturity is the year of maturity minus year *t*, Bid - ask spread is the annual average of monthly differences between the bond bid prices and ask prices, Liabilities to Assets represents the total liabilities over total assets, Log(Assets) is natural logarithm of total assets, GDP growth is the annual change in real GDP (%), Operating Margin is the operating income to net sales, Issuer credit rating take values between 1 and 21 according to the credit rating scale for foreign currency issues used by Standard & Poors (being 21 the best score, AAA, and 1 the worst, D) and Default take the value of 1 if the firm it's found in default and 0 otherwise. Firm level variables are used with 1 year lag. Regression are performed clustering standar errors at commodity index –year level. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

5.2 Quadratic and increase - fall effects

In Powell and Gilbert (1988) payments of sovereign debt of copper exporting countries are studied concluding that debt services and commodity revenues move together. The autors proposes different commodity linked bonds contracts based on variable coupon rates which are procyclical to copper price, eliminating the uncertainty of future payments to bondholders. In its framework the holder of the relevant country debt has an underlying long call option on a low price of the exported commodity and a short call option on a high price. The payoff structure is such that the debt holder has a constant profit at prices higher than the strike price of the short contract and a decreasing profit at lower prices than this[6]. This payment scheme reduce the financial burden on negative scenarios for the issuer with the promise of yields renegotiation in the near future. The motivation from this type of contracts emerges from the risky nature that presents common debt contracts issued by commodity producers agents, where the expected payments are reduced to falls in commodity prices. To illustrate this phenomen in Figure 3 the expected bond payment from commodity producer company is

Figure 3: Expected pay - off from commodity producer risky debt



Notes: This figure shows the expected pay - off of a bond issued by an oil company in June 2014 (where the price per barrel of crude oil was close to 110$) at a 4% annual coupon rate and maturity year 2019.

[6] It is assumed that call options have no cost.

shown. This emulates the first payment of a bond issued by an oil company in June 2014 (where the price per barrel of crude oil was close to 110$) at a 4% annual coupon rate and maturity year 2019. If between June 2014 and June 2015 the crude oil price shows improvements, it is expected that the company can meet its obligations, paying 4 to holders of this risky debt. On the other hand if the price gets worse, increases the likelihood that the company can't meet its obligations fully, decreasing the expected pay - off to a value below 4. The peculiarity of this payment pattern is that the expected pay - off is bounded above at the agreed coupon rate and decreasing to the current value (or at a point of evaluation) of commodity price, therefore negative variations should have a greater impact on debt value than positive changes.

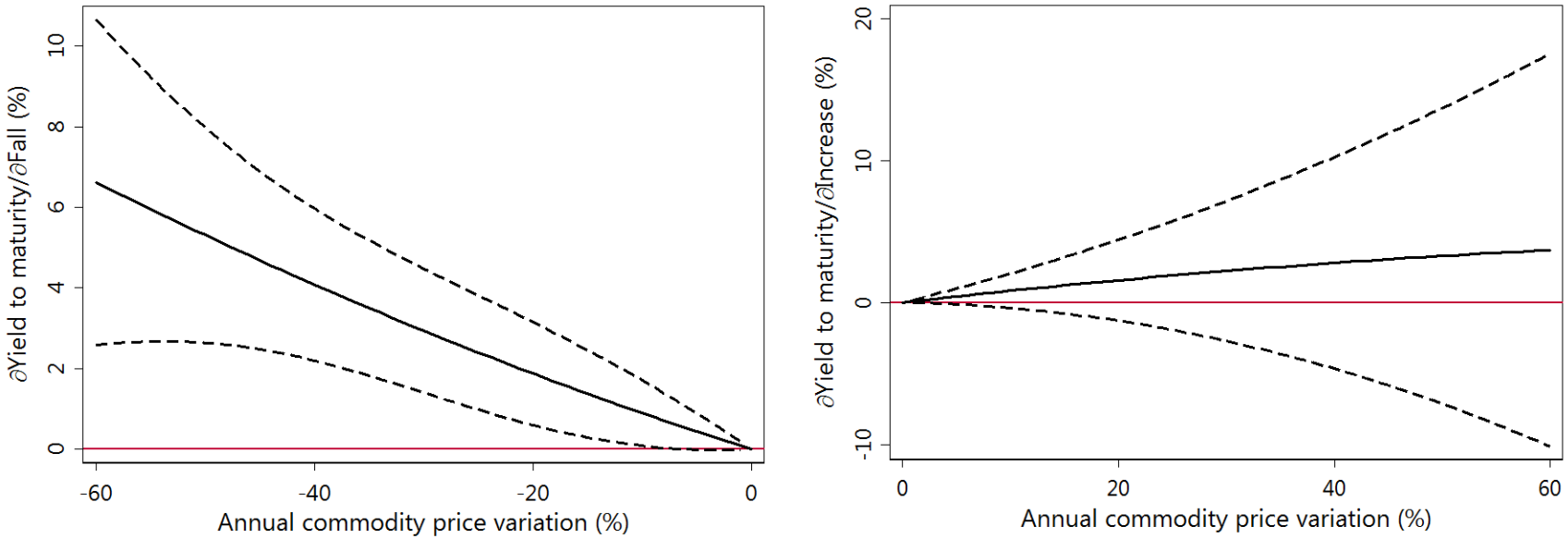
In Table 4 different specifications of the baseline model are estimated controlling for quadratic and increase - fall effects in commodity prices. In column (1) it's controlled for quadratic effect in commodity price variation; in column (2) this effect is divided by rises and falls in prices; column (3) allows rises - falls and common quadratic effects; and column (4) allows the same flexibility as in column (3) but the quadratic effect is separate to falls and rises. From (5) to (8) and (9) to (12) the dynamic is the same adding fixed effects per year and country - year, respectively. Analyzing the quadratic effect in the first set of specifications (1, 5, and 9) a small statistically significant convex effect is evidenced for the elasticity commodity price - yield to maturity. Dividing the effect between price increases and falls (2, 6 and 10) the statistical significance is lost on positive changes and per percentage point drop in prices the funding cost increases varies between 7bp - 4bp. In column (4), (8) and (12) it's found a positive quadratic effect for falls and one negative for increases. To better illustrate this last estimate marginal effects of a fall and an increase in commoditie prices on the yield to maturities are calculated and presented in Figure 4. This clearly shows a positive effect for falls in commodity prices statistically significant from a variation of around 10%, with a slight quadratic effect. For increases in commodity prices this exercise seems to have no statistical significance, a result that is in line with the previously proposed theoretical framework.

Table 4: Regressions for yield to maturity, quadratic and increase - fall effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\Delta\%$ Commodity price	-0.0376***				-0.0302***				-0.0235***			
	(0.0070)				(0.0069)				(0.0082)			
$\Delta\%$ Commodity price^2	0.0004***		-0.0001		0.0002***		-0.0002		0.0002**		-0.0001	
	(0.0001)		(0.0001)		(0.0001)		(0.0001)		(0.0001)		(0.0002)	
$\Delta\%$ Commodity price*Increase		0.0105	0.0216	0.0224		0.0056	0.0256	0.0257		0.0041	0.0159	0.0160
		(0.0097)	(0.0187)	(0.0184)		(0.0073)	(0.0183)	(0.0184)		(0.0074)	(0.0193)	(0.0197)
$\Delta\%$ Commodity price*Fall		-0.0722***	-0.0793***	-0.0634		-0.0544***	-0.0653***	-0.0497		-0.0425***	-0.0489***	-0.0114
		(0.0089)	(0.0122)	(0.0528)		(0.0095)	(0.0123)	(0.0579)		(0.0117)	(0.0143)	(0.0702)
$\Delta\%$ Commodity price^2*Increase				-0.0001				-0.0002				-0.0001
				(0.0001)				(0.0001)				(0.0002)
$\Delta\%$ Commodity price^2*Fall				0.0003				0.0002				0.0009
				(0.0014)				(0.0016)				(0.0020)
Constant	12.345**	11.375*	11.487*	11.414*	74.997**	75.585***	77.064***	77.871***	39.303*	41.009**	41.821**	44.803**
	(6.002)	(6.096)	(6.109)	(6.177)	(30.138)	(28.189)	(27.683)	(27.162)	(20.189)	(19.383)	(19.305)	(18.883)
Observations	3,463	3,463	3,463	3,463	3,463	3,463	3,463	3,463	3,463	3,463	3,463	3,463
R-squared	0.714	0.718	0.718	0.718	0.723	0.725	0.725	0.725	0.742	0.743	0.743	0.744
Bond FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Control variables	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	NO	NO	NO	NO	YES	YES	YES	YES	NO	NO	NO	NO
Country - Year FE	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES

Notes: Control variables refers to those used in column 4 (column 1 to 4), 8 (column 5 to 8) and 12 (column 9 to 12) of Table 2. Δ% Commodity price is the annual change in the index of commodity prices for the corresponding economic sector. Increase take the value of 1 if annual commodity price change is positive and 0 otherwhise; Fall take the value of 1 if annual commodity price change is negative and 0 otherwhise. Regression are performed clustering standar errors at commodity index –year level. Robust standard errors in parentheses *** p<0.01, ** p<0.05, *

Figure 4: Average Marginal Effects of a fall and an increase in commodity prices



Notes: This table provides estimated marginal effects on yield to maturity of a fall (left) and an increase (right) in commodity prices at different values in the magnitude of price variation. The base model for this estimate is presented in column (4) of Table 4. Deltha method is used to estimate marginal effects at a 90% confidence interval.

5.3 Stock prices and issuer credit ratings

In Jin and Jorion (2006) the effect of oil and gas price variation on the stock prices is evaluated for US energy mining companies between 1997 - 2002, finding that about 92% of the individual oil betas and 95% gas betas are positive, i.e increases in these commodity prices increases the value of companie related shares. In an aggregate analysis, Alenezi (2015) found that stock returns in Gulf Cooperation Council (GCC) countries are influencied by oil price risk, being this most relevant than other risk types, like exchange rate risk or interest rate risk. Motivated by this literature, this section evalutes the effect of commodity price variation on stock returns and issuer credit ratings. To addres this analysis the following two equations are estimated:

$$R_{fit} = \beta^{\Delta Price} \cdot \Delta Price_{it} + \beta^{\Delta Market} \cdot \Delta Market_{ct} + \gamma X_{ft} + \delta \mathrm{W}_{ct} + \mu_f + \epsilon_{it} \tag{3}$$

$$ICR_{fit} = \beta^{\Delta Price} \cdot \Delta Price_{it} + \gamma X_{ft} + \delta \mathrm{W}_{ct} + \mu_f + \epsilon_{it} \tag{4}$$

; where on the left hand side R_{ft} is the annual stock return and ICR_{ft} is the credit rating level (1 to 21) from firm f and commodity index – economic sector i in year t; on the right hand side we have $\Delta Market_{ct}$, which is the annual variation on the stock market index corresponding to country c in year t. Additional controls included in the regression, X_{ft} and W_{ct}, are the same controls previously used at firm and country level. The specification will be estimated with panel data regressions using firm fixed effects, μ_f, and clustering the standard errors at commodity index –year level, ϵ_{it}. Following the exercises of the previous section, specifications are also estimated segmenting commodity price changes in rises and falls.

Panel A of Table 5 estimates of equation (3) are performed. The results indicates that per 1% increase in commodity prices the stock returns of related companies increases 0.3%, however, when this effect is segmented, price falls loses significance, increasing it to 0.5% for rises. For issuer credit ratings (Panel B, Table 5) also a positive relationship is found: an increase of 100% in commodity prices increases by one step the credit rating, however, when this effect is segmented, price increases loses significance, increasing it to two steps for falls about the same variation.

Table 5: Regressions for stock prices and issuer credit ratings

	Panel A: Stock prrices							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ% Commodity price	0.321**	0.326**	0.371***	0.380***				
	(0.121)	(0.125)	(0.130)	(0.137)				
Δ% Market stock index	0.209**	0.206**	0.214**	0.219**	0.269**	0.276**	0.392***	0.389**
	(0.091)	(0.090)	(0.090)	(0.099)	(0.126)	(0.109)	(0.139)	(0.152)
Δ% Commodity price*Increase					0.366**	0.374**	0.570**	0.564**
					(0.180)	(0.186)	(0.256)	(0.256)
Δ% Commodity price*Fall					0.165	0.150	-0.168	-0.158
					(0.204)	(0.178)	(0.294)	(0.308)
Liabilities to Assets		0.303	0.291	0.377		0.313	0.281	0.342
		(0.293)	(0.280)	(0.330)		(0.302)	(0.270)	(0.303)
Log(Assets)		-0.518	2.730	4.165		-0.919	4.107	5.057
		(3.657)	(4.470)	(5.128)		(3.260)	(4.815)	(5.240)
GDP growth			3.627	3.403			5.509*	5.314*
			(2.204)	(2.239)			(3.065)	(3.122)
CBOE VIX			0.585	0.503			0.581	0.541
			(0.562)	(0.591)			(0.559)	(0.614)
Operating Margin				-0.087				-0.048
				(0.073)				(0.081)
Issuer credit rating				1.902				1.738
				(2.073)				(1.997)
Constant	-6.328***	-17.683	-67.152	-105.407	-8.268*	-16.591	-90.115	-121.865
	(2.028)	(49.168)	(59.320)	(92.805)	(4.776)	(47.998)	(70.726)	(99.499)
Observations	705	696	696	675	705	696	696	675
R-squared	0.280	0.283	0.301	0.296	0.282	0.286	0.323	0.315
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES

	Panel B: Issuer credit rating							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ% Commodity price	0.014***	0.010**	0.010**	0.008**				
	(0.005)	(0.004)	(0.004)	(0.004)				
Δ% Commodity price*Increase					0.000	0.000	-0.003	-0.003
					(0.005)	(0.004)	(0.005)	(0.005)
Δ% Commodity price*Fall					0.030***	0.021**	0.024**	0.021**
					(0.011)	(0.010)	(0.010)	(0.009)
Liabilities to Assets		-0.063***	-0.059***	-0.066***		-0.061***	-0.056***	-0.064***
		(0.012)	(0.012)	(0.010)		(0.012)	(0.012)	(0.011)
Log(Assets)		-0.234	-0.131	0.010		-0.226	-0.134	0.003
		(0.217)	(0.217)	(0.198)		(0.212)	(0.211)	(0.195)
GDP growth			0.084	0.111*			0.051	0.081
			(0.065)	(0.062)			(0.064)	(0.062)
CBOE VIX			0.042**	0.039**			0.051***	0.047**
			(0.019)	(0.019)			(0.018)	(0.019)
Operating Margin				0.008*				0.007
				(0.005)				(0.005)
Constant	10.286***	15.786***	13.655***	12.686***	10.613***	15.834***	13.718***	12.818***
	(0.126)	(2.072)	(2.119)	(1.884)	(0.146)	(2.022)	(2.017)	(1.840)
Observations	1,032	972	972	946	1,032	972	972	946
R-squared	0.849	0.873	0.875	0.890	0.853	0.875	0.878	0.893
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Δ% Commodity price is the annual change in the index of commodity prices for the corresponding economic sector, Δ% Market stock index is the annual stock market return (allocated based on the country - year of assessment), Liabilities to Assets represents the total liabilities over total assets, Log(Assets) is natural logarithm of total assets, GDP growth is the annual change in real GDP (%), Operating Margin is the operating income to net sales, Issuer credit rating take values between 1 and 21 according to the credit rating scale for foreign currency issues used by Standard & Poors (being 21 the best score, AAA, and 1 the worst, D). Firm level variables are used with 1 year lag. Regression are performed clustering standar errors at commodity index –year level. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

6 Robustness

6.1 Maturity, leverage, profitability and size

In this section, estimates are made in subsamples to assess the consistency of the results so far. This process is performed based on four variables used as control in above estimates: Years to maturity, Liabilities to assets, Operating margin and Log(Assets). For each of these four variables the historical average was calculated (at bond level for the case of Years to maturity and at firm level for other variables). Then, two subsamples are generated for each variable in analysis based on the median of the historical average calculated previously. Thus eight subsamples are generated: four contain those observations in which the values of its segmentation variables are above the median, and four in which these are below.

The robustness exercise is summarized in Table 6. In this it's evidenced that commodity price variation coefficient is statistically significant in all estimates on defined subsamples, corroborating the robustness of the effect that this has on yield to maturities. Also, large differences in coefficient are displayed between subsamples whithin the same segmentation variable. For the case of Years to maturity, the effect is lower in bonds with long maturity respect to short maturity bonds; for Liabilities to assets the effect is greater in companies whith higher leverage; and this is lower in companies with better profitability and larger size. In Appendix 4 the same results in Table 6 with year and country - year fixed effects are shown. The findings are similar, however the statistical significance is lost when more mature bonds and larger companies are evaluated. Also, the effect segmenting by leverage is ambiguous and loses significance. Table 7 shows tests for the statistical significance of the differences presented in Table 6 for each group of subsamples per variable. Differences in elasticity commodity price - yield to maturity are as follows: lower maturity bonds, smaller firms and companies with worse operating margins are 5bp, 2bp and 3bp more sensitive to percentage changes in commodity prices respecting their peers above the median, respectively. For less leveraged companies, these are 2bp less sensitive to prices compared to those with higher leverage.

Table 6: Regressions for yield to maturity, maturity-leverage-profitability-size robustness check

	Years to maturity		Liabilities to assets		Operating Margin		Log(Assets)	
	<p50	>p50	<p50	>p50	<p50	>p50	<p50	>p50
Δ% Commodity price	-0.067***	-0.021***	-0.021***	-0.038***	-0.056***	-0.028***	-0.039***	-0.024***
	(0.016)	(0.006)	(0.005)	(0.010)	(0.012)	(0.008)	(0.011)	(0.007)
Years to Maturity	-0.033	0.227**	-0.036	0.063	0.053	0.136	-0.227	0.178*
	(0.376)	(0.089)	(0.086)	(0.188)	(0.312)	(0.103)	(0.225)	(0.094)
Bid - ask spread	0.123	-0.106	-0.420	0.095	0.162	0.059	0.190	0.060
	(0.103)	(0.090)	(0.313)	(0.077)	(0.137)	(0.102)	(0.137)	(0.078)
Liabilities to Assets	0.041	-0.002	0.041**	-0.002	0.111**	-0.012	0.066**	-0.021
	(0.028)	(0.012)	(0.020)	(0.030)	(0.045)	(0.018)	(0.027)	(0.023)
Log(Assets)	-1.707	0.374	-0.944**	0.388	-2.466	0.287	-3.390***	0.541
	(1.328)	(0.444)	(0.433)	(0.788)	(1.726)	(0.489)	(1.161)	(0.475)
Sovereign close yield	0.910**	-0.011	0.431**	0.782**	0.379	0.453**	0.098	0.425**
	(0.372)	(0.199)	(0.192)	(0.301)	(0.429)	(0.221)	(0.410)	(0.188)
GDP growth	0.361	0.083	-0.000	0.186	0.917	0.030	0.789*	-0.008
	(0.279)	(0.111)	(0.143)	(0.259)	(0.554)	(0.123)	(0.399)	(0.101)
CBOE VIX	0.165*	0.017	0.011	0.060	0.062	0.056*	0.055	0.058*
	(0.087)	(0.025)	(0.031)	(0.055)	(0.069)	(0.032)	(0.062)	(0.032)
Country credit rating	-2.652	-2.017**	-1.952**	-2.549*	-5.062**	-1.662*	-4.234*	-1.471*
	(1.682)	(0.849)	(0.864)	(1.365)	(2.097)	(0.939)	(2.120)	(0.762)
Operating Margin	-0.044	-0.018**	-0.014	-0.056*	-0.041	-0.018*	-0.039	-0.014**
	(0.030)	(0.009)	(0.009)	(0.029)	(0.032)	(0.010)	(0.024)	(0.007)
Issuer credit rating	-1.334***	-0.450**	-0.428	-0.857***	-1.666***	-0.459**	-1.380***	-0.507***
	(0.375)	(0.202)	(0.326)	(0.224)	(0.402)	(0.219)	(0.297)	(0.184)
Default	12.407***			14.506***	7.705*	43.150***	10.411**	
	(4.018)			(3.457)	(4.436)	(0.750)	(4.116)	
Constant	30.815***	6.193	19.172***	11.896	38.211**	7.280	49.857***	4.358
	(10.684)	(5.875)	(6.747)	(8.615)	(15.191)	(6.098)	(11.361)	(6.240)
Observations	1,333	1,985	1,265	2,053	1,036	2,282	1,644	1,674
R-squared	0.759	0.500	0.742	0.706	0.732	0.711	0.713	0.719
Bond FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Δ% Commodity price is the annual change in the index of commodity prices for the corresponding economic sector, Years to Maturity is the year of maturity minus year t, Bid - ask spread is the annual average of monthly differences between the bond bid prices and ask prices, Liabilities to Assets represents the total liabilities over total assets, Log(Assets) is natural logarithm of total assets, Sovereign close yield is the yield to maturity of government bond with similar maturity and currency, GDP growth is the annual change in real GDP (%), CBOE VIX is the Chicago Board Options Exchange volatility index (%), Country credit rating take the value of 1 if the country credit rating is above or equal to AA+ and 0 otherwise, Operating Margin is the operating income to net sales, Issuer credit rating take values between 1 and 21 according to the credit rating scale for foreign currency issues used by Standard & Poors (being 21 the best score, AAA, and 1 the worst, D) and Default take the value of 1 if the firm it's found in default and 0 otherwise. Firm level variables are used with 1 year lag. The median value for Years to Maturity is 7, for Liabilities to Assets is 54, for Operating margin is 14, and for Log(Assets) is 8. Regression are performed clustering standar errors at commodity index –year level. Robust standard errors in parentheses *** p<0.0 1, ** p<0.05, * p<0.1. Appendix 4 shows these results controlling for year and country - year fixed effects.

Table 7: Δ% Commodity price coefficient difference between sub samples

Variable	H_0: $\beta^{<p50} - \beta^{>p50} = 0$	Std. Error	t	P>| t |	[95% Conf. Interval]
Years to maturity	-0.046	0.016	-2.88	0.005	-0.077 ; -0.014
Liabilities to assets	0.017	0.011	2.31	0.024	0.004 ; 0.047
Operating Margin	-0.034	0.014	-2.54	0.013	-0.062 ; -0.007
Log(Assets)	-0.015	0.033	-2.25	0.027	-0.046 ; -0.003

Notes: All differences in the Commodity price coefficient between subsamples are statistically significant nonzero with a 95% confidence.

6.2 Yield spreads

The measure of bond yields varies within the empirical literature related to the valuation and determinants of corporate debt, elucidating that there is no clear consensus about how the performance of these instruments is measured. For example, in Campbell and Taksler (2003) is studied the effect of equity volatility on corporate bond yields, defining these as the yield to maturity spread over the closest benchmark U.S treasury. Collin - Dufresne et al. (2001) used the changes in this spread to evaluate the empirical validity of the structural models of default. In a different way, Andreasen et al. (2015) evaluate de effect of capital controls on the cost of debt using as measure of bond yields the Option Adjusted Spread (OAS), calculated as the yield on a corporate bond in excess of a comparable U.S. Treasury security after accounting for the value of any embedded option. Other studies using OAS include Becchetti et al. (2010) and Pedrosa and Roll (1998).

In order to evaluate the consistency of the results to different measures of bond yields, regressions are estimated using as dependent variable the Option Adjusted Spread and the yield to maturity spread over the closest government bond with similar maturity and currency. Also, the yield to maturity spread over the Moody's seasoned Baa corporate bond yield is incorporated to the analysis. All the estimates are made for variables in level and in first difference. The results are shown in Table 8. Through all specifications the negative effect of the change in commodity prices on yield to maturities remains and is statistically significant, for both variables in level and in first difference. In Appendix 5 results with year and country - year fixed effects are shown, maintaining the same conclusions. Also, the elasticity has economic relevance respect to the other evidenced sensitivies for the case of sovereign spread and Baa spread. Based on the specification (1) an a increase (decrease) of 1.1% annually in commodity prices has an approximately equivalent effect on sovereign spread like and increase (decrease) of 1% in operating margin and a increase (decrease) of 22% has an equivalent effect on sovereign spread like and increase (decrease) of one step in issuer credit rating scale. These values are 1.4% and 28%, respectively, for the case of Baa spread based in specification (3). For OAS operating margin loses significance and equivalent variation for credit ratings is 30%.

Table 8: Regressions for yield spreads and commodity price changes

	(1) Sov. spread	(2) OAS	(3) BAA spread	(4) ΔYTM	(5) ΔSov. spread	(6) ΔOAS	(7) ΔBAA spread
Δ% Commodity price	-0.032***	-0.037***	-0.024**	-0.044***	-0.049***	-0.038***	-0.030***
	(0.008)	(0.009)	(0.009)	(0.007)	(0.007)	(0.011)	(0.010)
Years to Maturity	0.017	-0.505**	-0.138	0.226**	0.464***	-0.372	0.134
	(0.127)	(0.240)	(0.119)	(0.111)	(0.114)	(0.263)	(0.100)
Bid - ask spread	0.093	0.061	0.083	-0.046	-0.058	0.003	-0.069
	(0.070)	(0.113)	(0.065)	(0.060)	(0.063)	(0.091)	(0.057)
Liabilities to Assets	0.012	0.038	0.008	-0.033*	-0.023	-0.040	-0.045**
	(0.017)	(0.024)	(0.017)	(0.018)	(0.018)	(0.033)	(0.021)
Log(Assets)	-0.217	-1.960**	-0.199	0.686	0.735	-1.532*	0.565
	(0.578)	(0.909)	(0.544)	(0.495)	(0.493)	(0.881)	(0.469)
Sovereign close yield	-0.405*	-0.013	0.491**	0.106	-0.669***	0.390	0.268
	(0.220)	(0.211)	(0.200)	(0.213)	(0.208)	(0.248)	(0.212)
GDP growth	0.170	0.384**	0.200	0.437**	0.443**	0.510*	0.346
	(0.175)	(0.176)	(0.182)	(0.205)	(0.194)	(0.266)	(0.245)
CBOE VIX	0.051	0.231***	0.007	-0.018	0.050	0.182**	-0.009
	(0.038)	(0.070)	(0.036)	(0.044)	(0.048)	(0.088)	(0.038)
Country credit rating	-2.492**	-2.649*	-1.813*	-2.210**	-2.000**	-1.284	-1.859*
	(1.126)	(1.410)	(1.049)	(1.047)	(0.973)	(7.705)	(1.046)
Operating Margin	-0.036**	-0.011	-0.033**	-0.028*	-0.023	-0.024	-0.027*
	(0.015)	(0.012)	(0.015)	(0.014)	(0.014)	(0.016)	(0.015)
Issuer credit rating	-0.703***	-1.150***	-0.667***	-0.834***	-0.877***	-1.336***	-0.762***
	(0.197)	(0.215)	(0.180)	(0.174)	(0.183)	(0.243)	(0.157)
Default	14.633***	17.338***	14.653***	7.935**	7.178**	10.377*	7.665**
	(3.602)	(3.482)	(3.504)	(3.056)	(3.174)	(5.570)	(3.248)
Constant	15.773**	35.936***	12.165**	4.123	1.414	32.739**	5.705
	(5.993)	(9.944)	(5.408)	(5.818)	(5.896)	(14.151)	(5.287)
Observations	3,318	2,398	3,318	2,699	2,699	1,884	2,699
R-squared	0.741	0.771	0.716	0.674	0.668	0.674	0.661
Bond FE	YES	YES	YES	YES	YES	YES	YES

Notes: Δ% Commodity price is the annual change in the index of commodity prices for the corresponding economic sector, Years to Maturity is the year of maturity minus year t, Bid - ask spread is the annual average of monthly differences between the bond bid prices and ask prices, Liabilities to Assets represents the total liabilities over total assets, Log(Assets) is natural logarithm of total assets, Sovereign close yield is the yield to maturity of government bond with similar maturity and currency, GDP growth is the annual change in real GDP (%), Country credit rating take the value of 1 if the country credit rating is above or equal to AA+ and 0 otherwise, Operating Margin is the operating income to net sales, Issuer credit rating take values between 1 and 21 according to the credit rating scale for foreign currency issues used by Standard & Poors (being 21 the best score, AAA, and 1 the worst, D) and Default take the value of 1 if the firm it's found in default and 0 otherwise. Sov. spread is the yield to maturity spread over the closest government bond with similar maturity and currency, OAS is the Option Adjusted Spread and BAA spread is the yield to maturity spread over the Moody's seasoned Baa corporate bond yield. The symbol Δ refers to the first difference of the variables and YTM to Yield to maturity. Firm level variables are used with 1 year lag. Regression are performed clustering standar errors at commodity index –year level. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Appendix 5 shows these results controlling for year and country - year FE.

7 Conclusions

Motivated by the recent negative scenario for commodity producers and the wave of defaults experienced in related sectors during the last year the main goal of this paper was to explore the effect of commodity price variations in primary mining industry on the funding costs of incumbent firms, measured as the yield to maturity of bonds issued by these. After analyzing the list of SIC codes to 4 digits (Standard Industrial Classification) it were selected those representing better the primary mining industry joining these to 7 indices of commodity prices published by the IMF: Coal, Aluminum, Copper, Gold, Iron Ore, Energy Index and Metal Index. To control for all variables that could directly affect the financing costs, specifically the cost of borrowing capital in the bond market, standard determinants of yield to maturity according to structural credit risk models and the empirical literature on the determinants of corporate bonds were obtained from different financial plataforms (Merton, 1974; Collin-Dufresne et al., 2001; Campbell and Taksler, 2003; Andreasen et al., 2015) building a database at bond-commodity level between 2002 - 2015.

The main results of linear regression analysis suggest that annual commodity price variations have statistically significant negative effect on yield to maturity of bonds issued by linked commodity companies: for example a decrease (increase) of 10% annualy in the commodity price increased (decreased) by approximately 20 - 40 basis points the yield to maturity. When the effect is separated in increases and price reductions, a 10% fall in the annual price of a mining commodity (for example copper, oil or iron ore) adds about 70bp - 40 bp to the bond yields of incumbent firms, while an increase of similar magnitude has no statistically effect on these last. Also, this effect is greatest in companies belonging to the coal industry, lower maturity bonds, smaller companies and firms with higher leverage. When this effect is evaluated on the stock price of issuers and their credit ratings, the findings are similar on the last variable, however, for stock prices, only increases in commodity prices have statistical significance effects. The results are robust to the inclusion of variables at bond, firm,

year and country level, estimates in subsamples, and to different financing cost specifications, such as the Option Adjuted Spread (OAS) and the yield to maturity spread over the closest benchmark government bond. These findings are in line with recent episodes of financial stress experienced by mining companies and the consequent credit rating cuts by rating agencies as well as with the theorical relationship between commodity prices and the expected payoff of the risky debt, where the positive link between these two variables establishes a negative relationship between raw material prices and bond yields of related companies. Also, the asymmetric nature in the main effect is explained by the payment structure of these fixed income instruments, which have a constant expected payment to positive scenarios in commodity prices and one declining in the face of negative scenarios.

This nobel evidence brings a new fundamental channel by which the risk of commodity producer agents is affected, whereby negative commodity price variations decreases medium term solvency of related companies and increases financing costs for potential projects to be undertaken. The discussion that arises from these conclusions points to the way that commodity producer companies are financing their activities and the available options to mitigate the adverse effects that produce fluctuations in commodity prices. Taking up the proposals set out in Powell and Gilbert (1988), a way to index commodity price changes to financing costs is the use of commodity linked bonds. An advantage of the use of such instruments is the opportunity of share the appreciating market value of underlying commodities with bondholders in return for a lower coupon rate, borrowing at below - market interest rates (Budd, 1983). Another tentative alternative is the use of commodity future contracs to hedge revenues, however, the evidence tells us that these activities do not add value in companies linking to mining activities (Jin and Jorion, 2006). Furthermore, commodity linked bonds would reduce the enormous transactions costs that would be incurred if commodity producers were to dynamically hedge their revenues (Myers and Thompson, 1989). In future studies the incorporation in bond valuation models of hedge activities, commodity linked bonds, and the use of future prices as an alternative determinant to the spot price can be a contribution to the discussion and the existence literature.

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Appendix

Appendix 1: Splice between primary economic sectors and commodities

Table 9: Splice between primary economic sectors and commodities

SIC code at four digits	SIC Description	IMF Index	Index Detail
1221: Bituminous Coal Lignite Surface Mining 1222: Bituminous Coal Underground Mining	Establishments primarily engaged in producing bituminous coal or lignite at surface/underground mines or in developing bituminous coal or lignite surface/underground mines. This industry includes auger mining, strip mining, culm bank mining, and other surface mining/underground, by owners or lessees or by establishments which have complete responsibility for operating bituminous coal and lignite surface mines for others on a contract or fee basis. Bituminous coal and lignite preparation plants performing such activities as cleaning, crushing, screening or sizing are included if operated in conjunction with a mine site, or if operated independently of any type of mine.	COAL	Coal, Australian thermal coal, 12,000- btu/pound, less than 1% sulfur, 14% ash, FOB Newcastle/Port Kembla, US$ per metric ton
3334: Primary Aluminum	Establishments primarily engaged in producing aluminum from alumina and in refining aluminum by any process. Establishments primarily engaged in rolling, drawing, or extruding aluminum are classified in Industry Group 335.	ALUMINUM	Aluminum, 99.5% minimum purity, LME spot price, CIF UK ports, US$ per metric ton
1021: Copper Ores	Establishments primarily engaged in mining, milling, or otherwise preparing copper ores. This industry also includes establishments primarily engaged in the recovery of copper concentrates by precipitation and leaching of copper ore. Establishments primarily engaged in the recovery of refined copper by leaching copper concentrates are classified in Manufacturing, Major Group 33.	COPPER	Copper, grade A cathode, LME spot price, CIF European ports, US$ per metric ton
1041: Gold Ores	Establishments primarily engaged in mining gold ores from lode deposits or in the recovery of gold from placer deposits by any method. In addition to ore dressing methods such as crushing, grinding, gravity concentration, and froth flotation, this industry includes amalgamation, cyanidation, and the production of bullion at the mine, mill, or dredge site.	GOLD	Gold (UK), 99.5% fine, London afternoon fixing, average of daily rates
1011: Iron Ores	Establishments primarily engaged in mining, beneficiating, or otherwise preparing iron ores and manganiferous ores valued chiefly for their iron content. This industry includes production of sinter and other agglomerates except those associated with blast furnace operations. Blast furnaces primarily engaged in producing pig iron from iron ore are classified in Manufacturing, Industry 3312.	IRON ORE	China import Iron Ore Fines 62% FE spot (CFR Tianjin port), US dollars per metric ton
1000: Diversified Metals	Diversified metal mining including the jointly or separately extraction of iron ores, copper ores, lead and zinc ores, uranium, nickel and/or gold and silver ores.	METAL	Metals Price Index, 2005 = 100, includes Copper, Aluminum, Iron Ore, Tin, Nickel, Zinc, Lead, and Uranium Price Indices
1311: Crude Petroleum and Natural Gas	Establishments primarily engaged in operating oil and gas field properties. Such activities may include exploration for crude petroleum and natural gas; drilling, completing, and equipping wells; operation of separators, emulsion breakers, desilting equipment, and field gathering lines for crude petroleum; and all other activities in the preparation of oil and gas up to the point of shipment from the producing property. This industry includes the production of oil through the mining and extraction of oil from oil shale and oil sands and the production of gas and hydrocarbon liquids through gasification, liquid faction, and pyrolysis of coal at the mine site. Also included are establishments which have complete responsibility for operating oil and gas wells for others on a contract or fee basis. Establishments primarily engaged in performing oil field services for operators on a contract or fee basis are classified in Industry Group 138.	ENERGY	Fuel (Energy) Index, 2005 = 100, includes Crude oil (petroleum), Natural Gas, and Coal Price Indices

Appendix 2: Data distribution and variables description

Table 10: Data distribution by country, currency and year

Country	Freq.	Percent	Cum.
Australia	31	0.53	0.53
Brazil	50	1.39	1.92
Canada	459	12.77	14.70
China	277	7.71	22.40
India	72	2.00	24.41
Indonesia	36	1.00	25.41
Mexico	32	0.33	25.74
Peru	38	0.78	26.52
Russia	30	0.83	27.36
United Kingdom	164	4.56	31.92
United States	2,446	68.08	100.00
Total	3,593	100.00	

Currency	Freq.	Percent	Cum.
Australian Dollar	9	0.25	0.25
British Pound Sterling	3	0.08	0.33
Canadian Dollar	199	5.54	5.87
Chinese Yuan	274	7.63	13.50
Euro	26	0.72	14.22
Indian Rupee	72	2	16.23
Indonesian Rupiah	31	0.86	17.09
Mexican Peso	6	0.17	17.26
Russian Ruble	30	0.83	18.09
US Dollar	2,943	81.91	100.00
Total	3,593	100.00	

Year	Freq.	Percent	Cum.
2002	60	1.67	1.67
2003	62	1.73	3.40
2004	68	1.89	5.29
2005	85	2.37	7.65
2006	94	2.62	10.27
2007	121	3.37	13.64
2008	138	3.84	17.48
2009	173	4.81	22.29
2010	225	6.26	28.56
2011	288	8.02	36.57
2012	400	11.13	47.70
2013	661	18.40	66.10
2014	643	17.90	84.00
2015	575	16.00	100.00
Total	3,593	100.00	

Table 11: Variables description and source

Variable	Description	Units	Source
Yield to Maturity	Yield to Maturity	Percent	Thomson Reuters Eikon
Δ% Commodity price	Annual commodity price variation	Percent	IMF Commodity data
Years to Maturity	Maturity year - Year of observation	Years	Thomson Reuters Eikon
Bid - ask spread	Bid bond price - Ask bond price	Percent	Thomson Reuters Eikon
Liabilities to Assets	Total liabilities to Total Assets	Percent	Capital IQ
Operating Margin	Operating income to Net Sales	Percent	Capital IQ
Log(Assets)	Total Assets in millions of US$	Log	Capital IQ
GDP growth	Annual real GDP growth rate	Percent	World Data Bank
Issuer credit rating	Standard & Poor's long-term ratings in foreign cu.	1=D, ..., 21=AAA	Thomson Reuters Eikon
Default	Default status	1=D ; 0=Otherwise	Thomson Reuters Eikon
Country credit rating	Standard & Poor's long-term ratings in foreign cu.	1=CR>=AA+ ; 0=Otherwise	Capital IQ
CBOE VIX	Chicago Board Options Exchange volatility index	Percentage points	Bloomberg
Government close yield	YTM sovereign bond with similar maturity and cu.	Percent	Thomson Reuters Eikon
OAS	Option Adjuted spread	Percent	Thomson Reuters Eikon
BAA	Moody's seasoned Baa corporate bond yield	Percent	Federal Reserve
Stock price	Annual variation of Stock price	Percent	Thomson Reuters Eikon

Notes: CR refers to Credit rating.

Appendix 3: Correlation matrix between variables and unit root test for commodity prices

Table 12: Correlation matrix between principal variables

	Yield to Maturity	Commodity Price	Years to Maturity	Bid - ask spread	Liabilities to Assets	Operating Margin	Log(Assets)	GDP growth	Issuer Credit rating	Country Credit rating	CBOE VIX	Sovereign Close yield
Yield to Maturity	1											
Commodity price	-0.1629	1										
Years to Maturity	-0.1048	0.3416	1									
Bid - ask spread	0.0657	-0.0196	0.0037	1								
Liabilities to Assets	0.1911	0.0568	0.011	0.0308	1							
Operating Margin	-0.2969	0.121	0.2447	-0.0114	-0.1614	1						
Log(Assets)	-0.3504	-0.0429	0.1933	0.0268	-0.0792	0.2053	1					
GDP growth	-0.0178	-0.21	-0.2595	-0.0632	0.0137	-0.189	-0.1999	1				
Issuer Credit rating	-0.517	0.2286	0.3689	-0.0631	-0.1828	0.3055	0.5269	-0.1336	1			
Country Credit rating	-0.0222	0.0249	0.2013	0.0909	-0.0038	0.107	0.1469	-0.3102	0.097	1		
CBOE VIX	-0.0107	0.3239	0.207	0.054	0.0008	0.0382	0.0825	-0.3943	0.1733	-0.2888	1	
Sovereign Close yield	-0.0506	0.3392	0.4731	-0.0709	-0.0069	0.0921	-0.0661	0.2852	0.2094	-0.3139	0.2114	1

Table 13: Unit root test for commodity prices, level and first difference annual series, 2002 - 2015

	Level				First difference			
	0 Lag		1 Lag		0 Lag		1 Lag	
Commodity	Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value
GOLD	-1.39	0.59	-1.51	0.53	-2.18	0.21	-1.46	0.55
ALUMINUM	-2.43	0.13	-2.69	0.08	-3.29	0.02	-3.05	0.03
COAL	-1.75	0.41	-1.69	0.43	-2.98	0.04	-2.47	0.12
COPPER	-2.16	0.22	-2.25	0.19	-3.28	0.02	-3.03	0.03
IRON ORE	-1.27	0.64	-1.54	0.51	-2.31	0.17	-1.13	0.71
METAL INDEX	-1.97	0.29	-2.12	0.23	-2.74	0.07	-2.93	0.04
ENERGY INDEX	-1.73	0.41	-1.79	0.38	-3.11	0.03	-2.96	0.04
Panel test	-0.83	0.21	-1.14	0.12	-3.55	0.00	-1.62	0.05

Notes: Augmented Dickey - Fuller test for individual series. Im, Pesaran & Shin panel unit root (2003) for aggregated data. For level series test are performed with N=13 when it is not controlled for lags and N=12 when it's controlled for 1 lag. For first difference series test are performed with N=12 when it is not controlled for lags and N=11 when it's controlled for 1 lag.

Appendix 4: Maturity-leverage-profitability-size robustness check regressions with year and country-year FE

Table 14: Regressions for yield to maturity, maturity-leverage-profitability-size robustness check, year and country-year FE

	Years to maturity		Liabilities to assets		Operating Margin		Log(Assets)		Years to maturity		Liabilities to assets		Operating Margin		Log(Assets)	
	<p50	>p50	<p50	>p50	<p50	>p50	<p50	>p50	<p50	>p50	<p50	>p50	<p50	>p50	<p50	>p50
Δ% Commodity price	-0.083**	-0.004	-0.021*	-0.022**	-0.059**	-0.017*	-0.035**	-0.012*	-0.070**	-0.003	-0.021*	-0.008	-0.044**	-0.022**	-0.023*	-0.010
	(0.013)	(0.007)	(0.007)	(0.010)	(0.013)	(0.009)	(0.012)	(0.006)	(0.015)	(0.008)	(0.008)	(0.013)	(0.016)	(0.010)	(0.012)	(0.007)
Years to Maturity	-7.293**	0.478	-1.547	-4.550**	-11.547**	-0.377	-8.553	-1.517*	-6.624**	0.343	-0.961	-2.363**	-7.009**	-0.299	-5.235	-1.147
	(2.587)	(0.526)	(1.259)	(1.831)	(4.118)	(0.801)	(5.357)	(0.827)	(2.288)	(0.621)	(0.847)	(1.177)	(2.876)	(0.940)	(3.433)	(0.831)
Bid - ask spread	0.176*	-0.113	-0.458	0.122*	0.163	0.060	0.185	0.038	0.223**	-0.097	-0.445	0.176**	0.214	0.114	0.219	0.090
	(0.101)	(0.093)	(0.279)	(0.070)	(0.139)	(0.087)	(0.134)	(0.068)	(0.105)	(0.096)	(0.317)	(0.070)	(0.155)	(0.093)	(0.163)	(0.075)
Liabilities to Assets	0.043*	-0.018	0.032	-0.031	0.095**	-0.027*	0.062**	-0.026	0.041	-0.020	0.014	-0.037	0.060	-0.020	0.071**	-0.019
	(0.024)	(0.011)	(0.022)	(0.027)	(0.040)	(0.015)	(0.025)	(0.019)	(0.027)	(0.013)	(0.026)	(0.030)	(0.049)	(0.017)	(0.029)	(0.020)
Log(Assets)	-2.022*	0.444	-0.671	0.213	-2.784*	0.397	-3.463***	0.700	-1.356	0.981**	0.245	0.705	-0.291	1.328***	-2.726*	1.085***
	(1.189)	(0.436)	(0.430)	(0.762)	(1.554)	(0.485)	(1.174)	(0.450)	(1.500)	(0.402)	(0.448)	(0.931)	(1.667)	(0.460)	(1.401)	(0.406)
Sovereign close yield	0.892*	0.005	0.325	0.719**	0.733	0.438**	0.220	0.525***	1.124	0.119	0.631**	1.105***	1.968**	0.465***	0.936*	0.519***
	(0.488)	(0.131)	(0.277)	(0.312)	(0.707)	(0.177)	(0.518)	(0.162)	(0.855)	(0.139)	(0.310)	(0.349)	(0.806)	(0.156)	(0.534)	(0.144)
GDP growth (%)	0.964**	0.110	0.124	0.640**	1.420**	0.240	1.443***	0.105								
	(0.291)	(0.115)	(0.182)	(0.287)	(0.664)	(0.162)	(0.335)	(0.109)								
Country credit rating	1.344	-1.023	0.086	-0.277	-0.554	-0.120	1.777	-0.433								
	(0.977)	(0.752)	(0.461)	(1.240)	(2.211)	(0.912)	(1.111)	(0.848)								
Operating Margin	-0.051	-0.010	-0.006	-0.070**	-0.040	-0.013	-0.031	-0.012**	-0.055*	-0.017*	-0.023	-0.076**	-0.044	-0.026**	-0.044	-0.015**
	(0.031)	(0.008)	(0.011)	(0.030)	(0.033)	(0.010)	(0.029)	(0.006)	(0.031)	(0.008)	(0.014)	(0.032)	(0.033)	(0.010)	(0.029)	(0.007)
Issuer credit rating	-1.258**	-0.405*	-0.300	-0.702**	-1.500**	-0.375*	-1.361***	-0.445**	-1.597**	-0.521*	-0.778*	-0.833***	-2.489***	-0.494**	-2.141***	-0.414**
	(0.328)	(0.185)	(0.327)	(0.204)	(0.453)	(0.199)	(0.311)	(0.160)	(0.363)	(0.210)	(0.428)	(0.254)	(0.525)	(0.211)	(0.465)	(0.184)
Default	12.506**			15.139**	8.232*	43.678**	10.133*		11.217**			14.769***	5.293	43.332**	7.168*	
	(3.643)			(3.213)	(4.445)	(0.810)	(4.054)		(3.642)			(3.207)	(4.520)	(0.767)	(4.198)	
Constant	116.252*	-1.075	48.037*	110.078*	259.966*	17.132	213.920*	40.201**	101.324*	-1.829	32.159	57.485**	130.718**	3.687	102.714**	26.444
	(34.794)	(13.840)	(27.767)	(40.621)	(84.615)	(19.326)	(109.931)	(19.838)	(28.032)	(15.959)	(20.068)	(25.642)	(49.646)	(12.922)	(39.852)	(18.846)
Observations	1,333	1,985	1,265	2,053	1,036	2,282	1,644	1,674	1,333	1,985	1,265	2,053	1,036	2,282	1,644	1,674
R-squared	0.776	0.548	0.757	0.726	0.748	0.738	0.735	0.777	0.797	0.583	0.810	0.741	0.791	0.784	0.773	0.845
Bond FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO
Country-Year FE	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Δ% Commodity price is the annual change in the index of commodity prices for the corresponding economic sector, Years to Maturity is the year of maturity minus year t, Bid - ask spread is the annual average of monthly differences between the bond bid prices and ask prices, Liabilities to Assets represents the total liabilities over total assets, Log(Assets) is natural logarithm of total assets, Sovereign close yield is the yield to maturity of government bond with similar maturity and currency, GDP growth is the annual change in real GDP (%), CBOE VIX is the Chicago Board Options Exchange volatility index (%), Country credit rating take the value of 1 if the country credit rating is above or equal to AA+ and 0 otherwise, Operating Margin is the operating income to net sales, Issuer credit rating take values between 1 and 21 according to the credit rating scale for foreign currency issues used by Standard & Poors (being 21 the best score, AAA, and 1 the worst, D) and Default take the value of 1 if the firm it's found in default and 0 otherwise. Firm level variables are used with 1 year lag. The median value for Years to Maturity is 7, for Liabilities to Assets is 54, for Operating margin is 14, and for Log(Assets) is 8. Regression are performed clustering standar errors at commodity index –year level. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Appendix 5: Yield spreads regressions with year and country-year FE

Table 15: Regressions for yield spreads and commodity price changes, year and country-year FE

	(1) Sov. spread	(2) OAS	(3) BAA spread	(4) ΔYTM	(5) ΔSov. spread	(6) ΔOAS	(7) ΔBAA spread	(8) Gov. spread	(9) OAS	(10) BAA spread	(11) ΔYTM	(12) ΔGov. spread	(13) ΔOAS	(14) ΔBAA spread
Δ% Commodity price	-0.025***	-0.030***	-0.025***	-0.043***	-0.044***	-0.034***	-0.043***	-0.019**	-0.029***	-0.019**	-0.039***	-0.038***	-0.036***	-0.039***
	(0.008)	(0.007)	(0.008)	(0.008)	(0.007)	(0.012)	(0.008)	(0.008)	(0.009)	(0.008)	(0.009)	(0.009)	(0.013)	(0.009)
Years to Maturity	-3.055**	-1.372	-3.055**	-0.617	-0.723	-0.694	-0.617	-1.535	-0.636	-1.535	0.562	0.379	-0.308	0.562
	(1.388)	(1.514)	(1.388)	(1.136)	(1.219)	(1.662)	(1.136)	(0.952)	(1.146)	(0.952)	(0.813)	(0.900)	(1.161)	(0.813)
Bid - ask spread	0.111*	0.100	0.111*	-0.055	-0.060	0.006	-0.055	0.150**	0.105	0.150**	0.006	0.005	0.029	0.006
	(0.059)	(0.110)	(0.059)	(0.059)	(0.063)	(0.091)	(0.059)	(0.063)	(0.101)	(0.063)	(0.060)	(0.064)	(0.088)	(0.060)
Liabilities to Assets	-0.000	0.040*	-0.000	-0.036**	-0.032*	-0.040	-0.036**	-0.007	0.043*	-0.007	-0.026	-0.026	-0.026	-0.026
	(0.014)	(0.023)	(0.014)	(0.018)	(0.017)	(0.032)	(0.018)	(0.015)	(0.025)	(0.015)	(0.017)	(0.017)	(0.033)	(0.017)
Log(Assets)	-0.077	-2.098**	-0.077	0.741	0.867*	-1.599*	0.741	0.588	-1.272	0.588	0.920*	0.904*	-0.961	0.920*
	(0.562)	(0.920)	(0.562)	(0.471)	(0.454)	(0.889)	(0.471)	(0.538)	(0.964)	(0.538)	(0.491)	(0.488)	(0.933)	(0.491)
Sovereign close yield	-0.414*	-0.078	0.586**	-0.140	-0.420*	0.019	-0.140	-0.058	0.231	0.942***	-0.009	-0.270	0.109	-0.009
	(0.238)	(0.245)	(0.238)	(0.268)	(0.250)	(0.307)	(0.268)	(0.285)	(0.206)	(0.285)	(0.272)	(0.255)	(0.265)	(0.272)
GDP growth (%)	0.507***	0.470**	0.507***	0.623***	0.636***	0.500*	0.623***							
	(0.174)	(0.194)	(0.174)	(0.232)	(0.236)	(0.295)	(0.232)							
Country credit rating	-0.251	-0.698	-0.251	-1.840	-1.993		-1.840							
	(0.842)	(0.799)	(0.842)	(1.323)	(1.364)		(1.323)							
Operating Margin	-0.032*	-0.008	-0.032*	-0.029*	-0.030*	-0.023	-0.029*	-0.040**	-0.018	-0.040**	-0.035**	-0.036**	-0.035**	-0.035**
	(0.017)	(0.013)	(0.017)	(0.016)	(0.016)	(0.016)	(0.016)	(0.019)	(0.012)	(0.019)	(0.015)	(0.015)	(0.015)	(0.015)
Issuer credit rating	-0.601***	-1.205***	-0.601***	-0.765***	-0.771***	-1.356***	-0.765***	-0.768***	-1.437***	-0.768***	-0.774***	-0.765***	-1.503***	-0.774***
	(0.179)	(0.219)	(0.179)	(0.164)	(0.164)	(0.251)	(0.164)	(0.208)	(0.260)	(0.208)	(0.191)	(0.191)	(0.298)	(0.191)
Default	14.973***	18.252***	14.973***	7.865**	7.455**	10.145*	7.865**	14.537***	17.594***	14.537***	7.876**	7.518**	10.085*	7.876**
	(3.431)	(3.203)	(3.431)	(3.134)	(3.165)	(5.578)	(3.134)	(3.340)	(3.210)	(3.340)	(3.073)	(3.098)	(5.286)	(3.073)
Constant	78.634**	71.215***	71.184**	23.159	25.933	45.338	23.759	40.009**	47.588***	32.688	-5.147	-0.255	31.916*	-4.679
	(30.647)	(24.510)	(30.647)	(25.802)	(27.494)	(29.542)	(25.802)	(19.784)	(16.996)	(19.784)	(17.619)	(19.465)	(16.249)	(17.717)
Observations	3,318	2,398	3,318	2,699	2,699	1,884	2,699	3,318	2,398	3,318	2,699	2,699	1,884	2,699
R-squared	0.754	0.777	0.728	0.683	0.683	0.676	0.674	0.772	0.793	0.747	0.707	0.706	0.701	0.698
Bond FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO
Country-Year FE	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES

Notes: Δ% Commodity price is the annual change in the index of commodity prices for the corresponding economic sector, Years to Maturity is the year of maturity minus year t, Bid - ask spread is the annual average of monthly differences between the bond bid prices and ask prices, Liabilities to Assets represents the total liabilities over total assets, Log(Assets) is natural logarithm of total assets, Sovereign close yield is the yield to maturity of government bond with similar maturity and currency, GDP growth is the annual change in real GDP (%), Country credit rating take the value of 1 if the country credit rating is above or equal to AA+ and 0 otherwise, Operating Margin is the operating income to net sales, Issuer credit rating take values between 1 and 21 according to the credit rating scale for foreign currency issues used by Standard & Poors (being 21 the best score, AAA, and 1 the worst, D) and Default take the value of 1 if the firm it's found in default and 0 otherwise. Sov. spread is the yield to maturity spread over the closest government bond with similar maturity and currency, OAS is the Option Adjusted Spread and BAA spread is the yield to maturity spread over the Moody's seasoned Baa corporate bond yield. The symbol Δ refers to the first difference of the variables and YTM to Yield to maturity. Firm level variables are used with 1 year lag. Regression are performed clustering standar errors at commodity index –year level. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.