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Base metals, a base for stock prices

A study of metals and mining companies' stock return between May 2004 and May 2009

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Abstract

In this thesis we investigate three base metals' price changes relationship with metals and mining companies' stock return. A two-stage regression method is used with copper, nickel and zinc for eighteen companies. For each company we first run a multiple regression analysis with the three metals' price changes as variables to create beta values. Thereafter a regression on each metal beta is conducted with company specific and non-company specific variables. A conclusion of the thesis is that copper is the driving factor for the metals and mining industry stock returns. In general, the beta values are more dependent on market indicators rather than on company specific indicators. However, financial key ratios seem to influence the beta values.

Key words: beta, stock return, metal, mining, multiple regression

"In mining, no quote mining can help you."

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1 Introduction

During the 1980s and 1990s the commodity market acted in the shadow area of the financial market. Only the oil and gas market were given interest due to political focus and high volatility. However, from the beginning of this decade until Lehman Brothers filing for chapter 11 bankruptcy, many commodity prices have surged. Between 2002 and 2006, prices on fuels and some metal prices have doubled. A major force behind this has been China and India becoming significant commodity consumers. Due to higher commodity prices the investing in mining projects has increased to such extent that the immediate supply of input goods has ceased (Radetzki 2007, p. 9-10). The current financial crisis pushed metal prices through a correction. However, prices have rallied again when the current financial crisis moved on to a state of less uncertainty. Graph 3 in the appendix shows that since the first quarter of 2009 prices have steadily risen. The price drivers have again been China and India who have resisted the global economic downturn better than western economies (Keenan 2009).

The volatility in metal prices has increased since year 2000 due to rapid growth in the emerging markets and financial crises. The interest for investing and trading in commodities has intensified the last decade. The participants selling and buying metals today are not just metals and mining companies but also mutual and hedge funds. Mutual and hedge funds are not new on this market but the volume traded by these participants, especially by hedge funds, has increased (Radetzki 2007, p. 11, 127). Since there is a lot of money in this business it is interesting to investors what influences the stock prices. This thesis is trying to bring more clarity to the subject. Intuitively when a metal price increases the stock price for the metal and mining company will rise as well but the question is to what extent.

1.1 Discussion of the purpose

From an early stage we have focused our research on commodities from a financial point of view. Base metals are interesting because they are a foundation in the development of emerging markets. The prices for metals are both volatile and unpredictable and therefore interesting for analysis. This is due to the hedging possibilities, e.g. investing in commodities to hedge against high inflation. We expect the stock returns to be related to the changes in the metal prices and we want to investigate to what extent.

1.2 Purpose of the thesis

We want to analyze the relationship between metal price changes and stock returns for metals and mining companies. This thesis will try to create a two-stage model for stock returns of metals and mining companies that will depend on metal price changes.

The thesis aims to answer, for a given number of metals, the following questions:

1: To what extent do the price changes in these metals relate to the stock returns for mining companies?

2: What variables affect the beta values explaining the stock return exposure to metal price changes?

1.3 Delimitations of the thesis

We have chosen a limited selection of metals and mining companies to examine due to different features of the metals and therefore different price building mechanisms. We have found in early research that gold mining companies are often very concentrated in just gold mining, e.g. Barrick Gold Corp., Newmont

Mining Corp. and Newcrest Mining Ltd. We have also found that some metals and mining companies with high market cap have very differentiated business models, e.g. BHP Billiton Ltd. & Plc., Rio Tinto Ltd. & Plc. and Vale S.A. Therefore we will exclude these types of companies because we want to use the same few metals during the entire thesis. After further examination we have noticed that copper, nickel and zinc are commonly mined together in significant volume for many companies. Therefore we have chosen to concentrate on companies with a majority of its revenue coming from any combination of copper, nickel and zinc. We have not considered currency effects in our thesis. We do not believe it has a severe impact on our results.

2 Data and method

In this chapter we first present the data and explain how we have obtained it. Second we introduce and discuss our method.

2.1 Data

2.1.1 Chosen companies

We have found eighteen companies meeting our criteria; Antofagasta Plc., Boliden AB, Crowflight Minerals Inc., FNX Mining Company Inc., Freeport-McMoRan Copper & Gold Inc., Grupo México S.A. de C.V., HudBay Minerals Inc., Inmet Mining Corporation, Lundin Mining Corporation, Minara Resources Ltd., MMC Norilsk Nickel, Palabora Mining Company Ltd., Quadra Mining Ltd., Southern Copper Corporation, Teck Resources Ltd., Vedanta Resources Plc. and Xstrata Plc.

2.1.2 Selected time period

The metals and mining industry is characterised by its high mergers and acquisitions volumes. There are many small start-up companies, sometimes only consisting of only one mine. After establishing a successful mining operation they are often acquired by larger metals and mining companies. Therefore we have been forced to choose a time limit of only five years, i.e. from the week ending 2004-05-07 to the week ending 2009-05-01. Our youngest company in our analysis went public in the end of April 2004.

We chose to use weekly price changes instead of daily to smoothen out our data sample. Since we use weekly price changes neither price lags nor intraday volatility should be a concern in our results.

2.1.3 Data sources

The companies have been chosen by studying different metals and mining companies on their homepages, especially by looking at the annual reports. Table 1, which reflects the percentage of revenue from each metal, is taken from each company's latest annual report. This research was made in November 2009. Metal prices, stock prices, MSCI World Metals & Mining, Baltic Dry Index, market capitalization and quick ratio have been obtained from Datastream Advance 4.0.

2.1.4 Criticism of the sources

This thesis has not presented any previous research on the same subject. We have not found any good research on the topic. Most of the written information used in this thesis has been from articles, and not from written books. This is due to the fact that there is limited literature on the subject. We have used nine internet sources for this thesis. A problem with internet sources is that they might not be easily available in the future.

2.2 Choice of the method

We have conducted a two-stage multiple regression model. First, we have run a time series regression model on the stock return, with the metal price changes as explanatory variables.

(Equation 1)

$$R_i = \beta + \beta_{copper} * X_{1i} + \beta_{nickel} * X_{2i} + \beta_{zinc} * X_{3i} + e_i$$

In the equation "i" stands for weekly observation, X_1 for copper price change, X_2 for nickel price change and X_3 for zinc price change

For the first regression model we have tested for heteroskedasticity and multicollinearity. Even if there is heteroskedasticity there is no need to correct for this since we only used the beta values for regression models (II) which are not unbiased. To test for heteroskedasticity we have used Breusch-Pagan-Godfrey's test and White's test. To test for multicollinearity we have used three methods. The first one was to look at the p-values and R^2 values in each company regression. A sign of multicollinearity is when a regression has a high R^2 value but insignificant p-values. We have run single and multiple regressions between the variables. For the single regressions we have examined if there is a relationship between two metal variables. The R^2 values we have obtained in the multiple regression have been used in a Variance Inflation Factor test (VIF test), to see if there is multicollinearity. If there is severe multicollinearity, we need to respecify the model.

Second, we ran the same regressions as in regression (I) but for each single year instead. Those beta values were used in regression (II) as the dependent variable in our cross sectional regression model. Different regression analyses were run with combinations of five chosen variables possibly affecting the beta values. We have run a Ramsey's RESET test for the regression with the best variables to test if the model is correctly specified.

(Equation 2)

$$\beta_m = C_1 + C_a * X_{1i} + C_b * X_{2ij} \ldots . C_z * X_{nij} + e_i$$

In equation 2, "m" stands for type of metal, "i" for time period and "j" for company. The "j" sign is only needed for company specific variables. X_1, X_2....X_n stand for any given variable.

Instead of nominal stock and metal prices, we have used the price changes in our regressions since we are investigating beta values. In our regression analysis we have chosen 5 percent as significance level. This will be constant throughout the thesis. The metal prices for copper, nickel and zinc that we will use in our thesis has been the spot prices quoted on the London Metal Exchange (LME). These price quotes are the most commonly mentioned in the annual reports of our companies.

2.3 Discussion of the method

The stock return is exposed to many variables but for metals and mining companies our assumption is that the metal prices are crucial. We have used a linear model, because we have not found a strong reason to use a non-linear model. The reason we have run heteroskedasticity tests is that we want to draw conclusions from our first regression, and see whether those conclusions are reliable.

It is also interesting for the analysis to see which variables influence the beta values, which is why we have run a second regression on the beta values. They could for example be whether the mining takes place in politically risky areas, the state of the world economy or if the company has a large or small market cap.

2.4 Pros and cons of method

Since we assume that metal price changes for copper, nickel and zinc can be correlated there is a risk for multicollinearity in our models. However, even if there is multicollinearity the predictions generated from our models will be as accurate as if there was no multicollinearity. This is due to that multicollinearity does not decrease the predictive power in general. It merely affects the calculations of individual estimators. If we have multicollinearity in our variables the beta coefficients for the second regression might not be appropriate (Gujarati 2006, p. 251-253).

It is good for the analysis that metal goods are relatively homogenous since it is more difficult to analyze differentiated goods. However, to find enough companies that only mine these metals has been tricky since the numbers of participants on the market is limited.

A problem with our data is that we only analyzed over a five year period, which is because some of the companies have only been public for so long. However, we have preferred to rather have a high amount of companies than years. We believe a five year period should give us interesting results.

3 The market for metals

The market for metals has many special features. First, the goods are not very differentiated. Therefore the competition on the market is more about lowering costs and increasing efficiency than on other markets (Sheth 1985, p. 4).

Second, since the goods are so homogenous, the market is transparent and easy to trade in. Most of the trade goes through a few exchanges, where one of the biggest is LME.

Third, to participate in this market as a miner of metals you need big investments, and there might be economies of scale, reducing the numbers of participants in the market. Many mergers and acquisitions also take place in the metals and mining industry. It is easier for a company with a lot of cash to acquire a competitor than starting a new mining operation (Keehner 2007).

Fourth, metal is a commodity which can only be mined where there are natural assets, making some countries much more active than others. During our research we discovered that the owners of the companies are in many cases from other countries than where the mining operation takes place.

There is also a difference between metals. One example is between the base metals and the precious metals where the base metals are used for construction and industry and the others are mainly for jewellery and luxury products. This should make the demand features for these metals very different.

There are studies on the metal market as a whole. One example is that contractions in metal prices are on average longer than expansion periods. However there is no clear evidence for long term trends in real metal prices due to large volatility in both upturns and downturns. There is not a consensus whether the metal prices follow a random walk or not. This can depend on which scientific look you have on turning points (Roberts 2009, p. 97).

3.1 The copper market

The biggest producer of raw copper in the world is Chile. In terms of refined copper Japan was the biggest (2002), but without any own mining operations. China is also a huge refiner of copper, but not as big as a mining country. Mining of copper is not needed to have a big industry of copper refining. Copper can be recycled, but the life cycle of copper is tenths of years, and the amount recycled is irregular. In 2002 37 percent of the total amount of refined copper was recycled. The U.S. has been the biggest consumer of copper the last decades until China passed them ten years ago. Per capita the U.S. is a bigger consumer than China. Copper is used for electronics, construction, engines and transportation (Sveriges geologiska undersökning 2003, p. 57-60). Among our three metals, copper has the highest export value (Radetzki 2007, p. 42).

From the 1950s until the 1970s the price rose steadily and the copper mining industry was optimistic with many new projects. With the decline in the world economy in the end of the 1970s due to the oil crisis the copper price fell as well. Since 1975 until 2000 the price has halved in real terms (Sveriges geologiska undersökning 2003, p. 66).

3.2 The nickel market

More than 80 percent of all nickel is used in different alloys. Around 67 percent is used to produce stainless steel and 10 percent for nickel plating (Sveriges geologiska undersökning 2007, p. 39).

In nickel production there are not many participants. Most mining companies also refine the product, so the entire nickel producing chain is in the same company. One reason there are few participants on the market is due to mergers. The three biggest producers are the following (2006); MMC Norilsk Nickel, CVRD Inco and BHP Billiton Ltd (Sveriges geologiska undersökning 2007, p. 73). Many of the largest nickel producers are either conglomerates or government owned and will not be a further part of our analysis.

Nickel is often produced in another country than where it is mined, due to lower energy costs or other economic advantages. The largest consumer of nickel in the world is China followed by Japan and the U.S. The largest exporter of nickel is Russia, followed by Canada. In terms of import the U.S. is the largest followed by China. Nickel is traded on the LME, who also holds store of nickel on different places in the world. If the production exceeds the consumption some of the production is put in stock and vice versa. When production exceeds consumption the price also drops (Sveriges geologiska undersökning 2007, p. 76-81).

3.3 The zinc market

During the antiquity the base metal zinc was used in brass; an alloy made of zinc and copper. Some of the by-products were also used in medicine. Plain zinc was probably first used around 500 years after Christ in Persia. From there it spread to India and China. During the 17th and 18th century bigger amounts of zinc were produced in Western Europe (Sveriges geologiska undersökning 2004, p. 37). Today the three largest zinc mines are placed in Alaska, Australia and Peru (Sveriges geologiska undersökning 2004, p. 51). The three biggest producers of zinc are China, Peru and Canada (Sveriges geologiska undersökning 2009, p. 22).

From an energy perspective it is very beneficial to recycle zinc. More than 20 percent of the total zinc production comes from recycling. To produce zinc from zinc products only takes 4-5 percent of the energy needed to produce zinc from ore. However, compared to other base metals producing zinc from ore is relative energy efficient. Zinc is a useful metal in modern infrastructure. It is used as a corrosion protector for steel products. It is also easy to form which makes it favourable as cover panel, gutter and spout. Brass contains between 5 and 42 percent zinc. The brass is used in drilling, turning and milling. Zinc is also used in many chemicals (Sveriges geologiska undersökning 2004, p. 56-59).

4 Results and analysis

First, we have for regression models (I) presented and commented the regression results. Second we have presented and commented eventual heteroskedasticity and multicollinearity.

Table 1 has been used in our analysis of regression (I). It shows the percentage of the revenue each company received from each metal according to their latest annual report. One can argue that the revenue shifts over time, and since we have a five year period the numbers in table 1 might be inaccurate. However, our assumption is that mining is conducted over a long term period and that the numbers should be acceptable. The table was constructed in November 2009.

(Table 1)

% of Revenue, latest Annual Report	**Copper**	**Nickel**	**Zinc**
Antofagasta Plc.	91%		
Boliden AB	39%		34%
Crowflight Minerals Inc.		100%	
First Quantum Minerals Ltd.	96%		
FNX Mining Company Inc.	24%	31%	
Freeport-McMoRan Copper & Gold Inc.	62%		
Grupo México S.A. de C.V.	55%		3%
HudBay Minerals Inc.	56%		28%
Inmet Mining Corporation	54%		16%
Lunding Mining Corporation	62%	10%	17%
Minara Resources Ltd.		82%	
MMC Norilsk Nickel	25%	40%	
Palabora Mining Company Ltd.	69%		
Quadra Mining Ltd.	81%		
Southern Copper Corporation	71%		4%
Teck Resources Ltd.	31%		30%
Vedanta Resources Plc.	52%		20%
Xstrata Plc.	41%	11%	12%

4.1 Regression models (I)

We have run a regression model with the stock returns as dependent variable and the metal price changes as independent variables for the entire five year period. By doing this we have obtained a model for each company including a beta value for each metal price change. The purpose of this model is to see how the stock returns are related to the metal price changes.

Table 2 presents the results from the regressions for each company and is based on equation 1. The table will be analysed in section 4.1.3. These beta values are the values for the five year period.

(Table 2)

Observations: 261	**Intercept (Std)**	**Copper (Std)**	**Nickel (Std)**	**Zinc (Std)**	**R^2**	**Adj. R^2**	**Std**
Antofagasta Plc.	0.004 (0.003)	0.625 (0.098)	0.193 (0.056)	0.015 (0.079)	0.368	0.360	0.051
P-value	*0.189*	*0.000 ****	*0.001 ****	*0.845*			
Boliden AB	0.003 (0.004)	0.513 (0.119)	0.016 (0.068)	0.381 (0.095)	0.318	0.310	0.062
P-value	*0.498*	*0.000 ****	*0.814*	*0.000 ****			
Crowflight Minerals Inc.	0.004 (0.008)	0.804 (0.231)	0.244 (0.132)	-0.127 (0.186)	0.120	0.110	0.121
P-value	*0.637*	*0.001 ****	*0.066*	*0.494*			
First Quantum Minerals Ltd.	0.006 (0.004)	0.949 (0.133)	0.169 (0.076)	0.005 (0.107)	0.362	0.355	0.069
P-value	*0.190*	*0.000 ****	*0.027 **	*0.962*			
FNX Mining Company Inc.	0.002 (0.006)	0.957 (0.171)	0.503 (0.098)	-0.300 (0137)	0.315	0.307	0.089
P-value	*0.717*	*0.000 ****	*0.000 ****	*0.030 **			
Freeport-McMoRan Copper & Gold Inc.	0.001 (0.004)	0.867 (0.110)	0.206 (0.063)	-0.024 (0.088)	0.425	0.418	0.057
P-value	*0.713*	*0.000 ****	*0.001 ***	*0.789*			
Grupo México S.A. de C.V.	0.004 (0.003)	0.589 (0.104)	0.163 (0.059)	0.051 (0.083)	0.320	0.312	0.054
P-value	*0.225*	*0.000 ****	*0.007 ***	*0.545*			
HudBay Minerals Inc.	0.006 (0.006)	0.607 (0.183)	0.204 (0.105)	0.128 (0.147)	0.171	0.161	0.096
P-value	*0.330*	*0.001 ***	*0.052*	*0.387*			
Inmet Mining Corporation	0.004 (0.004)	0.805 (0.130)	0.175 (0.074)	0.090 (0.104)	0.347	0.339	0.068
P-value	*0.366*	*0.000 ****	*0.019 **	*0.387*			
Lunding Mining Corporation	-0.001 (0.004)	0.718 (0.137)	0.127 (0.078)	0.294 (0.110)	0.347	0.340	0.072
P-value	*0.904*	*0.000 ****	*0.106*	*0.008 ***			
Minara Resources Ltd.	0.003 (0.009)	0.724 (0.284)	0.848 (0.162)	-0.368 (0.228)	0.189	0.180	0.148
P-value	*0.742*	*0.011 **	*0.000 ****	*0.108*			
MMC Norilsk Nickel	0.003 (0.005)	0.949 (0.155)	0.321 (0.089)	-0.359 (0.125)	0.262	0.254	0.081
P-value	*0.550*	*0.000 ****	*0.000 ****	*0.004 ***			
Palabora Mining Company Ltd.	0.000 (0.005)	0.526 (0.140)	0.216 (0.080)	-0.045 (0.112)	0.175	0.165	0.073
P-value	*0.975*	*0.000 ****	*0.007 ***	*0.687*			
Quadra Mining Ltd.	0.003 (0.005)	1.117 (0.158)	0.210 (0.091)	-0.032 (0.127)	0.349	0.341	0.083
P-value	*0.531*	*0.000 ****	*0.021 **	*0.799*			
Southern Copper Corporation	0.005 (0.004)	0.723 (0.117)	0.272 (0.067)	0.029 (0.094)	0.383	0.376	0.061
P-value	*0.166*	*0.000 ****	*0.000 ****	*0.760*			
Teck Resources Ltd.	0.003 (0.005)	0.849 (0.153)	0.215 (0.088)	-0.049 (0.123)	0.264	0.256	0.080
P-value	*0.579*	*0.000 ****	*0.015 **	*0.688*			
Vedanta Resources Plc.	0.006 (0.004)	0.672 (0.131)	0.236 (0.075)	0.028 (0.106)	0.291	0.283	0.069
P-value	*0.190*	*0.000 ****	*0.002 ***	*0.789*			
Xstrata Plc.	0.003 (0.004)	0.899 (0.132)	0.237 (0.075)	-0.066 (0.106)	0.351	0.343	0.069
P-value	*0.458*	*0.000 ****	*0.002 ***	*0.537*			

4.1.1 Heteroskedasticity

In table 3 the results from our heteroskedasticity tests is presented. If H_0 is rejected we might have heteroskedasticity. We have marked possible heteroskedasticity with the colour red.

(Table 3)

Observations: 261	Breusch-Pagan-Godfrey	White
H_o = No heteroskedasticity	H_o	H_o
Antofagasta Plc.	Reject	Reject
Boliden AB	Not reject	Not reject
Crowflight Minerals Inc.	Not reject	Not reject
First Quantum Minerals Ltd.	Not reject	Not reject
FNX Mining Company Inc.	Not reject	Not reject
Freeport-McMoRan Copper & Gold Inc.	Not reject	Reject
Grupo México S.A. de C.V.	Reject	Reject
HudBay Minerals Inc.	Not reject	Not reject
Inmet Mining Corporation	Not reject	Reject
Lundin Mining Corporation	Not reject	Reject
Minara Resources Ltd.	Reject	Reject
MMC Norilsk Nickel	Reject	Reject
Palabora Mining Company Ltd.	Not reject	Not reject
Quadra Mining Ltd.	Not reject	Reject
Southern Copper Corporation	Reject	Reject
Teck Resources Ltd.	Not reject	Reject
Vedanta Resources Plc.	Not reject	Reject
Xstrata Plc.	Not reject	Reject

To detect heteroskedasticity in our models we have used two tests. The first is the Breusch-Pagan-Godfrey's test and the second is White's test. We have run both with help from the computer program Eviews.

The Breusch-Pagan-Godfrey's test is a Lagrange multiplier test of the null hypothesis of no heteroskedasticity against heteroskedasticity. It is only applicable on linear regressions. The formula used is $\sigma_i^2 = \sigma^2 h(z_i' \alpha)$, where *h* is an unknown differentiable function that does not depend on *i*. z_i is a vector of independent variables, typically this vector contains the regressors from the original least square regression (Verbeek 2005, p. 91).

The White's test is less specific than the Breusch-Pagan-Godfrey's test. It does exclude higher order terms and also detects more general forms of heteroskedasticity. The White's test can instead of detect heteroskedasticity expose specification errors, e.g. incorrect functional forms (Verbeek 2005, p. 92).

According to our tests we might have a heteroskedasticity problem in our estimators. To fix this there are different remedial measures. If the $\sigma^2{}_i$ is known it is easy to fix the problem with Weighted Least Squared (WLS). In practice though, the $\sigma^2{}_i$ is rarely known. In that case, to use WLS, one has to make assumptions about the true variance. Examples of this are that the variance is proportional to X_i or X_i^2 (Gujarati 2006, p. 291).

Another method instead of making assumptions of the true variance is to respecify the model. There is no standard way of doing this except for trial and error. Examples of respecifying are to remove, add or raise to two a variable (Gujarati 2006, p. 297). A third way is to use the Newey-West method. It is often used to help against autocorrelation but can also help against heteroskedasticity (Verbeek 2005, p. 356). For this thesis we will not correct for heteroskedasticity, partly because it is not needed for regression models (II), partly due to time limitation

4.1.2 Multicollinearity

There are several ways to detect multicollinearity. It is important to realize that multicollinearity always exists to some extent. "Multicollinearity is a question of degree and not of kind. [...] Since multicollinearity refers to the condition of the explanatory variables that are assumed to be nonstochastic, it is a *feature of the sample* and not of the population" (Gujarati 2006, p. 254). We have used three methods to detect multicollinearity.

If a regression model has a high R^2 value but insignificant p-values you can suspect multicollinearity. In table 2 there are no regression models with a high R^2 value and with all estimators not significantly apart from zero. However, the zinc estimator is in fourteen cases not significantly apart from zero. The nickel estimator is in four cases not significantly apart from zero. On the other hand the copper estimator is always significantly apart from zero and the highest R^2 value is 0.425. There are only two models with two estimators not significantly apart from zero; Crowflight Minerals Inc. and HudBay Minerals Inc. Notable for the two companies are the low R^2 values, 0.120 and 0.171 respectively. Therefore we can assume there is no severe multicollinearity in our models according to this method. Table 4 shows the single regression models between the three metals.

(Table 4)

Observations: 261	**Intercept (Std)**	**Copper (Std)**	**Nickel (Std)**	**Zinc (Std)**	**R^2**	**Adj. R^2**	**Std**
Copper	0.002 (0.002)		0.373 (0.035)		0.301	0.298	0.039
P-value	*0.393*		*7.062*				
Nickel	0.000 (0.004)			0.597 (0.067)	0.233	0.230	0.060
P-value	*0.841*			*1.232*			
Zinc	0.000 (0.003)	0.804 (0.054)			0.458	0.456	0.041
P-value	*0.859*	*0.000 ****					

We have run single regression models for our three metals to investigate if there is a high degree of correlation between the metal price changes. As we can see in table 4 there seems to be no strong correlation for nickel and other metals. The coefficient is not significantly apart from zero and the R^2 value is only 0.301. For zinc and copper however there seems to be some correlation, but since the R^2 value is only 0.458 we do not see this as a problem.

(Table 5)

Observations: 261	**Intercept (Std)**	**Copper (Std)**	**Nickel (Std)**	**Zinc (Std)**	**R^2**	**Adj. R^2**	**Std**
Copper	0.001 (0.002)		0.197 (0.033)	0.452 (0.041)	0.522	0.518	0.033
P-value	*0.545*		*0.000 ****	*0.000 ****			
Nickel	0.000 (0.004)	0.601 (0.102)		0.255 (0.086)	0.324	0.318	0.057
P-value	*0.984*	*0.000 ****		*0.003 ***			
Zinc	0.000 (0.003)	0.700 (0.064)	0.129 (0.044)		0.476	0.472	0.040
P-value	*0.859*	*0.000 ****	*0.003 ***				

In table 5 we have run a multiple regression model for each metal, based on the remaining two metals. We can see that in this model all our coefficients are significantly apart from zero. The R^2 value is around 0.5 for copper and zinc but only 0.324 for nickel. This confirms the results from the previous table that nickel is the metal that correlates the least with the other two metals. No regression model has two coefficients above 0.5 which indicates no serious multicollinearity (Schaub 2005).

To further test this we have run a VIF test. To do this we have used each metal's R^2 value in equation 3.

(Equation 3)

$$VIF = \frac{1}{1 - R_i^2}$$

The rule is that the higher the VIF value the higher the multicollinearity. In the most extreme case, if the R^2 value is 1, there is perfect multicollinearity. If the R^2 value is zero, there is no multicollinearity (Gujarati 2006, p. 257). There is no consensus of when the VIF value is too high. A normal threshold value is a VIF of 10 (Lynch 2003, p. 4). To get a VIF of 10 you need an R^2 of 0.9. The results we obtained from the VIF test were 2.092 for copper, 1.479 for nickel and 1.908 for zinc. Our VIF values are therefore far from our critical value of 10. The results from this test imply that we have no problem with multicollinearity.

Based on all three methods, we have drawn the conclusion that our variables are not multicollinear to such extent that we need to include and/or exclude variables.

4.1.3 Analysis of regression models (I)

We did not see any danger with multicollinearity which means we will stick to our three metals. However, according to our heteroskedasticity tests, there seems to be a problem in many of the regressions. For regression models (II) this does not matter since we only use the beta values. In the following analysis there is a problem in some cases.

As we can see in table 2 the copper coefficient is in seventeen out of eighteen regression models higher than the nickel and zinc coefficients. The only exception is Minara Resources Ltd., a company concentrated in nickel mining and with no copper operations. Crowflight Minerals Inc. is another company with no copper operations. Even for Crowflight Minerals Inc. the copper coefficient is the highest. The two mentioned companies have the highest standard deviation for their copper coefficients. The reason for this might be that both companies are mainly nickel miners. Among the five companies with the highest copper coefficients two of them are concentrated in nickel mining. The remaining three are concentrated in copper operations.

Boliden AB, HudBay Minerals Inc. and Lundin Mining Corporation are the three companies with the highest zinc coefficients. This seems rational because all three companies are among the top five companies with highest share of revenue from zinc. However, the zinc coefficient's p-value for HudBay Minerals Inc. is not significantly apart from zero. Teck Resources Ltd. and Vedanta Resources Plc., the remaining top five companies with highest share of revenue from zinc, have zinc coefficients close to zero. The company with the lowest statistical significant zinc coefficient is MMC Norilsk Nickel with a coefficient of -0.359.

There are six companies with high amount of revenues from nickel operations; Crowflight Minerals Inc., Minara Resources Ltd., MMC Norilsk Nickel, FNX Mining Corporation Inc., Xstrata Plc. and Lundin Mining Corporation. Noticeable is that Lundin Mining Corporation has the second lowest nickel coefficient among our eighteen models. However, only 10 percent of the company's revenues come from nickel operations. The top four companies in terms of revenue from nickel operations are among the top five companies with the highest nickel coefficients. The exception is Southern Copper Corporation with no nickel operations. It is also important to mention that the fifth highest nickel coefficient (Crowflight Minerals Inc.) is not significantly apart from zero with a p-value of 0.066. Our results reveal R^2 values between 0.12 and 0.43. Most values are above 0.30. Normally an R^2 value less than 0.30 can be considered a bit low. However in financial predictions, an R^2 value of 0.10 or even as low as 0.05 can be statistically useful (Nau).

According to our results it seems like copper is the main indicator of our metals. The reason for this might be that all of our companies, with two exceptions, have substantial copper operations. In fact fourteen of our companies get their biggest revenue percentage from copper operations. It is surprising that copper is the most important factor whether or not the company mines any copper.

4.2 Regression models (II)

In this section we have run a regression for each metal beta coefficient. We have first run the same regression as in table 2 but for each year individually. That means we have calculated three metals times eighteen companies times five years; a total of 270 beta values. We therefore have 90 beta values for each metal. The purpose of this model is to find variables that affect the beta values. To evaluate if there are any factors that affect the beta values over the period we have tested different variables. We have used both systematic and non-systematic variables. The systematic variables used are: *Baltic Dry Index* and *MSCI World Metals & Mining*. The non-systematic variables used are: *market cap, non-OECD presence* and *quick ratio*. The variables were used in equation 2.

By non-OECD presence we mean that the company mines in some countries that can be considered riskier. The criteria we had for this were OECD membership. There was one exception, Chile, which we considered as stable. As a matter of fact Chile was invited to OECD and will be a member in January 11th of 2010 (Chile invited to become a member of the OECD 2009). We consider mining as a long term operation and believe that our categorization is good enough concerning non-OECD presence.

Baltic Dry Index is a business cycle indicator. It is directly connected to the shipping price of bulk goods, i.e. non finished goods as our metals. If the demand for bulk goods goes up the index goes up, ceteris paribus. The index is therefore a leading indicator of the economy (Gross 2003). We suspect that low levels of the index will affect the beta value more than medium and high levels. When the shipping costs are low the negative effect that transactions cost have on demand is less and therefore we could have a higher beta value.

The equity index MSCI World Metals & Mining contains stocks from the metals and mining sector. Our guess is unclear in which way high or low index will affect the beta values. However, we think the index will have some relation with the beta values because it describes the stock market concerned.

Market cap describes the size and also to some extent the diversification in the company. For example a company with only two mines is very dependent on those mines. A larger company can probably take more shifts in their mining operations. Our best guess is that the higher market cap the lower beta value, hence lower risk.

Non-OECD presence was chosen since mining operations take place in many politically risky areas which might have some influence. Our guess is that the metals and mining companies with overall operations in politically stable regions have lower beta values. This is due to stronger property rights and better infrastructure, hence lower risk.

We also wanted to test a non-systematic financial ratio and were interested in liquidity ratios. The reasons for this are two. First, a company with low liquidity ratio is less affected by price changes in underlying metal due to its distressed situation. The focus for the stock price will be on the ability to inject capital, which will affect the stock price more. Second, a company with low liquidity can be very sensible for price changes in the goods that they are selling, which could create a higher beta value. Therefore we could argue for both signs on the exposure.

One can argue that the amount of revenue each company receives from each metal should be a variable in the second regression. We want to investigate other variables that affect the beta values instead. The results we obtain from this regression is only to be used for metals and mining companies.

4.2.1 Metal beta results

We have tested the variables in all possible combinations. To save space we only presented the final regression model. Table 6 shows the exposure for the beta values against our chosen variables, MSCI World Metals & Mining and quick ratio. The results have been analyzed in section 4.2.3. The chosen model, equation 4, is a specific version of equation 2.

(Equation 4)

$$\beta_m = C_1 + C_{MSCI} * X_{1i} + C_{quick\ ratio} * X_{2ij} + e_i$$

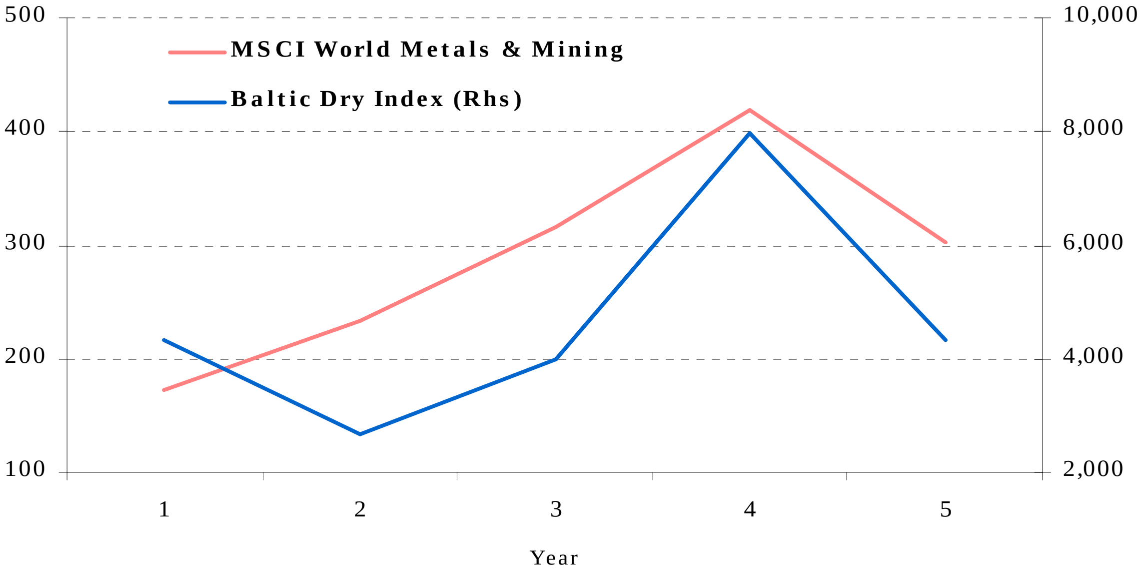
(Table 6)

Observations: 90	**Intercept (Std)**	**MSCI (Std)**	**Quick ratio (Std)**	**R^2**	**Adj. R^2**	**Std**
Copper	1.279 (0.128)	-0.003 (0.000)	0.014 (0.007)	0.368	0.354	0.325
P-value	*0.000 ****	*0.000 ****	*0.030 **			
Nickel	0461 (0.106)	-0.001 (0.000)	0.011 (0.005)	0.159	0.139	0.270
P-value	*0.000 ****	*0.002 ***	*0.038 **			
Zinc	-0.445 (0.129)	0.002 (0.000)	-0.017 (0.007)	0.298	0.282	0.326
P-value	*0.001 ****	*0.000 ****	*0.012 **			

First we tested each variable individually against the beta values. Some of the variables did not show any statistically significant results for any metal beta value. Thereafter we used combinations of the variables that were significant, to come up with a strong model.

The Baltic Dry Index coefficient was only statistically significant for the copper beta value. For the nickel and zinc beta values the index was statistically insignificant. The R^2 values for nickel and zinc were very low, both below 0.003. For copper the R^2 value was 0.05 and the Baltic Dry Index coefficient was negative. MSCI World Metals & Mining is a similar index, because it follows the business cycle. MSCI World Metals & Mining showed much better result than Baltic Dry Index. For all beta values the MSCI World Metals & Mining was statistically significant. The R^2 value shifted between 0.15 and 0.37. The coefficient was negative for the copper and nickel beta values and positive for the zinc beta value. After further evaluation we also discovered that MSCI World Metals & Mining and the Baltic Dry Index were heavily correlated. A regression between the two indices showed a high R^2 value and statistically insignificant coefficients, which indicates a collinear relation. We therefore decided to not use the Baltic Dry Index. Graph 1 further implies that the two variables are correlated. Graph 1 shows the MSCI World Metals & Mining index value on the left hand side and the Baltic Dry Index value on the right hand side over our five year period.

(Graph 1)



(Datastream Advance 4.0)

The market cap coefficient was negative for the copper and nickel beta values and positive for the zinc beta value. However, the variable showed no statistically significant result for any of the beta values. Also when used in any combination with other variables market cap showed statistically insignificant results. The R^2 values were very low. We decided to not use market cap.

For the non-OECD dummy variable 1 means non-OECD presence and 0 means only OECD presence. The coefficients were positive for the copper and zinc beta values and negative for the nickel beta value. However, the p-values were high and R^2 values always below 0.005. Combined with other variables the non-OECD dummy showed insignificant results. Together with the market cap variable the non-OECD dummy variable was the poorest.

The quick ratio coefficient was positive for the copper and nickel beta values and negative for the zinc beta value. The quick ratio variable used alone showed statistically significant results against each metal beta and R^2 values were between 0.06 and 0.09. The variable together with MSCI World Metals & Mining also showed statistically significant results. After extensive elaborations with different combinations we decided to use the MSCI World Metals & Mining and the quick ratio for our metal beta values.

4.2.2 Ramsey's RESET test

Ramsey's RESET test is used to detect if a linear model has an inappropriate function form, i.e. the model could be better expressed in a non-linear form. The test can also detect omission of variables (Gujarati 2006, p. 235-237).
With help of Eviews we have run the test. The following hypothesizes were used:

$$H_0 : \in \sim N(0, \sigma^2 I)$$
$$H_1 : \in \sim N(\mu, \sigma^2 I) \qquad \mu \neq 0$$

The hypothesizes can also be expressed as:

H_0 : Linear model: Y is a linear function of the X's
H_1 : Non-linear model: ln Y is a linear function of the X's or a log of the X's

In table 7 the critical value is the Chi-Square value. A value below 0.05 means that we will reject H_0. The results are presented in table 7:

(Table 7)

Observations: 90	**Intercept (Std)**	**MSCI (Std)**	**Quick (Std)**	**Fitted^2 (Std)**	**Fitted^3 (Std)**	**R^2**	**F-statistic**	**Prob. F(2,85)**	**Prob. Chi-Square(2)**
Copper	-4.381 (1.539)	0.011 (0.004)	-0.053 (0.019)	7.692 (2.368)	-3.156 (1.285)	0.489	10.059	0.000	0.000
P-value	*0.006 ***	*0.003 ***	*0.008 ***	*0.002 ***	*0.016 ***				
Nickel	-1.159 (0.570)	0.003 (0.001)	-0.054 (0.023)	15.792 (5.678)	-11.599 (5.612)	0.258	5.683	0.005	0.004
P-value	*0.045 **	*0.029 **	*0.019 **	*0.007 ***	*0.042 **				
Zinc	-1.088 (0.170)	0.005 (0.001)	-0.030 (0.022)	-2.973 (0.672)	-4.029 (1.283)	0.464	13.123	1.080	0.000
P-value	*0.000 ****	*0.000 ****	*0.189*	*0.000 ****	*0.002 ***				

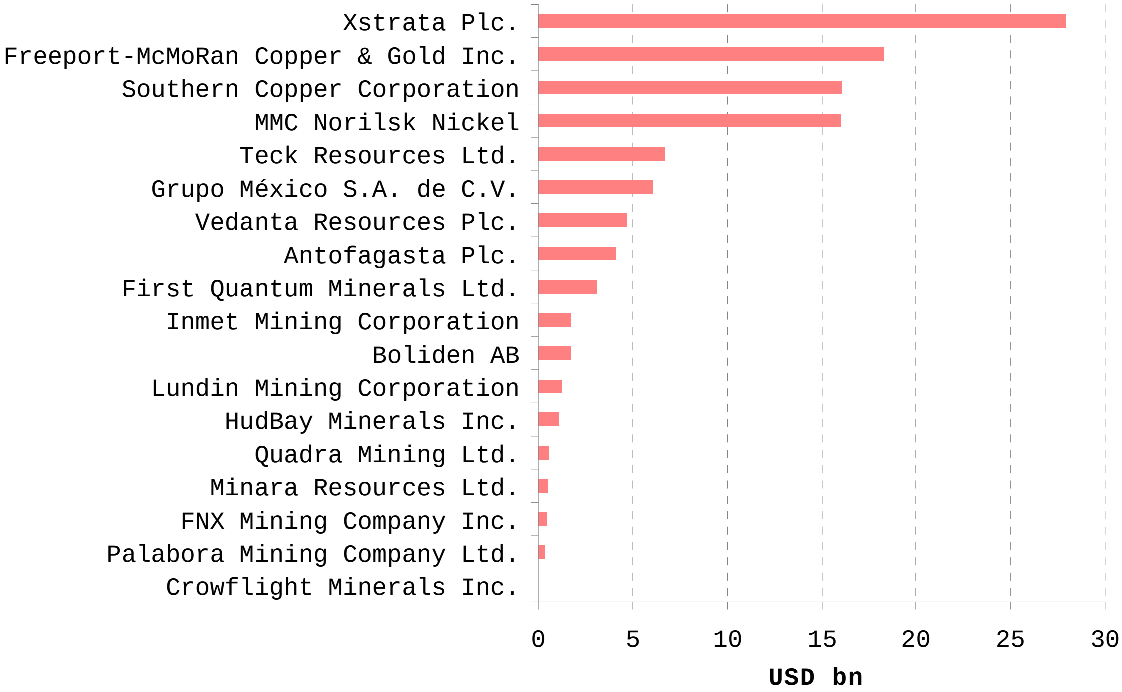
Since we reject H_0 for the three metals our models in table 6 might be mispecified. We still believe that the models expressed in table 6 are useful. In finance, there are often a high amount of indicators that influence an asset price. The markets can be very complex and in the same time efficient. As expressed before, an R^2 value as low as 0.1 can be useful.

4.2.3 Analysis of regression models (II)

Since the MSCI World Metals & Mining and Baltic Dry Index were correlated, we only concentrate on the MSCI World Metals & Mining variable of the systematic ones. The coefficient was negative for the copper and nickel beta values and positive for the zinc beta value. The reason for a negative coefficient could be that when the stock market is low the affect on changes in underlying metals have a high affect on stock prices. We suspect that when the market is low a price increase in metals is easily interpreted as a turning point in the industry. A price decrease in a low market can be a sign of doom and have a large impact on stock prices. This might be the reason why the beta value is higher when the market is low. In a behavioural economics point of view, we could argue that these reactions are not entirely economically rational, but this is subject for another thesis. The reason for the positive coefficient for the zinc beta value could be that our model is incomplete. Throughout this thesis the zinc values have followed their own path.

The market cap variable showed statistically insignificant results. This was a bit surprising for us considering the various sizes of our company sample. In graph 2 we can see how the companies vary greatly in market cap.

(Graph 2)



(Datastream Advance 4.0)

According to our result the company size does not matter. It can be explained from the reason that the commodities are not very differentiated. For example, the brand name and goodwill might not be important in this industry. Copper is copper and is traded in standardized forms, e.g. on the LME. During our sample search we discovered many metals and mining companies with only one or two mines in operation. This could indicate that entry barriers and economies of scale are insignificant in the industry. There is definitely a threshold in this industry because the capital needed to invest in mining operations is high. We are not as sure that the marginal cost is decreasing after this threshold because the market cap size has not indicated any significance in our model. This needs to be investigated further. As we have mentioned earlier in this thesis, there is a high volume of mergers and acquisitions in the industry which should indicate high levels of synergy. We do not see the reason why mergers and acquisitions otherwise would occur, assuming the companies are economically rational.

The non-OECD dummy was another variable showing statistically insignificant results. Despite problem to categorize we anticipated that the value for non-OECD presence would be higher. The result could be explained by our suspicion that the metals and mining industry is very capital intensive. Cheap labour does not have the same impact on the business compared to e.g. the manufacturing industry. It can also be explained by that our categorization is not sound. The dummy variable can be a problem, if we consider the non-OECD presence as number that jumps from 0 to 1, which is the case in our data sample. We have to admit that the non-OECD presence marking has its flaws. For example a company with operations exclusively in Africa might be less risky than a company with its operations in Canada. Non-OECD only considers political and economic risks, not geological ones for example.

The quick ratio proved to be statistically significant for all metal beta values. However, the quick ratio showed two positive coefficients and one negative coefficient. The result confirms one of our suspicions mentioned in section 4.2. There might be a relationship between low liquidity levels and low beta values. Once again, the coefficient in the zinc model follows its own path.

Since the MSCI World Metals & Mining and quick ratio variables showed statistically significant results and substantial R^2 values, we chose to combine these two as explanatory variables for our three beta values. This combination proved dominant over all other combinations tested.

Based on our results the industry in general seems to be less affected by non-systematic factors than systematic. This means that geography of operations, market cap is statistically insignificant for the metal beta values and indicators such as MSCI World Metals & Mining, which is associated with the business cycle, is statistically significant. However, the non-systematic variable quick ratio showed statistical significant results. This indicator differs from the other non-systematic indicators in that it is financially oriented and not business oriented. There are probably more key ratios important for the beta values that have not been a part of this thesis.

5 Conclusions of the thesis

In regression models (II) our R^2 values reached a maximum of 0.368. We can only speculate what other variables might influence the beta value. Some guesses are other macro variables such as economic growth, investment cycles and inflation. Economic growth because base metals are heavily used in emerging markets and inflation due to base metals are used as a hedging tool in times of high inflation. There are also other non-systematic variables that could have a positive effect on the R^2 value. As mentioned earlier the amount of operation in a given metal could affect the beta value for that given metal. Other key ratios might also be useful as explanatory variables.

The reason for copper being dominant in many regressions could be that copper is dominant in many products, e.g. in alloys containing our metals. Copper is also the base metal with the highest export value. In our thesis we have continuously obtained results where zinc moves in the opposite direction to copper and nickel. Zinc can be seen as the rogue metal. We have no economic arguments for this. The problem could be in our data.

Are our regression models (II) valuable to analyze other metals and mining companies? We have found some variables that influence the beta value but the model can be enhanced. There can also be specific companies in our industry with special price mechanisms, e.g. a company which is target of an acquisition. For those companies the model might be inadequate.

The models can be used to explain stock returns. If the beta values we have received are correct we should theoretically be able to make money. If you have a good prediction of metal prices you could use that to make money in the stock market. The model can also be useful to hedge a portfolio. Hypothetically, if our models are correct, we can hedge a zinc mining stock against a copper and/or a nickel mining stock. This is due to the opposite direction of the zinc beta value compared to the copper and nickel beta value. An assumption for this strategy is that all metal prices move in the same direction. In the worst case this thesis is valuable to increase the knowledge about price mechanisms on the market, hence improving your financial gut feeling.

6 Suggestions for further research

First, we have only studied one key ratio with surprisingly strong result. We therefore suspect there are more key ratios that might affect the beta values. It would be interesting to us with more research on key ratios.

Second, there are more commodities than copper, nickel and zinc. All commodities could be the subject for a similar thesis.

Third, copper has been the most dominant metal throughout the thesis, even if the company has no copper mining operation. A thesis could investigate why.

Fourth, the zinc coefficients have showed unanticipated results. We believe there should be further research why zinc so often differs from copper and nickel and are there more rogues out there?

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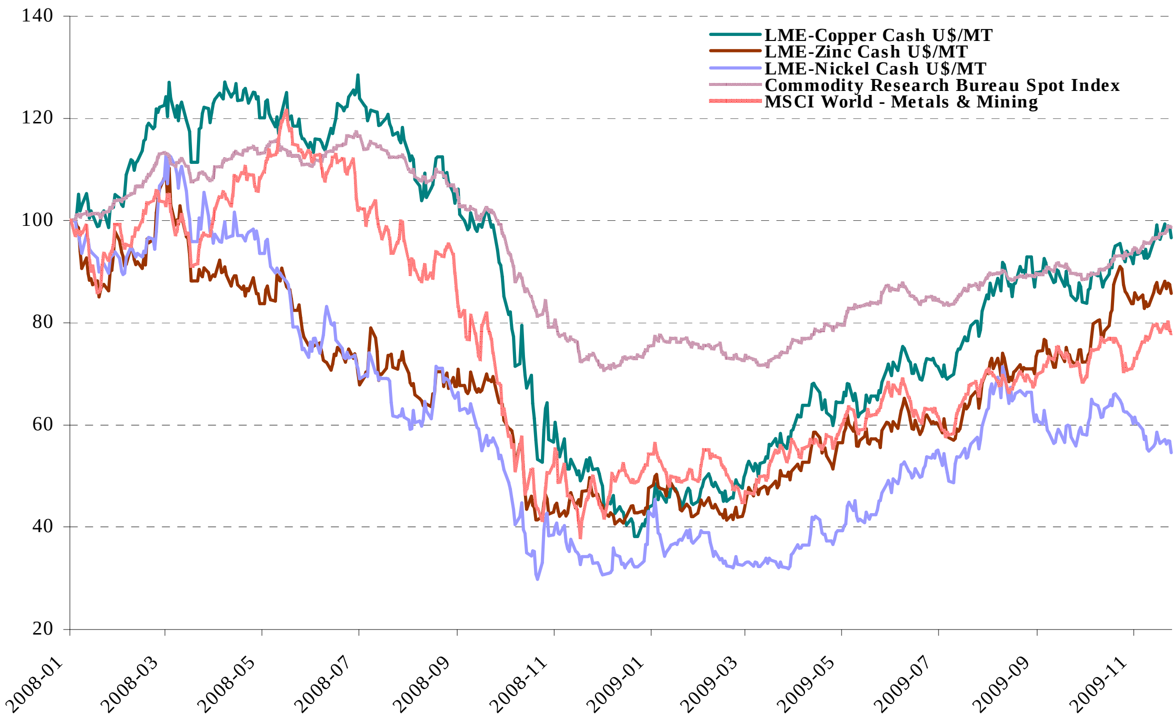
Appendix

(Graph 3)



(Datastream Advance 4.0)

Relevant theory

Collinearity

Collinearity or multicollinearity is defined as if there is a linear relationship between two or more explanatory variables.

Example:

$$X_{2t} = 6X_{3t}$$

If the variables can be written as a function of each other there is collinearity problem. However, there is always collinearity to some extent (Gujarati 2006, p. 98).

Dummy variables

Besides quantitative variables used in regression models there are also qualitative variables, also known as dummy variables. One requirement is that the dummy variables are dichotomous, which means they only adopt two values, e.g. small company = 0 and big company = 1. In this case, you need a clear definition of small company and big company (Körner & Wahlgren 2006, p. 400).

Heteroskedasticity

If the random variables have altered variances it is said to be heteroskedastic. This means that the restrictive distribution of each stock price dependent on a given value of X has different variances which means that every stock return are spread around their mean values with different variances. Heteroskedasticity neither makes the estimators biased nor incoherent. However it can incorrectly estimate the variance of the estimators, i.e. they are inefficient. If a regression contains heteroskedasticity a significant p-value can in fact be insignificant (Gujarati 2006, p. 55).

If this assumption, $\mathrm{var}(u_i) = \sigma^2$, does not hold there is heteroskedasticity in our model.

OLS – Ordinary least squares

Is used in regression analysis and makes the residual sum of squares $\sum e_i^2$ as small as possible, when creating a line through a scatter plot. (Gujarati 2006, p. 34)

Abbreviations, concepts and indices

Baltic Exchange Dry Index

Daily index made up of 20 key dry bulk routes (Baltic Exchange Dry Index 2010).

Market capitalization

The total market value of all of a company's outstanding shares, also referred to as market cap.

MSCI World Metals & Mining

MSCI World Metals & Mining is an index containing metals and mining stocks and is provided by the company MSCI Barra. The index is referred to as MSCI in the tables.

Quick ratio

Quick ratio is an indicator of a company's short-term liquidity. The quick ratio measures a company's ability to meet its short-term obligations with its most liquid assets. The higher the quick ratio, the better the liquidity position of the company.

The quick ratio is calculated as:

$$Quick\ ratio = \frac{Current\ assets - Inventories}{Current\ liabilities}$$

Quote mining

The practice of quoting out of context.

Star shorthand for significance levels

If the p-value is less than 0.001 we have a three star (***) significance level, i.e. high significance.

If the p-value is less than 0.01, but more than 0.001, we have two star (**) significance level, i.e. medium significance.

If the p-value is less than 0.05, but more than 0.01, we have a one star (*) significance level, i.e. low significance (Körner & Wahlgren 2006, p. 208).