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Diploma thesis

Economic analysis of industrial metals commodities

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DIPLOMA THESIS ASSIGNMENT

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Economics and Management

Thesis title
Economic analysis of industrial metals commodities

Objectives of thesis
Evaluation of industrial metals market in Czech Republic and prediction of future price movements in the area.

Methodology
Analysis will be done using: Technical, psychological and fundamental analysis.

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3/2013 thesis submission

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Recommended information sources

Žhavé komodity - Jim Rodgers, Grada publishing, ISO 978-80-247-2342-6
Metals trading handbook - Paddy Crabbe, Woodhead publishing limited, ISBN 0-8493-0518-7
The new commodity trading guide - George Kleinman, Pearson education Inc., ISBN 0-13-714529-2

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Prague January 9. 2013

Statutory Declaration

I hereby confirm that I wrote my diploma thesis "Economic analysis of industrial metals commodities" on my own with help of the listed bibliography.

In Prague 29.3.2013 ______________________________

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I would like to express my special thanks to Ing. Petr Procházka, MSc, Ph.D. for his professional guidance, patience and for giving me valuable advice and recommendations while working on my diploma thesis.

Economic analysis of industrial metal commodities

Ekonomická analýza komodit průmyslových kovů

Souhrn: Diplomová práce je zaměřena na ekonomickou analýzu trhu průmyslových kovů a hlavním cílem je objasnit pravidla cenových pohybů a predikce budoucích cen za použití fundamentální, technické a psychologické analýzy a ADF a ekonometrického modelu pro potvrzení nebo zamítnutí závislostí cen na vysvětlujících proměnných.

Klíčová slova: Průmyslové kovy, šrot, LME, komodity

Summary: Diploma thesis is focused on the economic analysis of industrial metals market and the main objective is to explain main price movements rules and predict future price movements using fundamental, technical and psychological analysis and ADF and econometric model to confirm or deny dependency of the price on the explaining variables and strength of the connections.

Keywords: Industrial metals, scrap, LME, commodity

Content

1 Introduction

Dynamic and unstable economy environment is reflecting into the everyday circumstances and purpose of the trader on the market is to predict future price movements and to have very spread knowledge about important points in the market and economy environment. For this purpose is market player missing one tool setting the time of the commodity price change.

Since I work as the business manager in the greatest and best performing scrap metal recycling company, I found one of the most important issues for the trader. The prediction of the price movements on the market is one step forward against competitors and it is a tool of greater value added for the team and business. The metals market in the Czech Republic is very dependent on the EU metals exchange and on the world metal market. This subject, as a part of the world industry supply, generates very big amount of money every year only depending on the demand of the consumers – world industry at general. For analysis of industrial metals is necessary to understand and find connection between world industry and world economy growth. When world economy performance growing, industry growing also and vice versa. With a tool or manner to calculate or predict future price movements of the metal commodities would Czech industry gain very important advantage in the expenditures and costs in the Euro competition. The diploma thesis concentrates on principles and conclusions.

Topic of economic analysis of industrial metals is very actual in the present. The market still remember hard times of the 2008 and 2009, when the prices decreased to 30% of its average and the recycling of the scrap almost stopped and it influenced performance of the industry as general and it influenced economy performance. This appearance was possible to feel in Czech Republic in European Union in United States of America – global economy problem.

Main objective is to evaluate industrial metals market and define factors influencing it. The result would help in the commodity metals evaluating and would help to understand the period when should be used market tools as hedging.

2 Objective and methodology

2.1 Objective

The main task of the diploma thesis is to evaluate main industrial metals on the market and define factor influencing it.

Using econometric is explaining dependency of the metal commodities on the world economy and industry consumption. In the case main hypothesis is proven the output would be easily defined and speculations on the stock market would be low risks, since is possible to collect data of the world economy performance. In the case the main hypothesis is refused or disproven the output would show strength of the connection between variables in the model and the strongest connection would bring the clue to follow on the stock market. All of the output is to analyze industrial metals commodities and the rules of its price movements.

2.2 Methodology

Chosen methodological tools define utilized scientific methods based on the technical, fundamental and psychological analysis, econometric model and ADF analysis of the industrial metals commodities, business and stock exchange including hedging and other stock market tools. Correctness of the research and model is supported by the combination of financial, economical, mathematics and statistical methods.

Diploma thesis is structured into introduction part, where the topic is defined with a stress on its importance and where is explained why the topic was chosen and where are defined objectives of the diploma thesis including main hypothesis and concrete aims of the diploma thesis.

Theoretical part – Literature overview - is the definition of main notions connected with a topic of the diploma thesis and collected in different, relevant and certified resources. Main thesis is the lead for the theoretical knowledge about stock markets, Czech Republic metals market, world economy performance and dependency of the metal price on the industry consumption. General frame of the evaluation of the industrial metals and industrial metals market and prediction of the price movements is supplemented by analysis on the general level of the stock market, mainly London Metal Exchange, and by the solutions reached or discovered by other authors, scientists and traders in the environment of the metals exchange.

The literature overview is followed by the own analysis based on the data collected from the LME, World Bank and IMF as a parameters for the research and main hypothesis. The fundamental analysis is done for the market to predict future price movements based on the data from world commodity markets in New York and London. For the personal and historical price movements prediction is used technical analysis, where are commodity price development charts explained using main technical analysis tools and the result is based on the emotional feelings of the price movement. The psychological analysis is employed as a market feeling operation behavior, where are trades and price movements dependent on it explained by the mentality and psychology of the single market players.

The main hypothesis defines aim of the research and procedure for the confirmation is done by the econometric model based on three endogenous variables, price of the copper, aluminum and steel, and four exogenous variables, world consumption of the copper, world production of aluminum and steel, and exogenous variables, percentage growth of the world GDP, which are supplementing main exogenous data. Economy performances are set by percentage change to highlight the differences in the economy performance. The econometric model is reliable in the case of the proven dependency of endogenous variables on the exogenous variables, in the case of very high or very important multicollinearity is used difference variable as the aspect of the weather – supporting consumption 1 (summer season) and rejecting consumption (winter season, snow, ice). The econometric model was calculated for the one equation model and also for the two equations model. In the two equation model were expected better and stronger results.

The last analysis done in the thesis is Advanced Dickey-Fullers test, the econometric model based on the OLS method introducing result as statistical variables explaining strength of the variables dependency in the time series model.

The output is evaluated in the economic and statistical verification analysis. The final conclusion covers main content of the thesis as a literate overview confirmation and disagreements based on the own research and analysis and the final recommendation by the equations concluded from the own analysis. At the end is the proposal of solutions – conclusion.

The conclusion covers main content of the thesis as a literate overview confirmation and disagreements.

3 Theoretical part

Introduction of industrial metals commodities as copper, aluminum and steel and trading platforms as LME and market tools and influences based on the world economy development.

3.1 Price decision making process

The first step to forecast commodity price and ability to predict commodity price movement is the part of the price decision making process – the main aspect of the business dependant on the stock market trading. Second very important step is to evaluate time of the market movements. Since commodity futures markets are so highly leveraged (initial margin requirements are generally less than 10% of a contract's value), minor price moves can have a dramatic impact on trading performance. Therefore, the precise timing of entry and exit points is an indispensable aspect of any market commitment. Timing is everything when dealing in the commodities markets, and timing is almost purely technical in nature. This is where a practical application of charting principles becomes absolutely essential in the price forecasting and risk management process.[1]

3.1.1 The futures market discounts everything

The technician believes that the price posted on the board of a commodity exchange at any given time is the intrinsic value of the commodity based upon the fundamental factors affecting the supply and demand of the product. Therefore, if the fundamentals are already reflected in the price, market action (charts- price, volume, open interest) is all that is needed to be studied to forecast future price direction. Although not knowing the specifics of the fundamental news, the technician indirectly studies the fundamentals by studying the charts which reflect the fundamentals of the marketplace.

[1] Trading Charts: Technical analysis. [online]. [cit. 2013-03-18]. DOI: Keystone Marketing Ltd. Available on: http://futures.tradingcharts.com/learning/index.html

3.1.2 **Prices move in trends**

Prices can move in one of three directions, up, down or sideways. Once a trend in any of these directions is in effect it usually will persist. The market trend is simply the direction of market prices, a concept which is absolutely essential to the success of technical analysis. Identifying trends is quite simple; a price chart will usually indicate the prevailing trend as characterized by a series of waves with obvious peaks and troughs. It is the direction of these peaks and troughs that constitutes the market trend.

3.1.3 **History repeats itself**

Technical analysis includes the psychology of the market place. Patterns of human behavior have been identified and categorized for several hundred years and are repetitive in nature. The repetitive nature of the marketplace is illustrated by specific chart patterns which will indicate a continuation of or change in trend.[2]

3.2 Fundamental analysis

On the market is price determined by the interaction of supply and demand – "The fundamental analysis". The law of supply and demand is base for the estimating market price for commodities, in this case industrial metals, and using specialized market tools as stock to use ratio.

3.3 Technical analysis

The technical analysis is pure data and graphs consideration and the result is not scientifically based. Observation and prediction of the historical movements of the

[2] What is technical theory?: Learning centre. In: *Tradingcharts.com* [online]. [cit. 2013-03-18]. Available on: http://futures.tradingcharts.com/learning/technical_theory.html

market price considering demand and supply and macroeconomic shock is the strongest tool of the technical analysis.

3.4 Psychological analysis

Psychological approach is searching for the motives for the market development and decision about buying or selling assets. The psychological approach is focused not on asset but on the human psychology, which is by that approach influencing commodity market price volatility.

3.5 Commodities

Commodity contract is agreement of two or more sides about buying or selling standardized amount of commodity or other asset in further specified quality by agreed value and to future date.

In the literature exists many definitions, usually is commodity referred as any good or raw material that may be sold or bartered. An important feature of commodities is the fact that they have tangible properties and thus provide an inner value; commodities either have a consumer benefit or are used for industrial purposes. In the financial world a commodity is characterized as an article of commerce or a product that can be used for commerce which is traded on an authorized commodity exchange.

Different types of commodities exist including agricultural products, metals and energy but also foreign currencies, financial instruments and indices. A further differentiation is made by distinguishing between so called “essential raw materials” from the primary sector and semi-finished products such as meat or refined copper. Primary commodities are normally defined as products grown on land, extracted from the land, or raised on the land that have been subject to only the first stage of processing. Contrary to this, semi-finished products have gained a significant proportion of their value by processing activities.[3]

3.6 Industrial metals

Investors interest commodity on the industrial metal markets are mainly copper, aluminum, nickel, lead, tin and zinc. Demand for them is highly correlated to economic growth or downturn. The greatest world consume of the industrial non-ferrous metals is China in the last 3 years. The demand is not elastic, because of the time needed to implement into market newly found mines of the chemically clear and precise non-ferrous metals. The time could be counted in decades of years, starting finding the new bearing to the start of extraction. Result is strong correlation between global economic growth and the prices of metals and mutual correlation between every single industrial metal to each other – this aspect leads on the market to the cycles of increasing and decreasing value of the industrial metals mining companies. Although the price movements of the copper, aluminum, tin a nickel are very similar the next aspect influencing price of them are resources traded on the LME – London Metal Exchange. On the demand side of the equation is the world population growth and economic growth. It means lager amount of consumers are able to buy lager amount of luxury gods as cars o houses, because of the disposable income growth. While in 1950, the area of an average house in the U.S. approximately 1000 square feet (about 93 m2), in 1990 the figure was 1,900 square feet (about 177 m2) and currently is the average size of a house in the country on the border of 2500 square feet (about 232 m2). Since the breakthrough of the millennium, the attention of economists focus on emerging markets, where it is much lower standard of living than in the developed world. China, India, Russia, Brazil and other countries are making every effort to catch up as fast as their

[3] ERHORN, Friederike. FRIEDERIKE ERHOM. *Commodities as an Asset Class in Portfolio Management*. München: GRIN Verlag GmbH. ISBN 978-364-0890-934.

developed counterparts. Gross domestic product in developing countries has been growing since 2000, two and half times faster than in developed countries.

Each of industrial metals is specific via chemical and physical behavior. Based on this is very specific use and manipulation. Copper is anticorroding but softer than stainless steel and has very high electrical conductivity. Aluminum is light and so is used in aviation industry, lead is opposite to aluminum and it is very heavy. Price and price development of these metals is very similar and very dependent on the economic development.

Use of the industrial metals in the world is very diversified – building industry, electro industry and machinery are the sectors with highest percentage of the world consumption. Important are in the coins production, aviation as mentioned above via aluminum. By the geographic point of view is the greatest consumer of industrial metals Asia, where flows more than 50% of the world supply of copper and aluminum and China consumes more than 25%. Second greatest consumer of the industrial metals supply is USA – which is one of the most economically developed countries of the world.

Divided into several categories are the metals as aluminum, copper, lead, nickel, tin and zinc are called as industrial metals. To include all of the metals providing base of economy in industry is necessary to mention also steel as one of very important metals. As the industrial metals have different value, the price movements are usually same or in very similar volatility on the stock market.

The most important trading centre for industrial metals is London Metal Exchange (LME). Because the most important markets for the copper and aluminum is China and USA and Europe is in strategic position to this market, the data from the LME will be used as an input data for this thesis.

3.7 Recycling

Metal recycling is part of metal industry and it is well established activity for recovering metal generated from manufacturing scrap as well as from scrap metal. Scrap metal recycling is indispensable to the metal industry. Depending on the technology applied, up to 100% of scrap can be used to produce high-quality metals.

The processing of scrap metals – whether iron, aluminum, copper or other metals – save scarce primary resources. So, natural iron ore deposits are preserved for the future of subsequent generations. The energy consumed when melting down scrap is up to 60% below the energy consumption necessary for the primary process.

So, scrap is both in one: raw material source and energy carrier. In thus a particular success that the worldwide share of scrap for the production of steel is of approximately 50% - with upward tendency.

Aside, metal recycling is very strong economic activity with still rising potential, generating over 64$ billion to the US in 2010, according to the IRIS statistics.

The metal supply chain is based on the basic market tools and it follows main economical rules even in the 21st century. It starts by the small collectors who dispose of scrap from the garden restorations or building restorations. They sell it to the small scrap yards from where it flows to the multinational scrap yards where usually companies operating with the scrap from the production lines and from there is scrap sold to the mills or foundries.

3.8 Scrap market description

Iron, including steel, is the most widely used metal. Iron and steel comprise about 95 percent of all the tonnage of metal produced annually in the United States and in the world. On average, iron and steel are by far the least expensive of the world's metals, and steel products are used in many construction and industrial applications. The steel market can be classified into two distinct types of production: a. production in large scale integrated mills that use Basic Oxygen Furnaces and b. production in minimills that use Electric Arc furnaces. For the last decade minimills and integrated mills have each accounted for about half of steel production. Minimills have increased market competition and have made steel prices more representative of market transaction prices. However, the basis of steel marketing remains contract based and producer prices are present. In contrast to non-ferrous metals steel is not traded on metal exchanges. The main reason for this is due to the high differentiation of steel products and the need of utilization of base prices for steel products and extras for specifications.[4]

Recycling steel is technologically possible and economically profitable. In consequence a significant industry has developed to collect old and new scrap. New scrap arises from preconsumer sources and old is generated from post-consumer sources. New scrap comes from all stages of industrial processing. It is generated within steel mills and foundries (home scrap) or industrial plants (prompt or industrial scrap) while making iron and steel products. The availability of home scrap has been declining as new and more efficient methods of casting have been adopted by the industry. Old scrap, or obsolete scrap, comes from many different products, both consumer and industrial and is composed by objects that no longer have further use. The North American steel industry’s overall recycling rate is around 55-60%.

Scrap prices react quickly to changes in supply and even more so to changes in demand. The major consumers of scrap are steel mills and ferrous foundries. When demand for steel mill and foundry products is low, demand for scrap is low, and prices fall. Dealers cannot influence sales of scrap if mills and foundries do not need it to charge their furnaces. On the supply side, dealers can hold back some scrap from mills

[4] *Forecasting with a Periodic Transfer Function Model*. ISBN 1-86125-019-3.

and foundries when prices are low. New scrap produced in industrial plants, however, must be disposed of frequently to make room for more scrap.

Prices are also influenced by technological changes in steel mills and foundries. Steel mills melt scrap in basic-oxygen furnaces (BOF), electric-arc furnaces (EAF), and to a minor extent, in blast furnaces, whose significance, however, has been declining over the years. The proportion of scrap in a BOF is limited to less than 30%, whereas that in an EAF can be as much as 100%.

Blast furnaces' and basic-oxygen furnaces' role has been declining over the years and new, relatively small and technologically simple steel plants (minimills) have been built to produce simple products, such as hot-rolled bars of steel. This new approach to steelmaking has caused record highs in steel production and scrap consumption. Minimills have been able to capture a significant share of the market by setting prices that the previously dominant steel companies were unable to match. They have also allowed scrap to become increasingly important to the steel industry.[5]

3.9 Aluminum

Aluminum could not be found in the nature as free metal. It was known by Greeks and Romans, but its potential was researched in the 18th century and reason was that it is not available in the nature as a free element opposite to gold, iron or copper. It has to be extracted from other ores, mainly bauxite. The way of getting aluminum led to its higher price of aluminum than price of gold in the Napoleon era.

[5] *Forecasting with a Periodic Transfer Function Model*. ISBN 1-86125-019-3.

Aluminum production is highly diversified. In the North America is produced more than 20%, in the middle and east Europe is produced 18% and in the west Europe is produced 17% of the world aluminum production. It is fact that aluminum is mostly engaged element in the earth surface, about 8% of the solid earth surface

Today is production of aluminum higher than production of all non-ferrous materials combined together and it is the most active contract traded on LME. It is the choice in automobile, aerospace, rail and marine industry – it is strong, durable, flexible, non-corroding and very light material – it is 100% recyclable. Combination of these factors delivers material with strength of steel, but three times lighter.

China is the greatest consumer of aluminum and in the long term the rising markets in emerging economies should support demand for this metal. Demand for aluminum has two key aspects. First it is sale of consumer goods as cars and second are the investments by the construction companies – the construction is the field of need light weight and strong material needs. Supply of aluminum is mainly from China, Russia, North America and Australia which is more than half of the world aluminum production. The concentration of the supply in these areas means that the production is really sensitive to disruption, particularly as aluminum production is not always a straightforward process.

Largest part of the production costs today is electricity, because to produce aluminum requires an unhindered supply of electricity, which means that electric power and its cost are greatest part from the producer costs. Therefore, power cuts and price rises in energy can mean some smelters have to cut production or close down operations completely. In 2001 in US the electric power shortages sent price for the power so high that it was more profitable for smelters to stop production and sell their electricity quotas to other users. This behavior immediately raised price of the aluminum on the markets.

Aluminum does have different supply dynamic to some other commodities – especially finite commodities such as oil and natural gas – because it is completely recyclable without any adverse effect on its properties. Producing secondary aluminum from scrap is much cheaper than producing primary aluminum, because it requires only 5% of electricity. This means that access to scrap and output of secondary aluminum are able to balance overall supplies. Aluminum was affected by the 2007 – 2009 financial crisis as demand slipped, lowering prices. However, in the long term there is evidence to suggest prices will be supported. By far the biggest risk to prices lies with China´s appetite for the metal. The growing industrialization and urbanization being carried out in the other emerging economies – where investments are being made in air, roads, rail, transport, packaging, construction and vehicle usage is anticipated to rise- is also an important factor. It should mean that aluminum experiences a sustained high demand as economies grow once again.[6]

3.10 Copper

Copper is soft metallic element with a reddish color. It is a good conductor of heat and electricity. Principle uses include in households as piping and electrical wiring, in electronics and in construction as waterproofer. As it is so soft, pure copper can be unsuitable for some of the uses it is put to and so it is regularly combined with other metals to form alloys – brass is an alloy of copper and zinc, and bronze is an alloy of an copper and tin. This ties the fortune fortunes of copper to other metals and in fact it has historically been regarded as a bellwether for the base metal markets, meaning that it has been thought the other industrial metals will follow where it leads.

[6] SCOTT, Philip. *The commodities investor a beginner's guide to diversifying your portfolio with commodities*. Petersfield [England]: Harriman House, 2010. ISBN 978-085-7190-284.

The copper price has been high in recent years, to such an extent that people would steal to get their hands on some. During the decline in the US housing market in 2008, reports were widespread of thieves visiting vacant properties in search of copper wiring and pipes to sell to scrap metals merchants. In the case of the US, the average family home uses around 205 kg of copper. This also suggests that when a housing market is good and new homes and buildings are being constructed demand for copper will be strong. Indeed, as country´s living standards improve, its demand for copper grows and so once again the emerging economies of the world are important considerations.[7]

Supply for copper reacted on the extreme demand in 2000 in slightly delayed period, what is consequence of technological factors. Building mine is capitol for several years or decade and after start of the production is still chance of shock as strikes of miners or accidents. This issue is typical for Chile, the greatest producer of copper in the world, because the working conditions there are very poor and hard. Also the transformation from ore to raw metal is expensive and refinery consuming enormous volume of electric energy.

Copper is a malleable and ductile metallic element that is an excedent conductor of heat and electricity as well as being corrosion resistant and antimicrobial. Copper occurs naturally in the Earth’s crust in a variety of forms. It can be found in sulfide deposits (as chalcopyrite, bornite, chalcocite, covellite), in carbonate deposits (as azurite and malachite), in silicate deposits (as chrysycolla and dioptase) and as pure "native" copper. Copper also occurs naturally in humans, animals and plants. Organic life forms have evolved in an environment containing copper. As a nutrient and essential element, is copper vital to maintaining health. Life sustaining functions depend on copper. Copper and copper-based alloys are used in a variety of applications that are necessary for a reasonable standard of living. Its continued production and use is essential for society's development. How society exploits and uses its resources, while ensuring that tomorrow's needs are not compromised, is an important factor in ensuring society's

[7] SCOTT, Philip. *The commodities investor a beginner's guide to diversifying your portfolio with commodities*. Petersfield [England]: Harriman House, 2010. ISBN 978-085-7190-284.

sustainable development. Copper is one of the most recycled of all metals. It is our ability to recycle metals over and over again that makes them a material of choice. Recycled copper (also known as secondary copper) cannot be distinguished from primary copper (copper originating from ores), once reprocessed. Recycling copper extends the efficiency of use of the metal, results in energy savings and contributes to ensuring that we have a sustainable source of metal for future generations.

The demand for copper will continue to be met by the discovery of new deposits, technological improvements, efficient design, and by taking advantage of the renewable nature of copper through reuse and recycling. As well, competition between materials, and supply and demand principles, contribute to ensuring that materials are used efficiently and effectively. Copper is an important contributor to the national economies of mature, newly developed and developing countries. Mining, processing, recycling and the transformation of metal into a multitude of products creates jobs and generates wealth. These activities contribute to building and maintaining a country's infrastructure, and create trade and investment opportunities. Copper will continue to contribute to society’s development well into the future.

The global demand for copper continues to grow: world refined usage has more than tripled in the last 50 years thanks to expanding sectors such as electrical and electronic products, building construction, industrial machinery and equipment, transportation equipment, and consumer and general products.

3.11 Steel

Steel is and alloy of iron and other elements – carbon mainly. Content of carbon in steel is between 0,002% and 2,1% by weight. The possibility of other elements is possible, but it depends on the demand of customers – manganese, sulfur. These elements are added to modify characteristic of steel, usually as hardening agent, preventing dislocations in the iron atoms.

Steel is a cornerstone and key driver for the world's economy. The industry directly employs more than two million people worldwide, plus two million contractors and four million people in supporting industries. Including industries such as construction, transport and energy, the steel industry is at the source of employment for more than 50 million people. Steel is at the core of the green economy, in which economic growth and environmental responsibility work hand in hand. Steel is the main material used in delivering renewable energy: solar, tidal and wind. All steel, even that created as long as 150 years ago, can be recycled today and used in new products and applications. The amount of energy required to produce a ton of steel has been reduced by 50% in the last 30 years. Steel touches every aspect of our lives. No other material has the same unique combination of strength, formability and versatility. Steel surfaces are hygienic and easy to clean. Surgical and safety equipment and commercial kitchens are all made with steel. Almost 200 billion cans of food are produced each year. Steel cans ensure that food remains safe and nutritious, and save energy as refrigeration is not needed. The can itself is 100% recyclable. Steel is an innovative and progressive industry committed to the safety and health of its people. The industry is committed to the goal of an injury-free workplace. Safety metrics show that the lost-time injury frequency rate is decreasing.

Globally, the steel industry spends more than €12 billion a year on process improvements, new product development and future breakthrough technology. Life cycle thinking: new solutions for new times. Life cycle assessment (LCA) considers production, manufacture, use phase and end of life recycling and disposal. Life cycle thinking leads to immediate environmental benefit. LCA is easy to implement, cost effective and produces affordable and beneficial solutions for material decision-making and product design.

3.11.1 **Demand for the steel**

Demand for steel is very specific aspect of commodity trading mainly supported by the quantity of products that users are willing to pay in given time period in a certain region or country. Every country has its own system of steel production as a legacy from the age of industrial era. This industrial infrastructure is the key to the success of the international steel trade because of the demand based on high efficiency of the production and also because of the friendly environmental behavior. Suppliers provide steel trades to the mills all around the World via main storage harbors in Europe and US and the main travel cost to the steel scrap material is stock price of oil. By this data is final price of steel manufactures (bars, ingots) calculated and it is also the part of the supply price for the traders for the next time period, usually set from 15^{th} day of current month to the 15^{th} day

3.12 London Metal Exchange

The LME is different from many futures markets in that it can result in actual delivery of a recognized (approved) metal, albeit that the range of product specifications may be reasonably large. Nevertheless market users know the parameters which are close enough to their end requirements to ensure that the prices established on LME are relevant to the metal or product that they are trading.

The LME has constantly reviewed its operations, being sensitive to the need to provide a practical service to its members and customers. Contracts have been updated and new metal contracts have been introduced to cater for the changing methods and trends within the metals industry.

Despite many changes, the LME has retained its individually and is a fine example of an exchange adapting to meet the current demands of its customers.[8]

4 Own analysis

Own analysis of the diploma thesis focused on the price of industrial metals, it´s value to the market and the price prediction to the future is based on the technical analysis of the industrial metals market and on the fundamental analysis based on the correlation table, where are introduced values to predict future price movements and prove it´s real value.

4.1 Fundamental analysis

On the market is price determined by the interaction of supply and demand – “The fundamental analysis”. The law of supply and demand is base for the estimating market price for commodities, in this case industrial metals, and using specialized market tools as stock to use ratio.

4.1.1 Supply vs. Demand

Supply and demand plays critical role in the industrial metals market evaluation. The price consumers are willing to pay is based on the price producers are able to achieve and both sides are still looking for the equilibrum on the market moving prices up and down.

[8] CRABBE, Paddy. *Metals trading handbook: a market companion for users of the London metal echange*. Repr. Boca Raton, Fla. [u.a.]: CRC Pr, 2003. ISBN 08-493-0518-7.

4.1.2 **Demand**

Consumers behavior is the key aspect to the understanding the law of demand and the application of demand to the fundamental analysis of the commodities. This economic theory is based on how consumers reflect or understand the market influences and they are playing the key role in this economic theory. The time value and history points will also introduce some expectations about demand in the future and development of market price.

Demand for the product is mainly the ability of consumer to pay for it or purchase it in various process. The relationship between price and quantity is connection to the final price of the commodity and its relationship is generally negative – meaning the price on higher level follows quantity on lower level and vice versa. This is a very standard and classical behavior on the industrial market and usually one and only aspect for the traders to trade the commodities at the time. Market demand is than the sum of all individuals within the marketplace and it will be affected by other influences of individual differences and values as higher margin or value added, handlings, location and even quality calculations or restrictions and financing factors. For example the prices for the industrial metals are usually calculated from the final product delivered to the mills as copper 99%, copper 95% etc. The producers in the system are than driven by the consumers and this is the most important part of the industrial metals evaluation and market value of the product is driven and determined by the value to the consumer. Opposite situation is when the consumers are unwilling to pay for current price the producers on the side of weak demand are forced to lower the prices and the slightly start turning from the estate or product with weak demand to the product with the higher demand. (Figure 1)

It is typical commodity market system of benefiting producers and consumers. Those which offering products that consumers want are rewarded and those who offering products consumers are not willing to buy are penalized. Steel mills have to produce depending on the markets, they can´t effort to produce and willing to find opened and profitable gap on the market.

4.1.3 **Supply**

The supply is representing the sum of total productions plus carryover stocks and the behavior of producers. Total supply is the quantity producers are willing to sell over a range of prices for any given time period. It is the total supply of the individual quantities each steelwork brings to the market. (Figure 2)

Increasing the price on the market will mainly lead steelmills, ironworks etc. wanting to increase the quantity of products ready to fill the market – the relationship between price and quantity is positive and market value of the product will be affected by the other variable in addition to the price. Other factors determining the price are number of firms, technology available, price of inputs and price of other commodities and mainly the weather.

The very useful and also very often used words connection:”discipline of the marketplace” is essence of the metals trading for the last century. A good marketers are ready to produce for the market and if not they change the way of production which leads to price turnover.

4.2 Price derivation

Interaction of supply and demand is the base for the derivation price of industrial metals and other commodities traded on the market and the final price is dependent on the fundamental elements and components of the market. In the time when demand and supply meets in the exact point it is called “equilibrium price”, the moment when customers agree to pay for the product amount of money that producers are ready to sell for. (Figure 3)

The market price is not relevant to all market players and some small differences occur during the trading period. The competitive positions of all participants on the market are dividing them in to the stronger and weaker positions. Guarantee and company behavior and quality of the material is the clue to the setting real price on the commodity and in case of strong position company and well built reputation the final price of the material is calculated with lower percentage of service fee – the discount by the quality material.

4.2.1 Weather conditions

Weather is the most unpredictable part of the price setting. Final price of industrial metal or commodity could turn down about 200 € only during few days because of the surprisingly strong snow storm in Chile or Russia even in Europe. The scrap metal production is by this influence stopped and the data and information transfer would inform immediately about the situation which would lead to the panic. The equilibrium price movement is obvious.

4.2.2 The stock to use ratio

The Stocks to Use Ratio is a convenient measure of supply and demand interrelationships of commodities. The stocks to use ratio indicates the level of carryover stock for any given commodity as a percentage of the total demand or use. The mathematical formula for this relationship is as follows

$$\frac{\textit{Beginning Stock} + \textit{Total Production} - \textit{Total Use}}{\textit{Total Use}}$$

This can be simplified by consolidating the upper portion of the relationship to:

$$\frac{\textit{Carryover}}{\textit{Total Use}} \times 100 = \textit{Stocks To Use Ratio}$$

Using the long hand formula, beginning stocks represent the previous year's ending or carryover inventories. Total production represents the total grain produced in a given year. Total usage is the sum of all the end uses in which the stock of grain has been consumed. This would include human consumption, export programs, seed, waste, dockage and feed consumption. By adding carry-over stocks to the total production is the total supply. From the total supply, subtract the total use and the resultant figure will be the year ending carryover stock. The carryover stock divided by the total usage can be expressed as a ratio which when compared with previous years gives the market analyst an indication of the relative supply/demand balance for a particular commodity. This ratio can then be used to indicate whether current and projected stock levels are critical or plentiful. The ratio can also be used to indicate how many days of supply is available to the world marketplace under current usage patterns.(eg. a 20% stocks to use ratio for wheat indicates that there are 75 days supply of wheat in reserve)

By comparing the current year's stocks to use ratio with years when carryover stocks were below normal as well as years when carryover stocks were above normal, it is possible to develop an estimate as to the direction of the price trend as well as the probable extent of price change whether higher or lower.[9]

4.3 Commodity price

To predict or determine commodity price is necessary very good source of information and sufficient tool to compare all of the variables. Bases for the price derivation or prediction is fundamental analysis, based on the supply and demand factors interacting on the market and it leads to raise or fall of the price of the industrial metal commodities. Volume of these factors is unlimited, most well known are floods, earthquakes, storms and other natural disasters other type are wars, politics, inflation or

[9] Tradingcharts.com/stock_ratio

exchange rates. Previously mentioned stock use ration is mainly tool to find equilibrium on the market of a commodity over time in order to determine if the current market price is over or under valued.

Technical, is based upon the study of the market action itself. While fundamental analysis studies the reasons or causes for prices going up or down, technical analysis studies the effect of the price movement itself. Technical analysts claim that markets do trend and that by charting market prices can be controlled commodity price risk management. They further claim that by combining the use of price charts with appropriate marketing tools and pricing strategies can have a major positive impact on your profitability and, therefore, the long term survival of the business. Charting can be used by itself with no fundamental input, or in conjunction with fundamental information.

4.4 Technical analysis

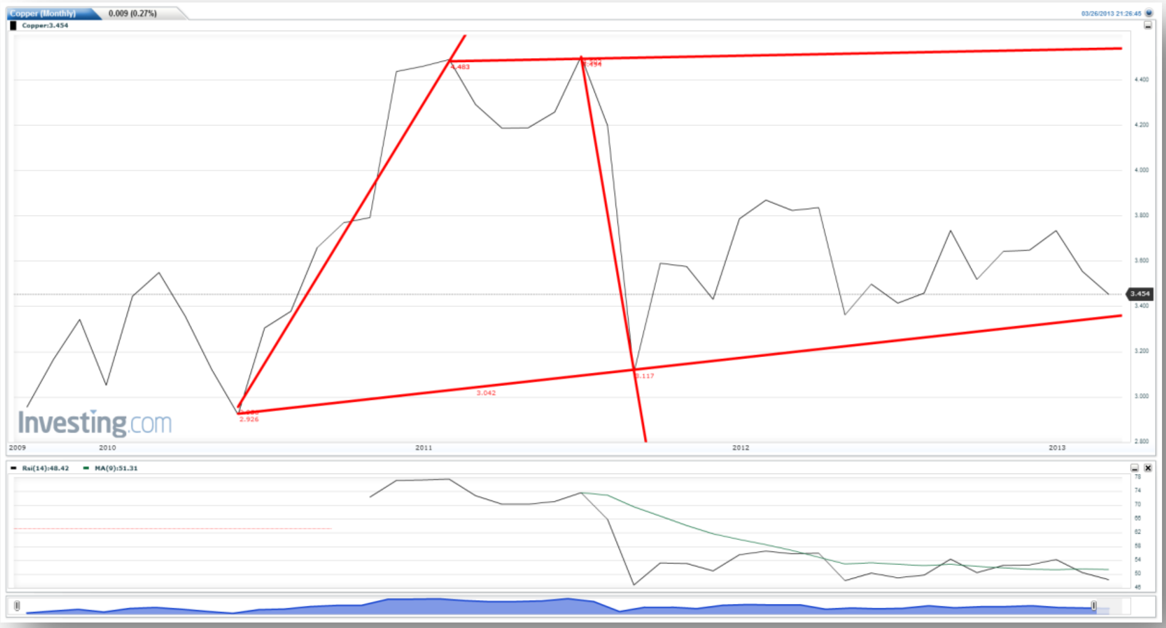
The technical analysis is pure data and graphs consideration and the result is not scientifically based. Observation and prediction of the historical movements of the market price considering demand and supply and macroeconomic shock is the strongest tool of the technical analysis. As a two main non-ferrous metals and main industrial commodity – steel, the technical analysis will be done to estimate future market price.

History of the price fluctuation is one of the most important technical analysis parts. Historically are also compared volume of the commodity marketed and its price. The main question than are: “What happened?” and “Why is that happened?”.

Technical analysis is the concept without emotion and the number are silently informing to buy or to sell on the market telling market price and price activity what is just happening. Than is possible to compare it to the historical charts or input he data to the mathematical model or business system.

4.4.1 **Copper**

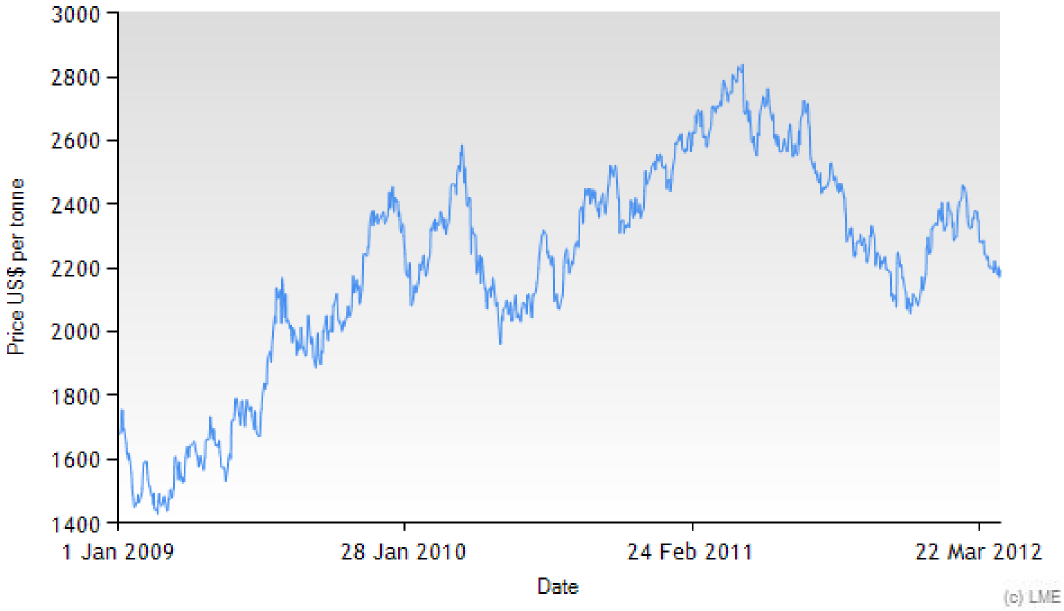
The price development graph below is showing monthly copper price development since 2009 until today. The main price shock was in 2008 and 2009 – time of the financial crisis, but it was the macroeconomic shock on the market and it is not desirable to implement this point into the technical analysis points, because it is highly not probable for this situation to occur without any market warnings. Lowest price flow is in the point 2 926 $ for 1 pound. Pound is recalculated to kilogram as exactly 0.45359237 kg. The second lowest point in the time period is 3117 $ and connection of these two lowest points is support line showing trend in the bottom of the price flow. The support line situated upwards and this is very good signal for the investor the price contracts would probably grow and it is a good option to invest with low risk and real time for the higher hedging contracts. Other two main important points in the chart are 4483$ and 4498$ in January 2011. The line connecting these two points is resistance line and in the case the contracts are closed above this line means also good future price prediction. Copper is today on the lower average flow and by the support and resistance line is very probable the price would grow, but it is based on the experience and subjective prediction of the price development. Last two vertical lines are highlighting the price development shocks, the greatest two in the chart. Rapid growth started the 6th of January 2010 and stopped on the 2nd of January 2011and rapid decrease started on the 7th January 2011 and stopped on the 9th January 2011. The power of the one year price increasing was lost in the time period of two day in 2011. It leads to the careful contracts closing during the rapid chart shocks.



Source: Investing.com

4.4.2 **Aluminum**

Aluminum chart for the same time period as copper in the chart above is following high volatility with an extra price growth at the end of March 2011. The support line is from February to May 2011 and it has strong line increase – the future price would be directed to the growth and same the resistance line from March 2010 to March 2011. But on the other side the price today is on the higher average of the price flow.



4.5 Psychological analysis

Psychological approach is searching for the motives for the market development and decision about buying or selling assets. The psychological approach is focused not on asset but on the human psychology, which is by that approach influencing commodity market price volatility.

LeBonev crowd psychology is founder of this psychology analysis branch. By this theory is crowd performance over the performances of the crowd members. It is not than only sum of the individual emotions, but new emotions appears. The crowd will “eat” the individual and push aside his character. Later is he losing rational consciousness and starts to be driven by own instincts and feelings. The crown is than missing rationality. It is necessary for investor to know the crowd behavior. The crown as whole is not lead by fundamental analysis even development and experiences from the past, technical analysis, but achieve hot investment tips and bets on the tips of other investors or analytics without own opinion domination. This manipulation of the market subject makes the market very unpredictable and hard to read.

This situation is very typical for the Czech Republic industrial metals market, when main steel consumers are in Germany, Poland and Austria and the price is diversified with 5% difference between all of the players mentioned. The monthly price is than very hard to predict into the future, even into next month.

4.6 Econometric model

Econometric model is the tool for the discovery of the dependency of industrial metal price on the economic environment including development of the economy, development of the industry and development of the complementary commodity price.

4.6.1 Simultaneous dynamic model

This model researches dependence of the chosen industrial metal, aluminum, and its price development, world gross domestic product percentage annual change, world annual aluminum production, world annual average copper price, steel rebar annual average price and world steel annual production.

4.6.2 Economic and econometric model

Main purpose of the economic model is to translate explored phenomenon based on the defined set of elements and connections to the mathematical language including specific connections between each variable. Condition is definition of the model behavior.

Econometric model is specific form of the algebraic model including one or more random variable.

4.7 One-equation model

In the econometric model is endogenous variable annual average aluminum price, explained by exogenous variables world GDP annual growth, world annual aluminum production, copper average annual price, steel rebar average annual price and world steel annual production. Econometric model is constructed with a random component and is set:

$$y_{1t} = \gamma_{11} x_{1t} + \gamma_{12} x_{2t} + \gamma_{13} x_{3t} + \gamma_{14} x_{4t} + \gamma_{15} x_{5t} + \gamma_{16} x_{6t} + u_t$$

Variables declaration:

y1t ……. Aluminum average year price (nominal $/MT)
x2t ……. world GDP growth annual (%)
x3t ……. World annual aluminum production (ths of MT)
x4t ……. Copper average year price (nominal $/MT)
x5t ……. Steel rebar average year price (nominal $/MT)
x6t ……. World steel annual production (ths MT)

4.7.1.1 ***Assumption, formulation and expectation of the model***

As a explained variable is chosen world aluminum price in $, average annual price, which is characterize how much the price changed during the year 1993 – 2010, for each year compared to the other. By the literature and traders experience is industrial metals price determined by the price of the complementary commodities and on the market and economy development. By that information was chosen as exogenous variables annual average price of copper, steel rebar and world aluminum production.

4.7.1.1.1 Table 1 Basic data set

Year	Aluminum average year price (nominal $/MT)	UV	world GDP growth annual (%)	World annual aluminium production (ths of MT)	Copper average year price (nominal $/MT)	Steel rebar average year price (nominal $/MT)	World steel annual production (ths MT)
	y1	x1	x2	x3	x4	x5	x6
1994	1476,78	1,00	3,40	19,147	2307,42	322,50	725,11
1995	1805,66	1,00	3,30	19,610	2935,61	381,67	725,29
1996	1505,66	1,00	3,80	20,859	2294,86	360,17	750,09
1997	1599,33	1,00	4,10	21,81	2276,77	325,17	798,95
1998	1357,47	1,00	2,60	22,72	1654,06	257,50	777,33
1999	1361,09	1,00	3,60	23,72	1572,86	234,17	788,97
2000	1549,14	1,00	4,80	24,66	1813,47	244,17	848,94
2001	1443,63	1,00	2,30	24,51	1578,29	221,46	851,07
2002	1349,92	1,00	2,90	26,16	1559,48	204,17	904,05
2003	1431,29	1,00	3,70	27,99	1779,14	265,83	969,92
2004	1715,54	1,00	4,90	29,86	2865,88	428,75	1061,25
2005	1898,31	1,00	4,60	31,91	3678,88	423,13	1146,58
2006	2569,90	1,00	5,30	33,98	6722,13	443,75	1248,99
2007	2638,18	1,00	5,40	38,13	7118,23	521,50	1347,00
2008	2572,79	1,00	2,80	39,49	6955,88	760,17	1341,21
2009	1664,83	1,00	-0,60	36,99	5149,74	486,04	1235,84
2010	2173,12	1,00	5,10	41,15	7534,78	562,50	1428,71
2011	2401,39	1,00	3,80	43,99	8828,19	630,00	1601,22

Endogenous variable is aluminum average price in $ in the interval since 1994 to 2011 and is explained by exogenous variables.

4.7.1.1.2 Table 2 Support table for the data set

Table 2 is containing average variable for each value, sum of the total values for each variable and standard deviation for each value added into the model. Main important aspect is the average value of the interested time period of aluminum average price – 1806,3$. This price responds to the price of the year 1995 and time between years 2004 and 2005, the decade of the price development was interested to the average price of the period 1994 – 2011.

Average	1806,3	1,0	3,7	31,1	3812,5	392,9	1030,6
Sum	32514,0	18,0	65,8	467,1	68625,7	7072,6	18550,5
standard deviation	445,72	0,00	1,38	7,13	2433,09	150,45	269,90

4.7.1.1.3 Table 3 Correlation matrix

Correlation matrix highlights the multicollinearity in the model. Multicollinearity is explaining dependency between two or more exogenous variables in the equation. In the case of high multicollinearity (value > 0,9) in the model is not possible to separate influence of each exogenous variables to endogenous variable, the multicollinearity is then undesirable. The perfect multicollinearity is in the case of dependency between two variables is deterministic – correlation coefficient or coefficient of multiple correlation is equal to 1. In that case is perfect multicollinearity present and this model is impossible to estimate.

High multicollinearity is present when the value of exogenous variables has low variability – to solve high multicollinearity is necessary to implement enough variability of the exogenous variable, but the multicollinearity in the model will be still present.

Presence of the high multicollinearity in the model allows not achieve exact estimation of the parameters of the exogenous variables that cause multicollinearity.

Presence of the multicollonearity can be identified in the correlation matrix. Correlation matrix consists of pair correlation coefficients of each exogenous variable.

Correlation matrix pattern is:

$X'^T * X'$ …… where X is matrix of the normalized vectors.

Corellation matrix

X´T*X	y1	x2	x3	x4	x5	x6
y1	1	0,38019352 9	0,85081311 9	0,92042451 8	0,85307263 1	0,82165288 4
x2	0,38019352 9	1	0,09201300 7	0,19029091 5	0,07688866 2	0,15330012 1
x3	0,85081311 9	0,09201300 7	1	0,98199618 3	0,88477254 8	1,07813611 2
x4	0,92042451 8	0,19029091 5	0,98199618 3	1	0,89785111 3	0,93068722
x5	0,85307263 1	0,07688866 2	0,88477254 8	0,89785111 3	1	0,82672026 8
x6	0,82165288 4	0,15330012 1	1,07813611 2	0,93068722	0,82672026 8	1

Red color highlights multicollinearity in the model.

It is clear the equation variables are highly connected and correlation matrix confirms this phenomenon. Main diagonal of the correlation matrix make ones. Other parts are pair correlation coefficients between pairs of the exogenous variables which should not be over 0,9. In case the value is higher than 0,9, it is very strong dependency between variables and that variables should not appear on the left and right side of the equation at once. In this model is matrix high correlation. This could be removed by the implementing differences or dummy variable. In the model was chosen difference.

4.7.1.1.4 Table 4 Modified data set

Table 4 interprets different and modified data set for the model. Highest multicollinearity is transformed by the difference of the X3, X4 and X5 variables. Because of the difference starting in the year 1994 is year 2011 missing, this modification is not really influencing whole model, because the development of the price in that year was predictable and there was no shock in the development of the values.

Year	Aluminum average year price (nominal $/MT)	world GDP growth annual (%)	World annual aluminium production (ths of MT)	Copper average year price (nominal $/MT)	Steel rebar average year price (nominal $/MT)	World steel annual production (ths MT)
	y1	x2	x3 diference	x4 difference	x5 difference	x6
1994	1476,78	3,40	0,46	628,19	59,17	725,11
1995	1805,66	3,30	1,25	-640,75	-21,50	725,29
1996	1505,66	3,80	0,95	-18,09	-35,00	750,09
1997	1599,33	4,10	0,91	-622,71	-67,67	798,95
1998	1357,47	2,60	1,00	-81,20	-23,33	777,33
1999	1361,09	3,60	0,94	240,61	10,00	788,97
2000	1549,14	4,80	-0,15	-235,18	-22,71	848,94
2001	1443,63	2,30	1,65	-18,81	-17,29	851,07
2002	1349,92	2,90	1,83	219,67	61,67	904,05
2003	1431,29	3,70	1,87	1086,74	162,92	969,92
2004	1715,54	4,90	2,05	812,99	-5,63	1061,25
2005	1898,31	4,60	2,08	3043,26	20,63	1146,58
2006	2569,90	5,30	4,15	396,09	77,75	1248,99
2007	2638,18	5,40	1,36	-162,35	238,67	1347,00
2008	2572,79	2,80	-2,51	-1806,14	-274,13	1341,21
2009	1664,83	-0,60	4,17	2385,04	76,46	1235,84
2010	2173,12	5,10	2,84	1293,41	67,50	1428,71

4.7.1.1.5 Table 5 Modified correlation matrix

The modified data set is the clue for the modified correlation matrix.

Corellation matrix

X'T*X	y1	x2	x3	x4	x5	x6
y1	1	0,393293116	0,010380825	-0,150739514	0,011486474	0,80714407
x2	0,393293116	1	-0,066580243	-0,109590146	0,200485372	0,163476206
x3	0,010380825	-0,066580243	1	0,694872449	0,645490575	0,262082892
x4	-0,150739514	-0,109590146	0,694872449	1	0,50569638	0,255166866
x5	0,011486474	0,200485372	0,645490575	0,50569638	1	0,164298361
x6	0,80714407	0,163476206	0,262082892	0,255166866	0,164298361	1

After the differentiation of the variables X3, X4 and X5 is correlation reduced and model is transparent to use OLSM method. Correlation values 0,8 are not considered as multicollinearity because of the chance of the rounding by the MS Excel.

4.7.1.2 ***OLSM***

Ordinary least square method is a method for estimating parameters in linear regression model. Purpose of the method is to minimize the sum of squared vertical distance between the observed responses in the dataset and the response predicted by the linear approximation. The OLSM is consistent when there is no perfect multicollinearity and the regressors are exogenous.

4.7.1.2.1 Table 6 OLSM data set

World annual aluminium production (ths	Copper average year price (nominal $/MT)	Steel rebar average year price (nominal	World steel annual production (ths	World consumption of copper (ths MT)	Production of total world industry index
x_2	x_3	x_4	x_5	x_6	x_7
0,46	2307,42	322,50	725,11	1 303,31	5 147,94
1,25	2935,61	381,67	725,29	1 466,36	5 170,63
0,95	2294,86	360,17	750,09	1 761,58	5 173,46
0,91	2276,77	325,17	798,95	1 884,92	5 184,84
1,00	1654,06	257,50	777,33	2 061,58	5 201,46
0,94	1572,86	234,17	788,97	2 149,02	5 218,21
-0,15	1813,47	244,17	848,94	2 269,70	5 186,11
1,65	1578,29	221,46	851,07	2 448,56	5 145,96
1,83	1559,48	204,17	904,05	2 567,53	5 139,06
1,87	1779,14	265,83	969,92	2 688,11	5 132,33
2,05	2865,88	428,75	1061,25	2 929,17	5 132,50
2,08	3678,88	423,13	1146,58	3 116,06	5 174,17
4,15	6722,13	443,75	1248,99	3 352,60	5 199,36
1,36	7118,23	521,50	1347,00	3 662,57	5 198,33
-2,51	6955,88	760,17	1341,21	3 848,41	5 232,33
4,17	5149,74	486,04	1235,84	3 739,23	5 286,46
2,84	7534,78	562,50	1428,71	3 775,24	5 268,89

Aluminum average year price (nominal $/MT)
y_1
1476,78
1805,66
1505,66
1599,33
1357,47
1361,09
1549,14
1443,63
1349,92
1431,29
1715,54
1898,31
2569,90
2638,18
2572,79
1664,83
2173,12

4.7.1.2.2 Table 7 OLSM table results

The results of the multiplication matrix X and transferred data of OSLM model. Result is equation coefficient for the each of the variables in the equation.

(XT* X) -1 XT * y		
	-4,560493084	y_1
	68,99628126	y_2
	29,64740133	y_3
	-0,154445366	y_4
	-0,168399752	y_5
	1,54783939	y_6

4.7.1.3 ***Final model***

$$y_1 = -4{,}56 + 68{,}99x_2 + 29{,}64x_3 - 0{,}15x_4 - 0{,}16x_5 + 1{,}54x_6$$

4.7.1.4 ***Economic verification***

Constant -4,56 represents the average annual price of the aluminum if every else variable was 0.

Parameter y12 is 68,99. If annual GDP growth increased by 1%, an annual aluminum average price would increase by 68,99%.

Parameter y13 is 29,64. In case of raising volume of aluminum production by 1 000, aluminum annual average price would be higher by 29,65%.

Parameter y14 is -0,15. If copper average price raised by 1$, aluminum average price would be lower by 0,15 %.

Parameter y15 is -0,16. If steel rebar average price raise by 1$, aluminum average price would be lower by 0,17 %.

Parameter y16 is 1,54. If world steel annual production raise by 1000MT, aluminum average price would increase by 1,55 %.

4.7.1.5 ***<u>Gretl confirmation of the results:</u>***

Model 3: OLS, za použití pozorování 1-17
Závisle proměnná: AluminumP

	Koeficient	*Směr. chyba*	*t-podíl*	*p-hodnota*	
const	-4,48151	260,083	-0,0172	0,98656	
ALproduction	29,5558	57,4091	0,5148	0,61686	
GDP	68,9881	40,8141	1,6903	0,11908	
CuP	-0,154421	0,0683861	-2,2581	0,04524	**
FeP	-0,167968	0,713251	-0,2355	0,81815	
Feproduction	1,54789	0,2378	6,5092	0,00004	***

Střední hodnota závisle proměnné	1771,332	Sm. odchylka závisle proměnné	447,2935
Součet čtverců reziduí	527383,6	Sm. chyba regrese	218,9611
Koeficient determinace	0,835252	Adjustovaný koeficient determinace	0,760366
F(5, 11)	11,15369	P-hodnota(F)	0,000518
Logaritmus věrohodnosti	-112,0330	Akaikovo kritérium	236,0659
Schwarzovo kritérium	241,0652	Hannan-Quinnovo kritétium	236,5628

4.8 Simultaneous model

For the first equation in simultaneous model was chosen aluminum average annual price as an endogenous variable. This variable depends on these exogenous variables: world annual aluminum production, copper average annual price, steel rebar average annual price, world steel annual production.

For the second equation was chosen as a dependent endogenous variable, world GDP annual growth. The explanatory endogenous is aluminum average annual price and exogenous variable are world consumption of copper, production of total world industry index.

4.8.1 Econometric model

Aluminum average annual price is a function of world GDP change, world aluminum production, copper average annual price and steel rebar average price and. Econometric model is constructed with a random component and is set:

$$\mathbf{y1t=\beta12y2t + \gamma11x1t + \gamma12x2t + \gamma13x3t + \gamma14x4t + u1t}$$

World GDP change is a function of aluminum average annual price, world steel annual production, world consumption of copper and production of total world industry index. Econometric model is constructed with a random component and is set:

$$\mathbf{y2t=\beta21y1t + \gamma21x1t + \gamma25x5t + \gamma26x6t + \gamma27x7t + u2t}$$

Variables declaration:

y_{1t} ……. Aluminum average year price (nominal $/MT)
y_{2t} ……. world GDP growth annual (%)
x_{1t} …….constant
x_{2t} ……. World annual aluminum production (ths of MT)
x_{3t} ……. Copper average year price (nominal $/MT)
x_{4t} ……. Steel rebar average year price (nominal $/MT)
x_{5t} ……. World steel annual production (ths MT)
x_{6t} ……. World consumption of copper (ths MT)
x_{6t} ……. Production of total world industry index (2005=100)

4.8.1.1 ***TSLSM***

The two stage least squares method is one of the most wide spread methods of the estimation structural parameters simultaneous model. It belong to the methods with the limited information, it means estimation of the parameters is made for each equation of the model. The nature of the method is repeated application of the ordinary square method for the estimation of the theoretical values of the explaining endogenous variables in the equation and then for the own estimation structural parameters of the equation. Basic idea in the first stage TSLSM is replacing matrix of the collected values Y2 by the matrix Y´2 consisting of the theoretical values, where are values of the variables estimated on the base of regression on all predetermined variables in the model. In that case are explaining correlated variables replaced by random non-stochastic values Y´2 and the assumption for OLSM and the 2nd stage of the TSLSM.

$(X^TX)^{-1}X^Ty$ …. Pattern of the TSLSM

4.8.1.1.1 Table 8 Data set

Aluminum average year price (nominal $/MT)	Copper average year price (nominal $/MT)	UV	World annual aluminium production (ths of MT)	world GDP growth annual (%)	Steel rebar average year price (nominal $/MT)	World steel annual production (ths MT)	World consumption of copper (ths MT)	Production of total world industry index (2005=100)
y_1	y2	x_1	x_2	x3	x_4	x_5	x_6	x_7
1471,20	2186,30	1	19,01	3,20	301,60	724,95	14,85	73,90
1476,78	2307,42	1	19,15	3,40	322,50	725,11	15,26	75,51
1805,66	2935,61	1	19,61	3,30	381,67	725,29	16,31	78,42
1505,66	2294,86	1	20,86	3,80	360,17	750,09	16,98	80,74
1599,33	2276,77	1	21,81	4,10	325,17	798,95	17,88	85,17
1357,47	1654,06	1	22,72	2,60	257,50	777,33	18,26	87,19
1361,09	1572,86	1	23,72	3,60	234,17	788,97	18,92	89,92
1549,14	1813,47	1	24,66	4,80	244,17	848,94	19,36	94,67
1443,63	1578,29	1	24,51	2,30	221,46	851,07	20,05	92,62
1349,92	1559,48	1	26,16	2,90	204,17	904,05	19,54	92,97
1431,29	1779,14	1	27,99	3,70	265,83	969,92	19,51	94,51
1715,54	2865,88	1	29,86	4,90	428,75	1061,25	20,35	97,61
1898,31	3678,88	1	31,91	4,60	423,13	1146,58	21,09	100,00
2569,90	6722,13	1	33,98	5,30	443,75	1248,99	22,23	103,77
2638,18	7118,23	1	38,13	5,40	521,50	1347,00	22,45	107,23
2572,79	6955,88	1	39,49	2,80	760,17	1341,21	23,79	105,14
1664,83	5149,74	1	36,99	-0,60	486,04	1235,84	22,05	92,38
2173,12	7534,78	1	41,15	5,10	562,50	1428,71	24,41	99,73

4.8.1.1.2 Table 9 Correlation matrix

Corelation matrix								
$X'^{T}*X$	y_1	y_2	x_2	x_3	x_4	x_5	x_6	x_7
y_1	1	0,927301713	0,758622068	0,398999638	0,837046546	0,811079177	0,686184306	0,690927217
y_2	0,927301713	1	0,869697877	0,213072954	0,885122832	0,903971113	0,766240368	0,650059037
x_2	0,758622068	0,869697877	1	0,100324369	0,773974285	0,991304875	0,957920889	0,864488734
x_3	0,398999638	0,213072954	0,100324369	1	0,081311412	0,176631293	0,127450519	0,322149233
x_4	0,837046546	0,885122832	0,773974285	0,081311412	1	0,794438465	0,65303691	0,525181494
x_5	0,811079177	0,903971113	0,991304875	0,176631293	0,794438465	1	0,934519194	0,853963002
x_6	0,686184306	0,766240368	0,957920889	0,127450519	0,65303691	0,934519194	1	0,928525175
x_7	0,690927217	0,650059037	0,864488734	0,322149233	0,525181494	0,853963002	0,928525175	1

Correlation matrix is showing high correlation values in many case of the variables dependency. For the application of the TSLSM model is necessary to remove this dependency and it is possible by the difference of the variable X2.

4.8.1.1.3 Table 10 Modified data set

Multicollinearity solution:

Aluminum average year price (nominal $/MT)	Copper average year price (nominal $/MT)	World annual aluminium production (ths of MT)	world GDP growth annual (%)	Steel rebar average year price (nominal $/MT)	World steel annual production (ths MT)	World consumption of copper (ths MT)	Production of total world industry index (2005=100)
y_1	y2	x_2 DIFERENCE	x3	x_4	x_5	x_6	x_7
1476,78	2307,42	0,46	3,40	322,50	725,11	1 303,31	5 147,94
1805,66	2935,61	1,25	3,30	381,67	725,29	1 466,36	5 170,63
1505,66	2294,86	0,95	3,80	360,17	750,09	1 761,58	5 173,46
1599,33	2276,77	0,91	4,10	325,17	798,95	1 884,92	5 184,84
1357,47	1654,06	1,00	2,60	257,50	777,33	2 061,58	5 201,46
1361,09	1572,86	0,94	3,60	234,17	788,97	2 149,02	5 218,21
1549,14	1813,47	-0,15	4,80	244,17	848,94	2 269,70	5 186,11
1443,63	1578,29	1,65	2,30	221,46	851,07	2 448,56	5 145,96
1349,92	1559,48	1,83	2,90	204,17	904,05	2 567,53	5 139,06
1431,29	1779,14	1,87	3,70	265,83	969,92	2 688,11	5 132,33
1715,54	2865,88	2,05	4,90	428,75	1061,25	2 929,17	5 132,50
1898,31	3678,88	2,08	4,60	423,13	1146,58	3 116,06	5 174,17
2569,90	6722,13	4,15	5,30	443,75	1248,99	3 352,60	5 199,36
2638,18	7118,23	1,36	5,40	521,50	1347,00	3 662,57	5 198,33
2572,79	6955,88	-2,51	2,80	760,17	1341,21	3 848,41	5 232,33
1664,83	5149,74	4,17	-0,60	486,04	1235,84	3 739,23	5 286,46
2173,12	7534,78	2,84	5,10	562,50	1428,71	3 775,24	5 268,89

4.8.1.2 ***Model identification***

$k_{**} \geq g_{\Delta} - 1$ k_{**} - number of predeterminated variables not included in the equation

$g_{\Delta} - 1$ - number of endogenous variables included in the equation minus the unit

1. Equation is overidentified

   k** = 3

   gΔ = 2

   1 = 2 – 1

   3 > 1

2. Equation is overidentified

   k** = 3

   gΔ = 2

   1 = 2 – 1

   3 > 1

4.8.1.3 ***Gretl confirmation results***

Gretl software results are confirming equation based on TSLSM and also confirming additional data calculated for the econometric model:

4.8.1.3.1 1st equation Gretl

Model 22: TSLS, using observations 1-17
Dependent variable: AluminumP
Instrumented: CuP
Instruments: const Alproduction SteelP FeProduction CuConsumption IndustryIndex GDPgrowth

	Coefficient	*Std. Error*	*z*	*p-value*

const	628.74	294.499	2.1349	0.03277	**
GDPgrowth	85.9781	34.9292	2.4615	0.01384	**
Alproduction	6.20472	43.3928	0.1430	0.88630	
CuP	0.0761777	0.0751078	1.0142	0.31047	
SteelP	1.45656	1.07651	1.3530	0.17604	

Mean dependent var	1771.332	S.D. dependent var	447.2928
Sum squared resid	363097.9	S.E. of regression	173.9487
R-squared	0.887181	Adjusted R-squared	0.849575
F(4, 12)	22.07970	P-value(F)	0.000018

Hausman test -
Null hypothesis: OLS estimates are consistent
Asymptotic test statistic: Chi-square(1) = 23.5223
with p-value = 1.23476e-006

Sargan over-identification test -
Null hypothesis: all instruments are valid
Test statistic: LM = 1.13814
with p-value = P(Chi-square(2) > 1.13814) = 0.566052
Weak instrument test -
First-stage F-statistic (3, 10) = 5.00347

4.8.1.3.2 2nd equation Gretl

Model 28: TSLS, using observations 1-17
Dependent variable: CuP
Instruments: SteelP FeProduction CuConsumption IndustryIndex GDPgrowth Alproduction const AluminumP

	Coefficient	*Std. Error*	*z*	*p-value*	
const	-65101.8	10492.5	-6.2046	<0.00001	***
AluminumP	2.12418	0.355529	5.9747	<0.00001	***
FeProduction	9.63118	1.82212	5.2857	<0.00001	***
CuConsumption	-1.73276	0.435819	-3.9759	0.00007	***
IndustryIndex	11.5355	2.05969	5.6006	<0.00001	***

Mean dependent var	3517.498	S.D. dependent var	2234.977
Sum squared resid	1126868	S.E. of regression	306.4404
R-squared	0.985900	Adjusted R-squared	0.981201
F(4, 12)	209.7719	P-value(F)	5.43e-11
Log-likelihood	-118.4867	Akaike criterion	246.9735
Schwarz criterion	251.1395	Hannan-Quinn	247.3876

4.8.1.4 ***Final model 1st equation***

$$y1t = 0{,}076\ y2t + 628{,}74 + 6{,}201\ x2 + 85{,}99\ x3t + 1{,}46\ x4t + u1t$$

4.8.1.5 ***1st equation economic verification***

Parameter β12 is 0,076. If copper price increase by 1$, aluminum price would increase by 0,076 $.

Constant 628,74 means if every else variable were 0, aluminum price would be 628,74$.

Parameter y12 is 6,201. If aluminum average annual production increase by 1000 MT, aluminum price would increase by 6,201$.

Parameter y13 is 85,99. If world annual GDP growth increased by 1%, aluminum price would raise by 85,99$.

Parameter y14 is 1,46. If steel rebar average price raised by 1$, aluminum price would decrease increase by 1,46$.

Economic theory is confirmed by variables y13 and y 14.

4.8.1.6 ***Final model 2nd equation***

$$y2t = 2{,}12\ y1t + 65101{,}8 + 9{,}63\ x5t - 1{,}73\ x6t + 11{,}54\ x7t + u2t$$

4.8.1.7 ***2nd equation economic verification***

Parameter β21 is 2,12. If aluminum price increased by 1$, copper average price raised by 2,12$.

Constant 65101,8 means if every else variable were 0, copper average price would be 65101,8$.

Parameter y25 is 9,63. If world steel annual production increased by 1MT, the copper average price would raise by 9,63$.

Parameter y26 is -1,73. If world consumption of copper increased by 1%, the copper average price would decrease by 1,73$.

Parameter y27 is 11,54. If production of industry by total world index increased by 1 point, the copper price would increase by 11,54$.

Economic theory is confirmed by variables y 25 and y 27.

4.8.1.8 ***<u>Statistical verification</u>***

4.8.1.8.1 1st equation statistical verification

	β12	γ11	γ12	γ13	γ14
Sii	33280,54819	5,11668E+11	11108514903	7197751121	6836831,042
Sbi	182,4295705	715309,8375	105396,9397	84839,56106	2614,733455
t-value	0,000417573	0,000878976	5,88701E-05	0,00101342	0,000557057
t-tab. (α=0,05)	2,1788	2,1788	2,1788	2,1788	2,1788
N/V	N	V	N	N	N

Based on results of statistical verification it is clear, that the significance level α=0,05 has only the parameter γ_{11} for exogenous variable x_1.

4.8.1.8.2 2nd equation statistical verification

	β21	γ21	γ25	γ26	γ27
Sii	0,103690928	486159547,6	34,08282889	1,205415049	15,7224066
Sbi	0,322010757	22049,026	5,838050093	1,097913954	3,965149001
t-hodnota	6,596611929	-2,952593008	1,649725481	1,578229327	2,909222326
t-tab. (α=0,05)	2,1788	2,1788	2,1788	2,1788	2,1788
N/V	V	N	N	N	V

Parameter B21 and y27 are significantly verified.

4.8.1.9 ***Matrix B, Γ and matrix M***

Matrix B

1	2,12418
0,076177662	1

Matrix Γ

628,739947	6,20472397	85,97810217	1,456556309	0	0	0
-65101,8	0	0	0	9,63118	-1,73276	11,5355

4.8.1.10 ***Matrix M***

-165735,121	-7,40257	-102,577	-1,73775	24,40793	-4,39127	29,23398
77727,11412	0,563911	7,81404	0,132378	-11,4905	2,067276	-13,7625

4.8.1.11 ***Reduced form of the model:***

$$\mathbf{y_{1t} = -165735{,}12 - 7{,}402\, x_{2t} - 102{,}58\, x_{3t} - 1{,}74\, x_{4t} + 24{,}41\, x_{5t} - 4{,}39\, x_{6t} + 29{,}23\, x_{7t}}$$

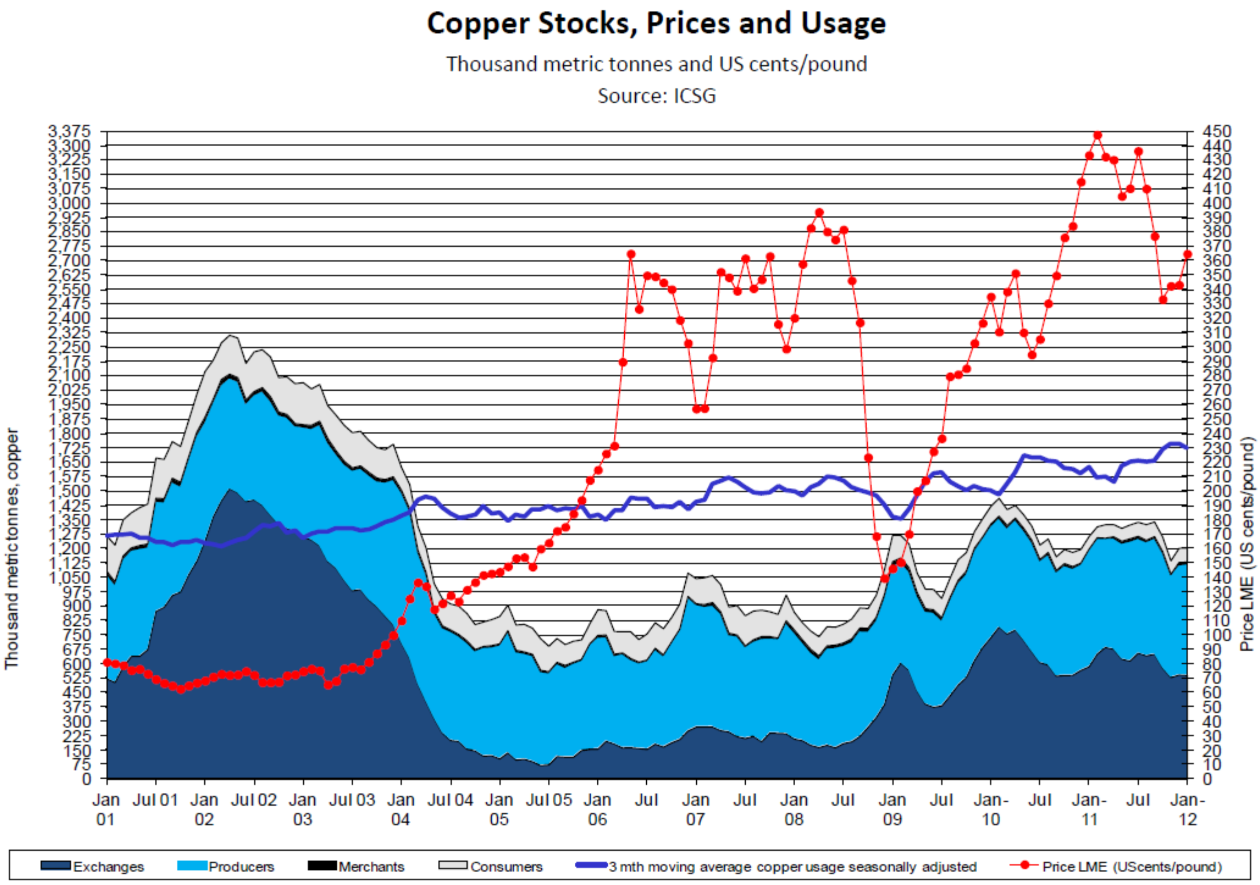
$$\mathbf{y_{2t} = 77727{,}11 + 0{,}56\, x_{2t} + 7{,}81\, x_{3t} + 0{,}13\, x_{4t} - 11{,}49\, x_{5t} + 2{,}06\, x_{6t} - 13{,}76\, x_{7t}}$$

Reduced form reflexes endogenous variables depending on predetermined variables, not on the others endogenous variables as in structured form. Reduced form show us how depends exogenous variables on the endogenous variables.

4.8.1.12 ***Econometric model conclusion***

The econometric model is significantly not verifying the real market situation because of the data verification. The variables were successfully and suitably. The econometric model of the industrial metals market is economically well defined, data are significant and process of the calculation was proven by the back control. To estimate market behavior is better to use fundamental or technical analysis, because of the possibility of using market rumors and news even the feelings or tradition of the market price movements. The weakest point of the econometric model is missing of the demand and supply cooperation on the market. This operation is not possibly employ into the model because there is no such as numerical explanation of the demand increasing by the consumers or producers of the industrial metals. Comparing the econometric model with the chart below consisting of the real market data is clear that copper price is not reacting as in the model. The line of the world copper production is not corresponding with the line of the copper price (LME commodity price). This was result from the 2nd equation of the model variable y26.

4.8.1.12.1 Copper price development LME



4.9 Unit root test

The spurious regression phenomenon in least squares occurs for a wide range of data generating processes, unit roots with drift, trend and trend stationarity. A real and important econometric task is determining the most appropriate form of the trend in the data. If the data are trending, than some trend removal is necessary. Unit root tests can be used to determine if trending data should be 1st differenced or regressed on the deterministic function.

Unit root test is well performed by the Dickey-Fuller test or Advanced Dickey-Fuller test also called as ADF test.

Dickey-fuller test:

Three different regressive equation to test unit root.

Dyt = gyt1 +et

Dyt = a0 +gyt1 +et

Dyt = a0 +gyt1 +a2t +et

From the equations by the ADF is tested null hypothesis – the model has a unit root. This is done by the comparing t-statistic to values from Dickey-Fuller table.

Advantage of the ADF is that it is easy estimated by the OLSM test, but disadvantage is that the ADF test is very week.

To test was chosen data from the World Bank data set commodity average values since 1962 to the present. Total amount of the observations is 609 for aluminum and 609 for copper. Result is summarized in the table below using MS Excel and ADF add-in, because of the econometric performance on the Phd. Level.

Null hypothesis = t-series has a unit root.

4.9.1.1.1 ADF test results

Null Hypothesis: tseries has a unit root
Exogenous: Constand and linear Trend
Lag Length: 5 (Automatic Based on AIC, MAXLAG=10)

			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-2,893420	0,165334
Test critical values:	1% level		-3,973210	
	5% level		-3,417270	
	10% level		-3,131004	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(tseries)
Method: Least Squares
Date: 27.3.2013 Time: 22:58:13
Included observations: 608 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob
tseries(-1)	-0,040289	0,013924	-2,893420	0,003949
D(tseries(-1))	-0,850382	0,040938	-20,772610	0,000000
D(tseries(-2))	0,470689	0,053182	8,850552	0,000000
D(tseries(-3))	0,324436	0,055408	5,855398	0,000000
D(tseries(-4))	-0,170683	0,054258	-3,145758	0,001739
D(tseries(-5))	-0,144104	0,040562	-3,552675	0,000411
C	31,543892	11,929127	2,644275	0,008401
@trend	0,057146	0,027610	2,069788	0,038900

R-squared	0,983003	Mean dependent var	1,722237
Adjusted R-squared	0,968130	S.D. dependent var	627,477791
S.E. of regression	82,282241	Akaike info criterion	11,671258
Sum squared resid	4062220,268861	Schwarz criterion	11,729287
Log likelihood	-3540,062499	F-statistic	4957,125270
Durbin-Watson stat	1,993088	Prob(F-statistic)	0,000000

4.9.1.2 ***ADF test results***

Test results from the industrial metal price observation since 1962 to the March 2013 are summarized in the data box above. By the result is null hypothesis confirmed and tseries in the model has a unit root – a unit root is an attribute of a statistical model of a time series whose autoregressive parameter is one. T-statistic is statistically verified by comparing calculated t value and table value on the 1, 5 and 10% level – parameters are statistically verified. Most important calculation is R^2 = 98,3% - the model is from 98,3% explaining the situation.

5 Conclusion

Economic analysis of industrial metals market using fundamental, technical and psychological analysis, explained many possible market price movements – predictable and unpredictable.

Fundamental analysis explained dependency on the supply and demand cooperation and how the market players reflect it. As a complete tool is not fundamental analysis scientific prove for the market price movements. Technical analysis in follow of the fundamental analysis is predicting future price movements, but based on the single trader opinions and feelings using support line of the bottom line of the price decrease. Key to the analysis is commodity chart, easily achievable on the internet. The evidence and 100% of sure on the future price movements it is not achieved from the analysis. Psychological analysis is based on the behavior of the market players and it is very highly unpredictable, but very common crowd panic behavior on the market.

Econometric model is well calculated, statistically verified and for not each variable economically verified. Result equation of the one equation model is $y_1 = -4{,}56 + 68{,}99x_2 + 29{,}64x_3 - 0{,}15x_4 - 0{,}16x_5 + 1{,}54x_6.$ Two equation model equations are $y1t = 0,076\ y2t + 628,74 + 6,201\ x2 + 85,99\ x3t + 1,46\ x4t + u1t$ and $y2t = 2,12\ y1t + 65101,8 + 9,63\ x5t - 1,73\ x6t + 11,54\ x7t + u2t$. Based on the very strong correlation matrix showing high dependency of the most of variables is clear the data and variables are correct, but in the methodology of the model is mistake.

The economic analysis of the industrial metals market results are combination of all of the analysis used and econometric model is not sufficient tool to estimate the market future prices. As a last tool is used advanced Dickey-Fuller test of the aluminum and copper monthly prices since 1962 to the present and it is base for the next econometric modeling on the higher or Phd level.

Combination of all of the results of each analysis is a good tool to predict future price of the industrial metals commodities, but there is not such a tool to precise prediction of future price only changing variables data or the model has to be consisting of complex and higher econometric models.

Final conclusion for the trader is to follow macroeconomic shocks and individuals participating in the commodity trading and reflect personal emotion into the technical analysis based on the econometric model – the data of all of the projects should be compared and the result would only show rise or decrease of the price.

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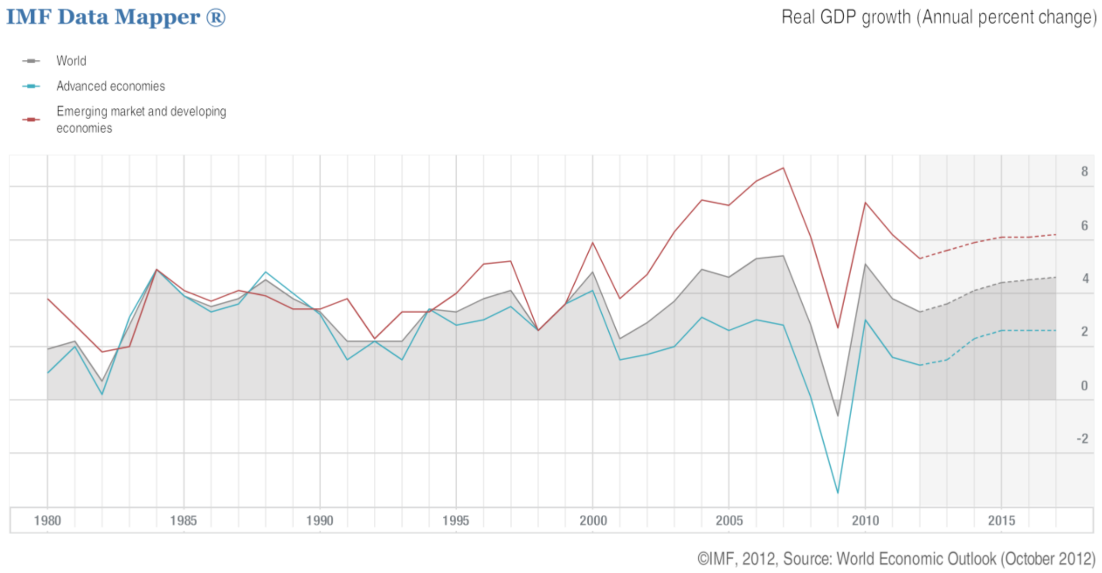
7 Attachments



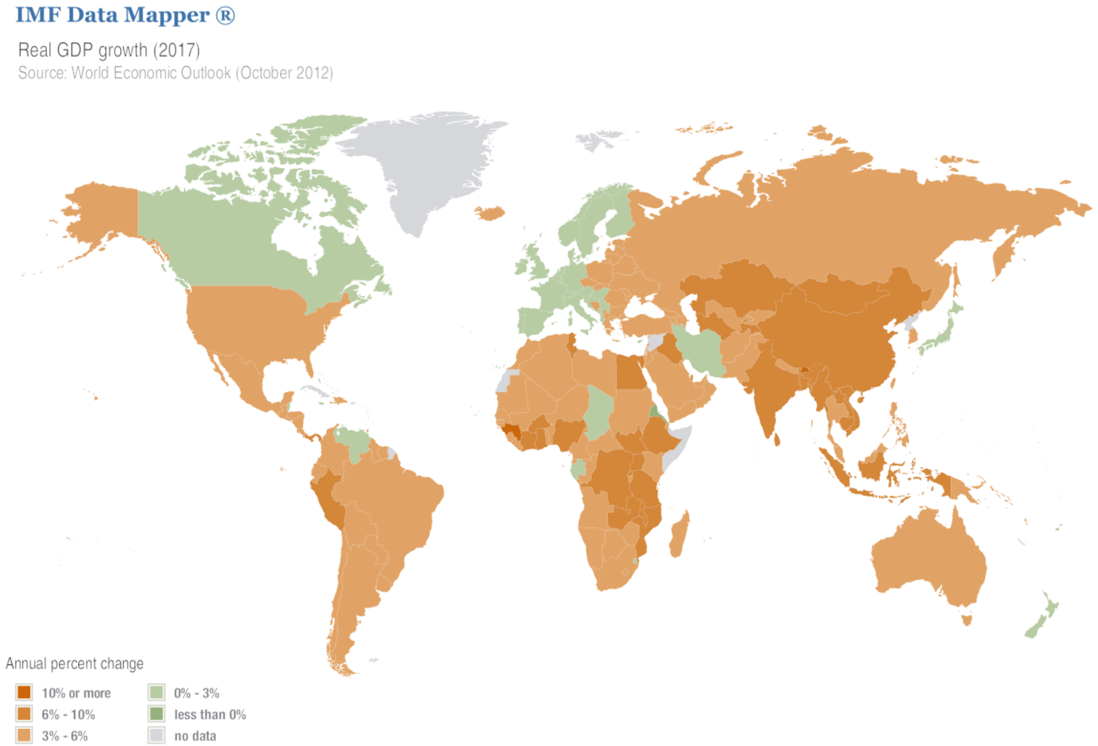


Figure 1 Market Demand Curve

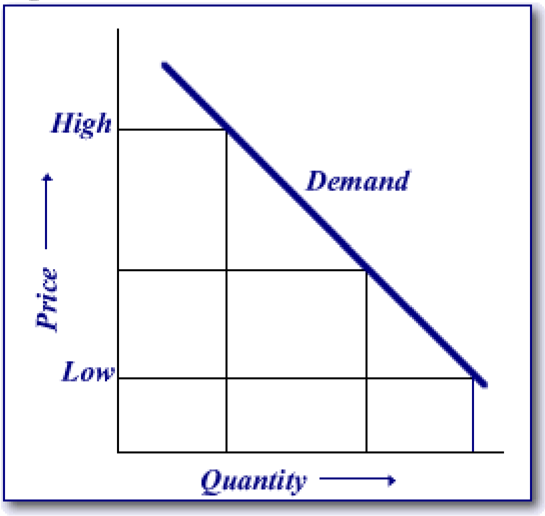


Figure 2 Market Supply Curve

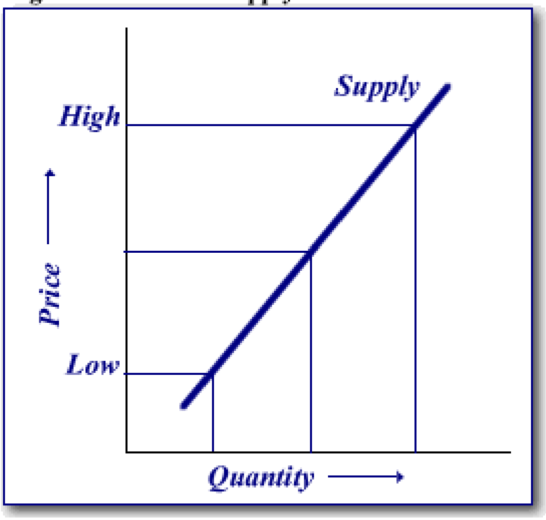


Figure 3 Equilibrium Price

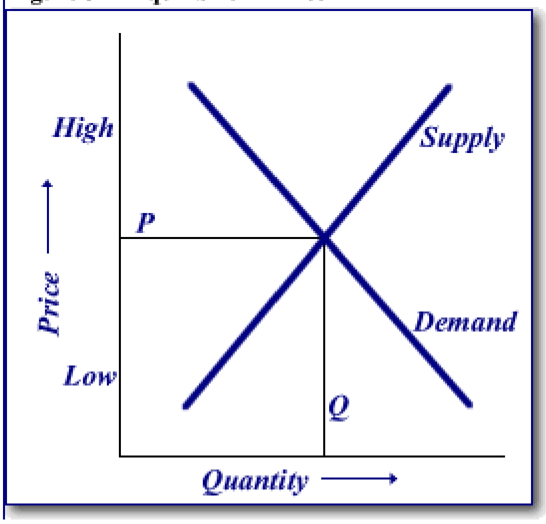
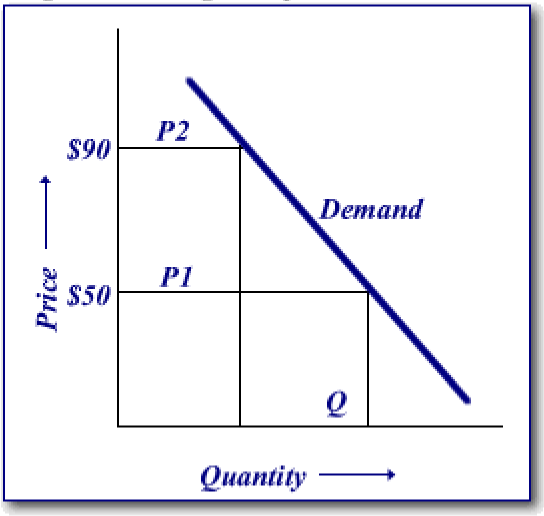


Figure 4 Change in Equilibrium Price



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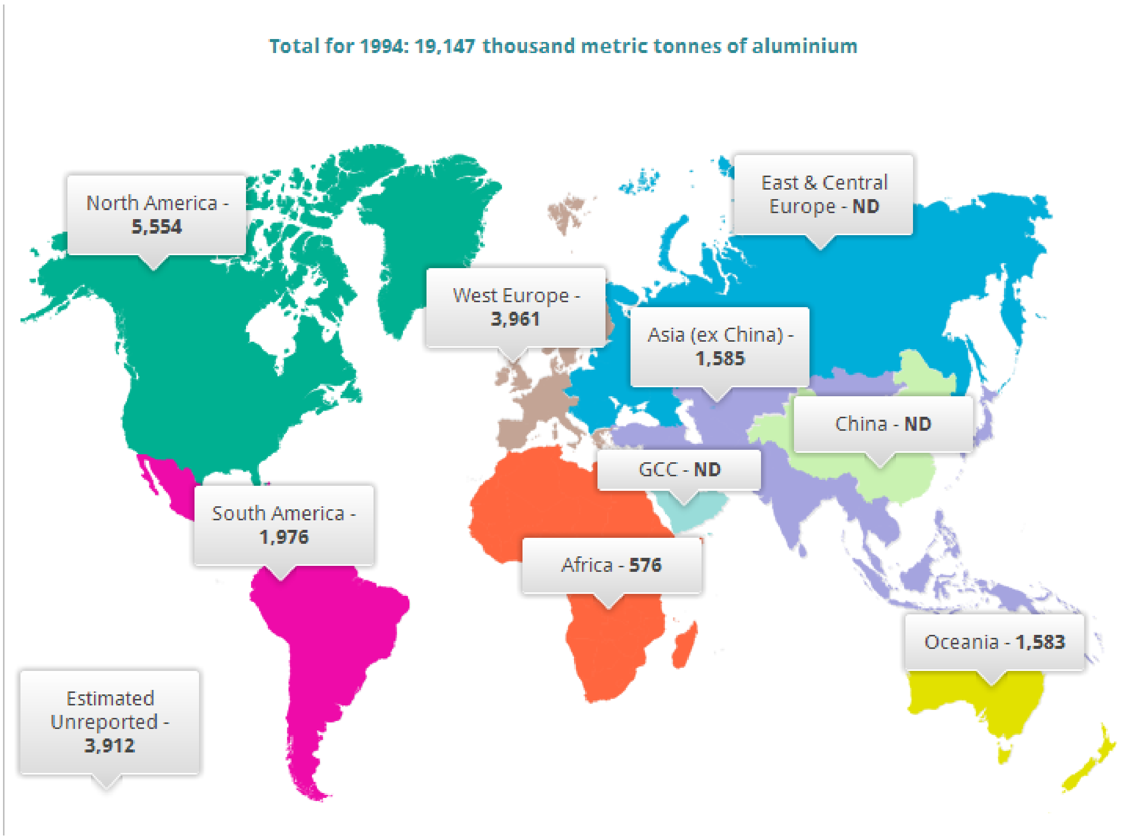

Source: world-aluminium.org