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Diploma Thesis

Analysis of the copper market and the direction of China's copper industry

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Analysis of the copper market and the direction of China's copper industry

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Objectives of thesis

Copper, as a widely used industrial metallic material, plays a decisive role in the national economy. As we know, China is the world's largest copper consumer and producer. The objectives of this thesis is to find the advantages and difficulties of Chinese copper industry through the analysis of situation of copper market for both global and domestic. Relative factors influenced the copper price will be given, methods to solve problems and how to promote the stable and long-term development of copper industry will be found out.

Methodology

The descriptive and comparative methods will be used frequently and time series analysis will be conducted for analyzing time series data in order to extract meaningful statistics and other characteristics of the data. In the demonstration section, how some important factors affect copper price volatility will also be given by the linear model.

The proposed extent of the thesis

60 – 80 pages

Keywords

Copper, copper industry chain, consumption, production, copper price, copper recycling, financialization, pricing power.

Recommended information sources

Derviş,K. Publisher: Center for Global Development, 2005. ISBN 0815717636

GALLANT, A R. *An introduction to econometric theory : measure-theoretic probability and statistics with applications to economics.* Princeton: Princeton University Press, 1997. ISBN 0-691-01645-3.

International Economics Theory & Policy NINTH EDITION Krugman,P.R.,Obstfeld,M.,Melitz,M.J. ISBN-13: 978-0-13-214665-4

Todaro,M.P., Smith,S.C.,Economic Development 12th Edition ISBN 10: 0-13-340678-4

W. T. Elwell I. R. Scholes: Analysis of Copper and Its Alloys 1st Edition. ISBN: 9781483149509

Yining, Li: Chinese Economy in Dual Transition 2013 ISBN: 9787300181400

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Declaration

I declare that I have worked on my diploma thesis titled "**Analysis of the copper market and the direction of China's copper industry**" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the diploma thesis, I declare that the thesis does not break copyrights of any their person.

In Prague on 27th, Mar.2019 _____

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Analysis of the copper market and the direction of China's copper industry

Abstract

As an important strategic raw material, copper plays a vital role in the world economy. This paper analyzes the distribution, production and consumption of international copper resources from different stages of the copper industry chain. It highlights the status, advantages and disadvantages of China's copper industry in the international market and its development direction.

In the empirical research section, this paper selects 6 variables including the global crude oil price, global gold price, U.S. IPI, China's GDP, global copper consumption and Shanghai futures copper price to quantitatively analyze the dominant factors affecting global copper price through the linear regression model. Considering the correlation between the variables, two econometric modelings were established and tested separately.

The study found that there is a highly close relationship between Shanghai copper futures price and global LME copper price, P-value reach 0.0000134, Shanghai copper futures price can be said to impact or even dominate the trend of global copper price. Followed by global crude oil price and U.S. IPI also contributed to the fluctuation of global copper price. The global gold price plays a controversial role in the copper price changes, the main reason roots in its investment attributes. In addition, the superiority of the China's copper industry and its existing problems were discovered through Porter's Five-Force Analysis method to help it enhance its core competitiveness in international competitions.

Keywords: copper, copper industry chain, copper supply, copper consumption, copper price, financialization, pricing power.

Analýza trhu s mědí a směrování čínského průmyslu výroby mědi

Abstrakt

Jako důležitá strategická surovina hraje měď zásadní roli ve světové ekonomice. Tato práce analyzuje distribuci, výrobu a spotřebu mezinárodních zdrojů mědi v různých fázích řetězce průmyslu výroby mědi. Zdůrazňuje stav, výhody a nevýhody čínské výroby mědi na mezinárodním trhu a její směřování.

V empirické výzkumné sekci této práce je vybráno 6 proměnných, včetně globální ceny ropy, světové ceny zlata, indexu průmyslové výroby USA (IPI), čínského HDP, globální spotřeby mědi a cen futures v Šanghaji za účelem kvantitativní analýzy dominantních faktorů ovlivňujících světovou cenu mědi prostřednictvím lineárního regresního modelu. S ohledem na korelaci mezi proměnnými byly stanoveny a testovány dva ekonometrické modely.

Autorka zjistila, že existuje velmi úzký vztah mezi Šanghajskými cenami futures pro měď a globální cenou mědi LME, p-hodnota dosáhla čísla 0,0000134. Je možno konstatovat, že tato proměnná má největší dopad a dokonce dominuje ve vztahu ke globální ceně mědi. K celosvětové změně ceny mědi přispívají také ceny ropy a IPI v USA. Celosvětová cena zlata hraje kontroverzní roli ve změnách cen mědi, hlavním důvodem jsou investiční možnosti zlata. Kromě jiného byly výhody čínského průmyslu výroby mědi a jeho stávající problémy podrobeny Porterově analýze pěti sil, která pomohla identifikovat konkurenceschopnost tohoto odvětví v mezinárodní konkurenci.

Klíčová slova: měď, řetězec průmyslu mědi, dodávky mědi, spotřeba mědi, cena mědi, financování, cenová síla.

Table of Content

List of Figures

List of Tables

1. Introduction

Copper is a very important industrial raw material, a valuable non-ferrous metal and an extremely important strategic substance. In recent years, with the advancement of China's industrialization process, China copper demand is increasing rapidly, and China has surpassed the United States to become the world's largest copper consumer. However, China is also a country with extremely scarce copper resources. Copper mines are highly dependent on overseas. The large fluctuation in copper price have had a huge impact on China's related industries, and the lack of pricing power has seriously affected China's economic and trade stability. In order to get rid of the plight of China's copper industry, it is especially important to understand the distribution of global copper resources, the status of global copper production and consumption, and the position of Chinese copper companies in the international arena. How can Chinese copper companies get out of this dilemma and seek development? Is the traditional supply and demand theory a perfect interpretation of the current international copper industry? How are the commodities such as gold and oil related to copper? As the world's No. 1 power, whether the U.S. domestic industrial production performance affects the price of copper? China as the emerging biggest copper importer and consumer, whether the Chinese factors can dominate the trend of copper? All of these controversial issues will be explained in this article.

2. Objectives and Methodology

2.1 Objectives

The objectives of this thesis are to find the advantages and difficulties of Chinese copper industry through the analysis of situation of copper market for both global and domestic, methods to solve problems and how to promote the stable and long-term development of copper industry will be found out. Furthermore, to use statistical and econometric methods to investigate a relationship between global copper price and selected macroeconomic indicators within the period 2002 – 2016. On the basis of the regression analysis, the aim will be to determine the impact of the chosen variables on global copper price.

2.2 Methodology

In order to analyze this subject as thoroughly as possible, the thesis will be divided into two part: theoretical and practical part. The methodology in theoretical part mainly includes three types, namely the literature analysis method, the consumption trend method and the industry demand method. This thesis will start from providing literature review and theoretical information on copper and its utilization. Based on historical data research, the cyclical changes in global copper production and consumption will be found out. Finally, by analyzing the pricing mechanism of copper, recommendations for obtaining pricing power will be discovered. For this purpose, secondary data from books, statistical communique, reports, official papers, publications, and other materials relevant to the topic are necessary to be adopted.

After that, in practical part, two analysis methods will be applied. First is the linear regression analysis methods, global copper price and selected indicators from 2002 to 2016 will be collected and presented in the form of charts and tables, all data will be tested to determine the dependence and validity of the variable relationships by using linear regression analysis in Gretl software. The results obtained will be verified using economic, econometric and statistics verification. The second method is the Porter Five Forces

analysis model, it is used to identify the competitiveness of China's copper industry environment which is helpful for choosing the appropriate strategy.

2.2.1 Econometric Modelling

Econometrics is a discipline that studies the changing laws of various economic variables in a quantitative way. It uses data to test existing assumptions in economics and predict future trends.[1] Econometrics starts with a series of propositions about certain aspects of the economy. Linear regression models are the simplest and most commonly used tool in econometrics. Linear regression models are used to study the relationship between dependent variables and one or more independent variables[2] It evaluates whether the independent variables explain the dependent variable.[3] The following are the main assumptions of the regression model, and violating any of them will make the model unreliable.

- Linear relationship
- Multivariate normality
- No or little multicollinearity

2.2.1.1 Economic Model

In most cases, econometric analysis begins from an economic model which follows the rules of deductive logic.[4] First, it is necessary to formulate theoretical assumptions and relationships between economic indicators. Then, propose an economic model corresponding to the set hypothesis. In addition, it is also important to focus on the accurate selection and classification of variables, including the consistency of variable units. There are three steps to formulate an economic model:

[1] Investopedia [online]:"Econometrics Definition" 2019. WWW: <https://www.investopedia.com/terms/e/econometrics.asp>
[2] Greene, William: "Econometric Analysis" 2003. p. 7. ISBN: 0-13-066189-9
[3] Statistics Solutions [online]: "Assumptions of Linear Regression" 2017. WWW: <http://www.statisticssolutions.com/assumptions-of-linear-regression>
[4] Lumen Learning [online]: "Economic Models" 2009. WWW: <https://courses.lumenlearning.com/boundlesseconomics/chapter/economic-models>

- Clarify subject
- Select appropriate variables
- Determine functional form

The economic model can be mathematically written as follows:

$Y = f(X_{1t}, X_{2t}, X_{3t}, X_{4t}, X_{5t}) + U$

Where:

Y = Explained variable

X_{1t-5t} = Explanatory variables

U = Random variable

The economic model need to meet the assumptions that there is no simultaneous relationship between the explained and explanatory variables, or between the explanatory variables.

2.2.1.2 Econometric Model

In order to confirm that the assumptions are consistent with reality, the establishment of an econometric model is important, which is different from economic model:

- Contains stochastic variable
- Contains parameters
- Specific functional form

The development of the econometric model mainly includes the following steps:

- Identify the required variables and classify them
- Make reasonable assumptions about the expected value of the estimated parameters
- Select the mathematical shape of the model

The econometric model can be mathematically written as follows:

$Y_t = \gamma_1 X_{1t} + \gamma_2 X_{2t} + \gamma_3 X_{3t} + \gamma_4 X_{4t} + \gamma_5 X_{5t} + U_t$

Where:

Y_t = Endogenous variable at time t

γ_{1-5} = Parameters of exogenous variables

X_{1t-5t} = Exogenous variables at time t

Ut = Stochastic variable

The endogenous variables are those whose values can be determined or affected by other variables in the system and is generally labelled Yt, whereas the exogenous variables are independent of all other variables in the system, and changes in other variables do not affect the variable, and are labelled Xt.[5] The stochastic variable, also known as random variable which is labelled Ut, is part of a stochastic model equation.[6]

2.2.1.3 Estimation of Parameters

Among several methods for estimating the parameters of the econometric model, the most common method is the ordinary least squares (OLS), which is also the default method for fitting linear models. The biggest advantage of it compared to other methods is that it has no problem when dealing with small sample observations.[7]

2.2.2 Porter Five Forces Analysis

The Porter Five Forces Analysis model combines numbers of different factors into a simple model to analyze the underlying competition in an industry. Any industry will be subject to the competition of these five aspects, that is bargaining power of suppliers, bargaining power of buyers, threat of new entrants,threat of substitutes and rivalry among existing competitors. This is an effective indicator to measure the industrial situation.[8]

[5] Statistics How to [online]: "Endogenous Variable and Exogenous Variable: Definition and Classifying" 2014. WWW: <https://www.statisticshowto.datasciencecentral.com/endogenous-variable/>

[6] Vance, Martin: "Econometric Modelling with Time Series - Specification, Estimation and Testing" 2012. p. 161. ISBN: 978-0521139816

[7] Encyclopedia.com[online]: "Ordinary Least Squares Regression" 2008. WWW: <https://www.encyclopedia.com/social-sciences/applied-and-social-sciences-magazines/ordinary-least-squares-regression>

[8] Investopedia: [online]: "Porter's 5 Forces" 2019. WWW: <https://www.investopedia.com/terms/p/porter.asp>

3. Theoretical part (Literature search)

3.1 Copper characteristics

Copper was the first metal used by mankind. The content of copper in the earth's crust is about 0.01%, ranking 26th in all elemental content, 18th in non-ferrous metal, and 6th among 10 common non-ferrous metals. It has the advantages of good ductility, thermal conductivity and high electrical conductivity.[9] Therefore copper has been widely used in electricity, transportation, machinery manufacturing, construction industry, national defense military and other fields.

Due to the good physical and chemical properties of copper metal, copper has a unique property that distinguishes it from other metals and has wide applicability.

- High thermal conductivity and electrical conductivity
- Strong chemical stability and strong corrosion resistance.
- High tensile strength, easy to weld, good plasticity and ductility.
- Recyclability. The products made of copper can be recycled multiple times without compromising its mechanical properties.

3.2 Copper industry chain analysis

3.2.1 What is copper industry chain

According to the relationship between raw materials, production and products, the copper industry chain can consist of three stages.

The first stage belongs to the upstream of the industrial chain, that is, the supply side, and can be divided into the stage of mining and smelting. Copper smelting methods mainly include copper pyrometallurgy and copper hydrometallurgy. The pyrometallurgical process is used to treat copper sulphide ore and high grade oxidized ore, of which 80% to 85% of

[9] T. Elwell I. R. Scholes: “Analysis of Copper and Its Alloys” 1967. p.14. ISBN: 9781483149509

copper is produced. The hydrometallurgy process is utilized to treat oxidized ore, waste ore, etc., which are difficult to be enriched in mineral processing, of which 15-20% of copper is produced by this method. Regardless of the process, the final product is electrolytic copper (99.95~99.98%), also called cathode copper, which is sold to its downstream copper processing enterprises. Therefore, products of copper smelting enterprises are mainly cathode copper.[10]

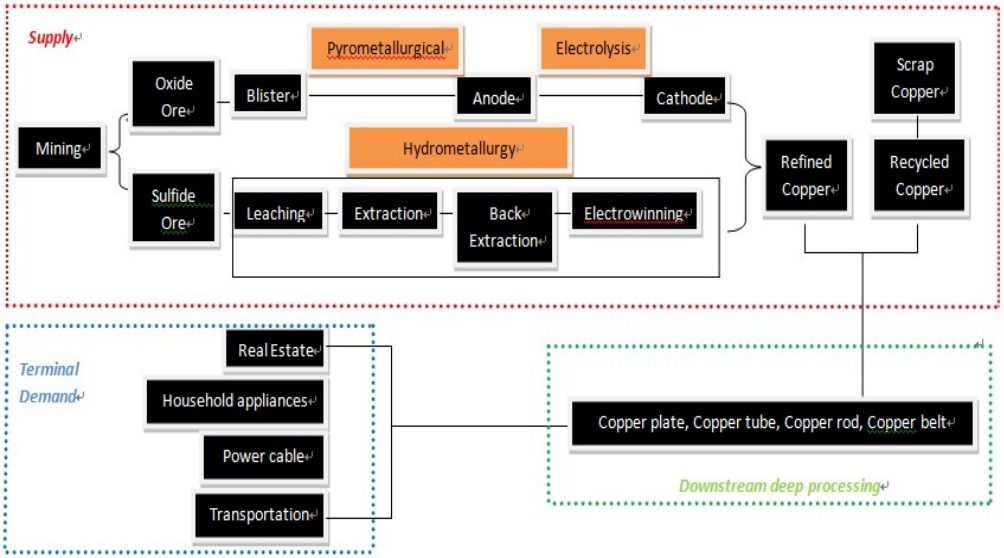
The second stage belongs to the middle of the industrial chain, that is, the copper processing section. The professional technology mainly includes copper calendering processing. The enterprise types are mainly metal processing enterprises, such as Codelco (Chile), BHP Billiton (Australia) and Zhejiang Hailiang Group (China). The copper processing enterprises, which use cathode copper or reclaimed copper as raw materials, and have been refined to obtain different types of copper products required by end users such as electricity, machinery, construction, and defense. Therefore, the products are mainly various types of copper materials with application value required by the application market.

The third stage belongs to the downstream of the industrial chain, that is, demand consumer terminals. The types of enterprises are mainly users of diverse industries, such as air conditioning and refrigeration (Carrier), electronic products(Apple), and shipbuilding industry(CSIC) etc..[11] The structure of these three stages of the copper industry chain is illustrated in Figure 1

[10] Asia Metal [online]:"Copper: smelting and classification" 2016. WWW: <http://metalpedia.asianmetal.com/metal/copper/extraction.shtml>

[11] IISD.ORG [online]:"Sustainable Development and the Global Copper Supply Chain: International research team report"2011. WWW. <https://www.iisd.org/sites/default/files/publications/sus_dev_chinese_copper.pdf>

Figure 1 Copper Industry Chain



Source: Own elaboration based on data from Aurubis

3.2.2 Copper industry chain analysis

3.2.2.1 Upstream: copper mining and smelting

In the upstream section, the supplier is the mine and the demand side is the refinery. In terms of mining section in the upstream section,there are 1,637 copper mine projects with global resources and reserves of more than 10,000 tons, the total metal volume is about 2.71 billion tons. Among them, there are only 24 copper mines with copper resources and reserves of more than 20 million tons, accounting for less than 1.5% of the total global projects, but their copper resources and reserves account for about 40% of the world total. Depending on ICSG data[12], copper mining quantity in Latin America soared from less than 750,000 tons in 1960 to 8.4 million tons in 2017, accounting for 42% of global production. At the same time, Asia has seen significant growth, from 6% to 17%. In contrast, North America's share fell from 36% to 13%. Among these changes, the most abrupt increase is Latin America, and Chile as an important global player in the production of metal minerals. In 2017, this country was the world's largest copper producer, accounting for 29.9% of global production.

[12] ICSG [online]: "The world copper factbook 2018" 2019. WWW: <https://www.icsg.org/index.php/component/jdownloads/finish/170/2876>

Copper mine reserves are abundant and distributed unevenly among countries, but relatively concentrated, generally distributed in the Americas, Central Africa and northern Asia. By country, copper resources are highly concentrated in more than 10 countries. According to the Statista data, by 2017, the heavy hitters are Chile, Australia, Peru, Mexico and the US.[13] Chile has the largest copper reserves of any country by far, with 170 million tons as of 2017, accounting for 23.4% of the world's proven reserves. It is the world's richest copper resource and has the world's number one large copper mine - the Chuquikamata mine (reserves 69.35 million tons) and the world's second largest copper mine - the Elt Niente mine (reserves about 67.76 million tons), is known as the "kingdom of copper". Chile is also the world's largest copper producer, having produced some 5.3 million tons of copper from mines in 2017. Followed by Australia, whose copper reserves reach 88,000 million tons and the third country is Peru whose copper reserves are 81,000 million tons. Total these three countries, make up almost half of the global reserves which have a significant impact on global copper supply and price movements.

The world copper mine output is placed on the rise annually, global sales for copper ore exports by country totaled US$45.3 billion in 2016 and increased almost 28% to reach US$58.2 billion in 2017, which shows the rapid supply current in copper raw material. Over half of worldwide copper ore exports came from Latin America.[14] Chile maintained the largest producer and exporter of copper mine production in the world in the past several years, far more than the other countries. Chile's copper mining production is mainly for export, account for 85% of its total output. Asian countries are the main importers for the copper ores, account for more than 75% of global imports, of which China accounts for 45%, followed by Japan with 19%.[15] The world's top five countries' imports account for 80% of the world's imports, so the concentration is obvious. From the current point of view, there will be no major changes in the supply and demand pattern of copper ore in the future. In the next few years, countries such as Chile and Peru will remain the world's major

[13] Statista [online]: "Global copper reserves as of 2017, by country" 2018. WWW: <https://www.statista.com/statistics/273637/copper-reserves-by-country/>

[14] Statista [online]: "Total copper mine production worldwide from 2006 to 2017" 2018. WWW: <https://www.statista.com/statistics/254839/copper-production-by-country/>

[15] OEC [online]: "Copper ores and concentrates" 2018. WWW: <https://atlas.media.mit.edu/en/profile/hs92/260300/>

copper ores exporters, and their supply capacity will continue to increase. China, Japan and India, these Asian countries are still the main importers of copper ore, especially with current of maintaining rapid growth of the developing countries such as China and India, their demand for copper will increase prominently.

With regard to the possession of global copper resources, they are being monopolized by large multinational companies. From Figure 2, we can find that among the biggest copper mines all over the world, Chile occupies an absolute share and is in a monopoly position in copper mining, seven of the top 20 are owned by Chile. The top 10 mining giants monopolize more than 60% of copper resources worldwide. With the large-scale mergers and acquisitions of international mining giants in recent years, a large part of resources have gradually been in the hands of large international mining companies. Among these top 20 copper mine owners, except Chile's Codelco is a domestic company, the other are basically large international mining companies, such as BHP Billiton, Group Mexico, Anglo American, Freeport-McMoRan, Rio Tinto.[16]

Figure 2 Top 20 copper mines by capacity 2018

Top 20 Copper Mines by Capacity (basis 2018)

Thousand metric tonnes copper

Source: ICSG Directory of Copper Mines and Plants – H1 2018 Edition

Rank	Mine	Country	Owner(s)	Source	Capacity
1	Escondida	Chile	BHP Billiton (57.5%), Rio Tinto Corp. (30%), Japan Escondida (12.5%)	Concs & SX-EW	1,370
2	Grasberg	Indonesia	P.T. Freeport Indonesia Co. (PT-FI), Rio Tinto	Concentrates	700
3	Morenci	United States	Freeport-McMoRan Inc 72%, 28% affiliates of Sumitomo Corporation	Concs & SX-EW	520
4	Buenavista del Cobre (former Cananea)	Mexico	Grupo Mexico	Concs & SX-EW	510
5	Collahuasi	Chile	Anglo American (44%), Glencore plc (44%), Mitsui (8.4%), JX Holdings (3.6%)	Concs & SX-EW	504
6	Cerro Verde II (Sulphide)	Peru	Freeport-McMoRan Copper & Gold Inc. 54%, Compañia de Minas Buenaventura 19.58%, Sumitomo 21%	Concentrates	500
7	Polar Division (Norilsk/ Talnakh Mills)	Russia	Norilsk Nickel	Concentrates	450
7	Antamina	Peru	BHP Billiton (33.75%), Teck (22.5%), Glencore plc (33.75%), Mitsubishi Corp. (10%)	Concentrates	450
9	Las Bambas	Peru	MMG (62.5%), Guoxin International Investment Corporation Limited (22.5%), CITIC Metal Co., Ltd. (15%)	Concentrates	430
10	El Teniente	Chile	Codelco	Concs & SX-EW	422
11	Los Bronces	Chile	Anglo American 50.1%, Mitsubishi Corp. 20.4%, Codelco 20%, Mitsui 9.5%	Concs & SX-EW	405
12	Los Pelambres	Chile	Antofagasta Plc (60%), Nippon Mining (25%), Mitsubishi Materials (15%)	Concentrates	370
13	Kansanshi	Zambia	First Quantum Minerals Ltd (80%), ZCCM (20%)	Concs & SX-EW	340
14	Chuquicamata	Chile	Codelco	Concs & SX-EW	330
15	Kamoto	Congo	Katanga Mining Ltd (86.33% Glencore plc) 75%, Gecamines 25%	SX-EW	300
16	Radomiro Tomic	Chile	Codelco	Concs & SX-EW	290
17	Bingham Canyon	United States	Kennecott	Concentrates	280
18	Sentinel	Zambia	First Quantum Minerals Ltd	Concentrates	250
18	Toromocho	Peru	Chinalco	Concentrates	250
20	Olympic Dam	Australia	BHP Billiton	Concs & SX-EW	225

Source: ICSG

In terms of smelting section, world copper smelter production rose by 30% from 17.9

[16] ICSG [online]: "The world copper factbook 2018" 2019. WWW: <https://www.icsg.org/index.php/component/jdownloads/finish/170/2876>

million tons in 2007 to the highest quantity almost 23.5 million tons in 2017.[17]

Matching Asia's position as the world's largest copper ore importing region, Asia is also the world's largest producer of refined copper. More than half of the refined copper are produced in Asia, with China leading the way in refined copper capacity. In 2017, China accounted for 38% of world copper refined production, followed by Chile (10%), Japan (6%) and the United States (5%).[18] With the strictness of environmental protection policies and the increase in production costs, small copper smelters with high cost and backward technology will be shut down, large and medium-sized smelters will further expand production scale and reduce costs. Through technology upgrades, further improving the utilization rate of raw materials and maximizing the recovery of valuable elements in waste slag, waste water and waste gas during the smelting process will be the most important means of reducing costs.

Considering the non-renewability of copper resources and environmental protection issues, scrap copper seems to play an increasingly important role in the supply of copper. Generally, scrap copper can be divided into two categories: one is the mechanical processing materials generated in the production process are collectively referred to as new scrap copper. The other one is the copper in discarded transformers, motors, wires and cables, copper pipes, etc. which can't be used anymore. These scrap copper in the equipment are collectively referred to as old scrap copper. At present, the global scrap copper raw materials account for about 35% of the total copper consumption. There are many methods for reclaiming and utilizing scrap copper, mainly are the direct utilization and indirect utilization. Direct use is to direct smelt high-quality scrap copper into refined copper. Indirect use is to remove other metals in scrap copper by special smelting process, then cast it into the anode copper plate, finally get the cathode copper through electrolyzation. According to ICSG data, reclaimed copper produced by scrap copper in the world accounts for 15% of the proportion of refined copper. In the future, the global

[17] ICSG [online]: "Copper: Preliminary Data for 1st Half 2018"2018. WWW: <https://www.icsg.org/index.php/component/jdownloads/finish/114/2869?Itemid>

[18] Statista [online]: "Distribution of refined copper production worldwide in 2017"2018. WWW: <https://www.statista.com/statistics/605555/distribution-of-global-refined-copper-production-by-select-country/>

reclaiming rate of scrap copper will gradually increase, and the influence of the supply of global copper raw materials will also increase.

3.2.2.2 Midstream: copper processing industry

The midstream of the copper industry chain, namely the deep processing section. The product range is complex and the model specifications are different. According to the type of alloy, its product type can be separated into copper, brass, bronze etc.. According to the shape of the product, it is separated into copper ingot, plate, belt, foil, tube, rod, wire and so on. In terms of world copper processing output, copper wire account for the largest proportion to reach around 50%, and plates occupy the second place with an average of 20%, followed by pipes and bars.

Since 2003, China has been the world's largest producer and consumer of copper processing materials. In 2017, copper production reached 17.225 million tons, accounting for 67% of the world. As the copper processing industry with the largest consumption of refined copper, how to save copper consumption, look for copper substitutes, and take full advantage of reclaimed copper material to directly produce copper products have become the huge challenges for China's copper processing industry. China's copper processing industry now is facing fierce market competition. One reason is serious overcapacity of domestic production, the other reason is the technical issue, while Germany and Japan are major exporters to China.

3.2.2.3 Downstream: consumer terminals, China is the largest copper consumer

Downstream of the industrial chain is mainly refer to copper end users. Globally, equipment manufacturing used the highest proportion, accounting for about 31% of the total, followed by the building construction industry and infrastructure, separately accounting for 28% and 16%.[19]

From the perspective of the different industrial divisions and technological strengths, the

[19] Agri-Pulse [online]: "the world copper factbook 2017" 2018.
WWW: <https://www.icsg.org/index.php/component/jdownloads/finish/170/2462>

proportion of copper demand in different fields varies from country to country. If we compare China and the United States as examples of developed and developing copper consumption, we can find: In China, the main consumer terminals of copper are electricity (46%), household appliances(15%), transportation,(11%) construction(9%) and electronics(9%). The United States has a slight difference. The building construction industry accounts for almost half of the copper quantity to 43%, followed by the use of electronics and transportation equipment, both accounts for 19%.[20] This is determined by the separate stages and priorities of economic development. In the long run, with the gradual improvement of China's infrastructure construction and the improvement of people's living standards, the consumption structure of the copper industry will tend to be similar with developed countries. The trend is the demand for copper in the construction industry will increase, while in the power industry will gradually decrease. From the perspective of changes in the amount of consumption, the use of refined copper shows a significant polarization. Asia is an area with a significant increase in the use of refined copper, while other developed countries are in a downward trend. In the past 10 years, China has undoubtedly been the largest consumer, reaching 11.8 million tons, while the traditional consumer countries, the United States and Japan, have experienced varying degrees of decline. But China and the United States remain the dominant regions that dominate copper consumption. On the contrary, world consumption excluding China has decreased by 10%, mainly because the development of developed countries tends to be stable, and the use of refined copper is significantly reduced, with the more prominent regions being the EU (-20%). Japan (-22%) and the United States (-15%).[21]

3.3 Copper supply and demand analysis

3.3.1 Refined copper pricing model

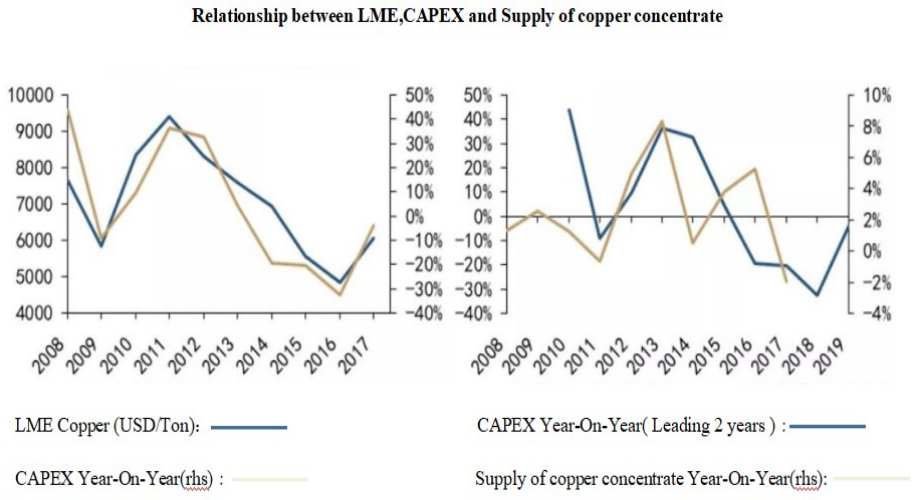
There are three major copper exchanges around the world, the London Metal Exchange

[20] Geology.com [online]: "Facts About Copper" 2018. WWW: <https://geology.com/usgs/uses-of-copper/>
[21] Atlantis Press [online]: "Study on Copper Consumption in China and Abroad" 2016. WWW: <file:///C:/Users/asus/Downloads/25861271%20(1).pdf>

(LME), the Chicago Mercantile Exchange (COMEX) and the Shanghai Futures Exchange (SHFE). The copper price of the three major exchanges is the basis of spot pricing, and the pricing method is "Spot price = futures price + premium discount". Since the price of refined copper is equal to the price of copper concentrate plus comprehensive processing fee, the pricing basis for futures prices is essentially determined by copper concentrate. In the upstream segment, the miner sell the copper concentrate to the smelter, the comprehensive processing fee is the cost that the miner pays to the smelter to process the copper concentrate into refined copper. It is represented by TC/RC (Treatment Charge and Refining Charge) and is divided into two parts: roughing fee and refining fee. The current practice is that after the copper concentrate is processed, the miner and the smelter negotiate the TC/RC fee in advance, and then deduct the TC/RC fee from the price determined based on the LME benchmark price, which is the selling price of copper concentrate. The TC/RC determines the refinery's revenue. If the TC/RC goes higher, it will stimulate the refinery to increase production, while the refinery will reduce production. An important factor in determining the level of TC/RC is the supply and demand relationship of copper concentrate. In general, when copper concentrates are in short supply, the miners take the initiative in negotiations with smelters, and the TC/RC they pay will fall. Conversely, when copper concentrates are abundant, TC/RC will rise. In other words, TC/RC has a positive relationship with the supply of copper concentrate. Because of this, the change in TC/RC can generally be referred to as the barometer of copper concentrate supply and demand. The growth rate of capital expenditure (CAPEX) of mining enterprises is consistent with the price of copper, that is, mining companies will only increase CAPEX when copper prices rise. The release of copper mine capacity lags behind the increase in CAPEX. Historically, copper production capacity has lagged behind CAPEX for about 2 years.[22] See Figure 3

[22] DBS Group Research[online]:"Copper And Its Electrifying Future" 2018. WWW: <file:///C:/Users/asus/Downloads/181004_insights_copper_and_its_electrifying_future.pdf>

Figure 3 Relationship between LME,CAPEX and Supply of copper concentrate



Source:DBS Group Research

3.3.2 The core elements of refined copper supply and demand analyses

Overall, global copper supply continues to be excessive. Depending on the WBMS report, the global copper market has a surplus of 81,000 tons from January to October 2018, and the global supply surplus in 2017 was 117,200 tons.[23] The bottleneck in the supply of refined copper is copper concentrate production rather than refining capacity. From the perspective of the production cycle, copper mines take about five to seven years or more from exploration to mine, and the refinery construction takes only about two years. If the copper price is low for a long time, the mining company will shut down the mine and reduce or stop the exploration and development of the new mine. After the lack of investment in long-term investment, if the demand suddenly increases, the refinery capacity can be increased in a short period of time, but the bottleneck of the production capacity of the mine will lead to tight supply of copper concentrate, which in turn will drive up the price of copper. On the contrary, after the copper price continues to increase, the mining enterprises will increase the utilization rate of existing mines and increase the exploration and development of new mines. During copper mine production release period,

[23] World Bureau of Metal Statistics[online]:"News and announcements" 2018. WWW: <http://www.world-bureau.com/readnews.asp?id=63>

if the demand declines, the mines and refineries will not stop production immediately. The copper concentrate and refined copper surplus will cause the copper price to enter a prolonged bear market and enter a new round of production capacity. Therefore, the core of supply and demand analysis of refined copper lies in the contradiction among mine production cycle, refining capacity and terminal demand.

3.3.3 Refined copper supply status

In terms of the supply of copper mines in upstream of copper industry chain，the number of factors affecting copper supply has increased significantly in 2017. First, the world's largest Escondida copper mine strikes for 44 days, and the output is reduced by about 200,000 tons, followed by the ban on copper concentrate exports in Indonesia will reduce the production of Grasberg, the world's second largest copper mine, by approximately 31,800 tons per month, all of those affected the global supply of copper to varying degrees. In addition, global copper investment has dropped significantly since it was capped in 2013. Chile has seen the fastest decline in investment, from nearly $9 billion in 2013 to $5.5 billion in 2015, and only $3.5 billion in 2016, this result in declining of copper mine production. Peru, Congo and other fruit investment have declined too.[24] From the perspective of copper mine expansion and new mine investment, from 2017 to 2020, among the world's top ten copper ore companies, only Glencore increase the supply of copper in 2018, but the total amount is only 200,000 tons, while other miners have no production increase projects, so the overall outlook for the production of the top ten copper concentrate enterprises is declining. Despite this, the copper supply has not yet experienced a shortage as expected in the previous market, and continues to maintain an excess status.

3.3.4 Refined copper demand status and its forecast

From the perspective of refined copper demand in various regions of the world, China is a leading consumer, making up nearly 50% of global demand, therefore, we first start with

[24] Statista [online]: "Major countries in copper mine production worldwide from 2010 to 2018"2019. WWW: <https://www.statista.com/statistics/264626/copper-production-by-country/>

the analysis of copper demand in China.[25]

3.3.4.1 China's copper demand status

Whether China's copper demand is boosted is a key factor affecting global copper demand. Here we analyze one by one from the top three industries in China's copper demand.

Electricity aspect (46% of the total copper demand): The electricity industry dominates China's copper terminal demand, accounting for more than 45%, also its investment growth is fast, mainly from fiscal expenditures. Therefore, the annual investment in the electricity industry has a greater impact on copper demand, and its higher investment will guarantee domestic copper demand in the long run. Stimulated by the national electricity network construction plan and the upgrading of rural electricity network, the growth rate of electricity investment in 2016 rose to 16.9%. With the in-depth development of the energy revolution with electrification, the Energy Bureau plans to invest no less than 2 trillion yuan(350 billion USD Dollars) in domestic electricity network construction and renovation from 2015 to 2020.

Household appliances aspect (15% of the total copper demand): The home appliance industry is also an important area for copper downstream demand, which is ranking second position. Copper is mainly used in conductive and heat-conducting components of home appliances such as air conditioners, refrigerators, microwave ovens, etc. Among them, air-conditioning copper consumption is the main force in home appliances, accounting for 67% of total copper consumption in the home appliance industry. In the long run, demand for home appliances such as air conditioners will continue to grow due to the increased disposable income and high urbanization rate.

Transportation aspect (11% of the total copper demand): Under the environmental protection trend, electric vehicles have obviously played a pivotal role in the demand for refined copper. Electric vehicles require three times as much copper in manufacturing as ordinary cars. Ordinary engines typically require 55 pounds of copper, hybrid engines

[25] Freedonia[online]:"World Copper" 2019. WWW: <https://www.freedoniagroup.com/industry-study/world-copper-3274.htm>

require 110 pounds, and electric cars require 165 pounds. In the past five years, global electric vehicle sales have grown at an average annual rate of 32%, by 2021, China expects electric vehicle sales to account for 4% of total sales, that is, China's electric vehicle sales will be around 1.12 million units, billion pounds of copper will be used. In fact, the Chinese government plans to have 7 million electric vehicles in China by 2025, total of 35 million cars, it requires almost 2.1 billion pounds of copper in Chinese car market.[26]

3.3.4.2 Global copper demand status

While the "One Belt, One Road" initiative has also given a strong shot to the world's copper demand. The "One Belt, One Road" initiative invests in electricity plants, roads, railways and other transportation and logistics infrastructure, accounting for half of the total project expenditure. In the next few decades, the positive spillover effects of such infrastructure projects will be promoted along the route. The annual per capita copper consumption in more than 100 countries along the "One Belt, One Road" initiative is 1.35kg, far below the world average of about 4kg. This means the copper demand in the countries along the "One Belt, One Road" initiative has a large room for growth, and the lack of copper resources in most countries will promote the development of copper cross-border trade to a certain extent. It can be seen that both China and the world, copper future demand is in a steady rising channel. It is anticipated that the annual growth of global copper demand will be increased by 4% to 5% in the next 10 years. Historically, the yearly increase in global copper production has averaged only by 3.42%. This shows that the demand for copper will soon exceed the supply of copper.[27]

3.4 Global copper price

Global copper price basically adopt futures pricing, which is the cathode copper futures plus premium or deduct discount. There are two main ways to determine the global copper

[26] Green car congress [online]: "BNEF forecasts EVs to hit 54% of new car sales by 2040; decreasing importance of PHEVs" 2017. WWW: <https://www.greencarcongress.com/2017/07/20170706-bnef.html>
[27] Mining-technology [online]: "Belt and Road: how China's global plans will affect copper" 2018. WWW: <https://www.mining-technology.com/features/how-chinas-global-plans-will-affect-copper/>

price, namely the average price and the spot price. Copper concentrate is the main raw material of cathode copper, its pricing formula is:

Copper Concentrate Price = Copper Cathode Price - Processing Fee (TC/RC)

In general, when the copper cathode price remains stable, the higher TC/RC indicates the lower copper concentrate price, the more favorable it is for the smelting enterprises.[28]

3.4.1 Pricing power of global copper resources

Pricing power means that a company or organization can determine its own product price according to its own situation. As far as global copper resources are concerned, it is the global pricing power, which is a certain country or institution uses its own advantages to exert a significant influence in the formulation of global copper price and trade rules, thereby controlling the supply and demand of copper resources. The global pricing power includes two aspects: one is how the global copper resources pricing mechanism is formulated, and the other is the enterprises' bargaining power capability.

3.4.1.1 Global copper resources pricing mechanism

In recent years, the price volatility of global copper resources has been more hard to explain only by the supply and demand theory, and it shows obvious characteristics of financialization. The global pricing power of copper resources exists not only between physical traders but also in the hands of futures traders, the traditional futures trading pattern has also been greatly changed with the participation of financial institutions and speculators. This change makes the formation mechanism of copper price no longer completely dependent on the basic physical supply and demand relationship, but more on the dynamics of the futures market.[29] On the one hand, the spot copper price in the physical market is increasingly obvious affected by the price of futures copper, in addition to the normal hedging transactions taken by actual buyers and sellers to avoid risks, the

[28] Aurubis[online]: "LME / Hedging" 2017. WWW: <https://belgium.aurubis.com/fileadmin/media/pdf/CH/Hedging_at_Aurubis.pdf>

[29] Unrisd [online]: "Valueworks: Effects of Financialization along the Copper Value Chain" 2018. WWW: <http://www.unrisd.org/unrisd/website/projects.nsf/(httpProjects)/E340375ACE363D36C12580B2004C8053?OpenDocument>

speculative trading volume of financial institutions has also increased the price fluctuations of global copper resources. On the other hand, the global pricing power of copper resources is mainly determined by the London Metal Exchange(LME), the international financial giant and the state power behind it control the pricing power of several famous futures trading markets, thus controlling the global price of copper resources.

3.4.1.2 Enterprises' bargaining power capability

The global copper resources pricing model has gradually changed from traditional negotiations between trade parties to futures pricing. In this process, production and finance are two major sectors that affect the pricing power of global copper resources. In the global copper resource market, pricing power is in the hands of companies or institutions that control copper resources. Among the top 10 copper groups in the world, Codelco, BHPBilliton, RioTinto, Freeport-McMoRanInc, and Glencore, these five major international mining oligarchs, has monopolized 70% of the world's copper ore resources and controlled the pricing power of global copper resources. The amount of production they provide directly affects the supply of copper resources in the international market, they have obvious advantages in pricing copper resources. As far as financial sector is concerned, international financial institutions such as investment banks and funds hold a large amount of financial capital, which can not only control the financial market, but also form a monopoly position in resource market. Copper giant Rio Tinto and BHP Billiton have basically the same shareholders, both HSBC, JP Morgan and Citibank.[30] Glencore's major shareholders are Qatar Holding, L.L.C. and BlackRock Investment Inc.[31] These major global financial institutions play a dominant role in global credit, not only providing financial capital for miners' oligarchs, but also giving credit and financing opportunities to them. The mining oligarchy gradually consolidated the strong position of its copper mine producers, financial speculators, and dominated the price trend of global copper resources.

[30] Independent Australia [online]: "Who owns corporate Australia?" 2013. WWW: <https://independentaustralia.net/business/business-display/who-owns-corporate-australia,5033>
[31] Marketscreener [online]: "Shareholders" 2018. WWW: <https://www.marketscreener.com/GLENCORE-29423547/company/?iCStream=1>

3.4.2 The impact of copper's "Lost Pricing Power" on China and its reaction

As an important strategic national resource, the energy issue has become a constant source of conflict in today's world. China has a high volume of copper trade quantity but it is completely excluded from the participation and construction of international trade mechanisms. The pricing power of global copper resources determines the profit distribution of copper products transactions. Countries or organizations with pricing power can obtain high profit in international trade, while other countries are passively accepted and exploited, which is not equal in the market economy environment that promotes fair trade. Therefore, the issue of "Lost Pricing Power" for global resources has become an serious problem in the process of China's development. Here I want to mention a very successful country in this field, Japan. Japan is a country with extremely scarce resources, but he can avoid being affected by international price fluctuations in the pricing of global metal resources, not only that, he is the leader of the game and can benefit from it. This is due to his financial group system, in which the well-known trading company Mitsui play a pivotal role. As early as the 1960s, Mitsui of Japan actively participated in the development of upstream mineral resources, and establish a close tie with the world's leading miner oligarchy BHP Billiton, Rio Tinto, Vale.[32] The price negotiation of resource products in Japan is not the responsibility of the enterprise itself, but is solely delegated to the powerful trading company Mitsui. And Mitsui has formed a mutually beneficial cooperative relationship with several large domestic production companies. In this way, the trading company is responsible for the negotiations, the factory is responsible for the production, and each has its own duties. This has formed an efficient integration of the upstream, middle and lower reaches of the whole industrial chain. When copper price rise, Mitsui earn profit and allocate part to associated manufactures. It is win-win.

Chinese government and enterprises already realized this problem, and start to counterattack. Learn from the successful experience of Japanese companies, more and more competitive Chinese companies have been encouraged to go out and seek

[32] Mitsui [online]: "Major Activities" 2018. WWW: <https://www.mitsui.com/ap/en/business/1216135_9193.html>

cooperation to develop overseas energy. In 2014, China Minmetals Corporation acquired the Peruvian Bambaster Copper Mine.[33] In 2018, China CITIC Group and Canada's Ivanhoe Mines reached an acquisition agreement to become a shareholder of Africa's top copper mine Ivanhoe Mine.[34] These signs all indicate that Chinese companies are gradually moving towards the direction of industrial chain integration, but it is just a start.

As far as the financial sector is concerned, China has begun to improve its futures market, RMB internationalization and actively participate in global pricing mechanisms. By August 2018, China's four major exchanges included a total of 55 types of futures products, Chinese futures market are encouraged to introduce more trading varieties to attract global investors, improve trading system and laws, protect the rights and interests of investors, and establish a regulatory system that is in line with international standard. Another important action is RMB internationalization, the International Monetary Fund (IMF) announced on September 30, 2016 that the Chinese RMB will be included in the new Special Drawing Rights (SDR) currency basket.[35] This signifies that the RMB has officially become an international currency, it is a milestone in the internationalization of the RMB and is also conducive to China's monetary system reform.

3.5 The direction of China's copper industry

As previously analyzed, global refined copper consumption will grow steadily in the next few years driven by increased demand from the power industry, rising output of electric vehicles (EV) and good prospects for global economic recovery. However, due to the reduction of capital investment by mining enterprises and the difficulty of mining, it will become increasingly difficult to produce copper from primary mines. How to alleviate the impact of insufficient copper supply while maintaining efficient sustainable development becomes a severe problem in front of governments of the world, especially China. Can the

[33] The New York Times [online]: "Glencore to Sell Peruvian Mine to Chinese Group for $6 Billion" 2014 WWW: <https://dealbook.nytimes.com/2014/04/14/chinese-consortium-buys-peru-mine-for-6-billion/>

[34] Mining.com [online]: "China's CITIC to be Ivanhoe Mine's top shareholder in $548m-deal" 2018. WWW: <http://www.mining.com/chinas-citic-ivanhoe-mines-top-shareholder-548m-deal/>

[35] IMF NEWS [online]: "IMF Adds Chinese Renminbi to Special Drawing Rights Basket" 2016.WWW: <https://www.imf.org/en/News/Articles/2016/09/29/AM16-NA093016IMF-Adds-Chinese-Renminbi-to-Special-Drawing-Rights-Basket>

development of copper substitutes and the use of recycled copper be the key to solving this problem, and will serve as the main force for China's copper supply in the future? We will give a deep analysis next.

3.5.1 Copper alternative developments

Owing to the current shortage of copper resources and the low aluminum prices, some people suggest to use aluminum to replace copper. This issue needs to be treated rationally and can't be generalized. To study copper substitutes and their feasibility, the physical properties of copper should be considered first. Copper is widely used in the industrial field mainly due to its excellent electrical conductivity, thermal conductivity and its stable chemical properties.See Figure 4. According to the performance of copper, copper applications can be divided into three major areas, namely power cable industry, radiator and air conditioning refrigeration industry and other low value-added products industry, they will be analyzed one by one.[36]

Figure 4 Copper performance & application

Copper Performance & Application			
Copper performance	Level	Alternative	Uses
Electrical conductivity	Doubled than aluminum	Aluminum	Copper wire, electrical cable
Thermal conductivity	Two times higher than aluminum	Aluminum	Radiator, refrigeration system
Corrosion resistance		Stainless steel	Water pipe, valve, sink

Source:Copper Development Association

3.5.1.1 The power cable industry

In the power cable industry, copper is the main raw material, and it is also the area where the highest appeal for aluminum as alternative of copper. However, after careful analysis of

[36] Copper Development Association [online]:"Copper: Properties and Applications" 2018. WWW: <https://copperalliance.org.uk/knowledge-base/education/education-resources/copper-properties-applications />

the feasibility, we found that the current reality in China is not suitable for large-scale promotion of aluminum instead of copper, because whether it is conductive, mechanical or corrosion resistance, copper is superior to aluminum, and it is also the current power cable field in the world. In residential buildings and public transmission lines that emphasize high security, in order to protect the safety of residents' lives and property, the government mandates that all copper wires must be used. Only when the technology and management level is high, aluminum can be considered to replace copper, but at present, China has not yet reached adequate level, for safety reasons, does not have a large number of conditions using aluminum and aluminum alloy conductors.

3.5.1.2 Air conditioning and refrigeration industry

In the air conditioning and refrigeration industry, because the demand of its product quality is lower than the cable industry, the technical requirements can also meet the performance requirements of the product, some world-class companies have begun to use innovative technologies to replace high copper alloys with low-copper alloys, reduce copper pipe wall thickness and pipe diameter to reduce costs and make connectors replaced with stainless steel or aluminum material. The high-efficiency new heat exchanger developed by China Sanhua Holding Group and Danfoss Group of Denmark has higher energy efficiency and reliability than traditional copper heat exchangers, which greatly reduced the overall cost of the customer, so it has been welcomed in the market. Another prominent copper substitute is the copper-aluminum tube, which is a high-tech product developed by a research institutes, it is currently widely used by air-conditioning manufacturers. After switching to copper-aluminum tubes, it can reduce production costs by nearly half per year in Chinese air-conditioning market. Copper-aluminum tubes are not merely recognized by domestic air conditioning manufacturers for their energy saving, corrosion resistance and easy installation, but they are also exported to countries including the European Union and Japan. In addition to technical guarantees, relevant government agencies such as the Quality Supervision Bureau and the Environmental Protection Agency recognize the quality of these products at the national level, air conditioning companies who are the user

of these products have promised a ten-year warranty to eliminate the worries of consumers. All of these measures are all escorting the promotion of aluminum-based copper products in the field of air conditioning.

3.5.1.3 Other low value-added product areas

In addition to the two major industries mentioned above in which copper is used, some other low value-added products also use copper and face the situation of copper substitutes. Such as construction, hardware, water pipe fittings, aluminum and stainless steel substitutes can fully meet the basic needs. For products in this field, the substitution ratio largely depends on the fluctuation of copper price, when copper price go up, the market demand urgently for copper substitutes, and when the copper price falls, the demand for copper will increase. All in all, as long as the mechanical difficulties are overcome, these low value-added products are highly likely to use copper substitutes in the future, which is very advantageous from the perspective of resource recycling and environmental protection.[37]

3.5.2 Copper recycling and sustainability

The physical properties of copper determine that it has beneficial recycling characteristics. Theoretically, non-ferrous metals can be recycled indefinitely, and there is almost no loss in actual recycling. As copper resources tendency to be depleted, it is an inevitable trend that resources are exhausted. It is an irresistible trend to develop a circular economy of copper products. Therefore, regardless of the resource shortage trend, environmental carrying capacity, or national economic security, the customary copper industry progress model based on the original copper resources is difficult to sustain. It is urgent to step out a modern copper industry development path characterized by recycling and utilization of copper resources.

With the improvement of economic level, the resources of recycled copper are increasing,

[37] Metalbulletin [online]:“Copper substitutes caused by high copper price”2011. WWW: <https://www.metalbulletin.com/events/download.ashx/document/speaker/6513/a0ID000000X0jLpMAJ/Presentation>

the scale of China's recycled copper resources industry is growing. However, compared with developed countries, the scale and utilization rate of recycled copper in China is not high. The utilization rate of recycled copper in developed countries such as France and Germany is more than 40%, and in Italy it is almost 100%. There are many technical bottlenecks in China's recycled copper industry, a large number of dismantling and recycling are still mainly labor-based, the recycling process lacks advanced sorting technology, the mechanization and automation of the processing is low.[38] In order to overcome these difficulties, Chinese scrap copper industry focused on three aspects to improve: First aspect is industrial concentration. Internet technology is used to connect the copper waste source with the recycling enterprise, optimize the recycling network distribution through big data analysis, create a waste copper recycling system. At the same time, vigorously promote the elimination of backward production capacity of copper smelting, shut down or transform the recycling copper enterprises with high pollution hazards and unqualified equipment level, promote the recycling of copper industry to environmentally-friendly, technologically advanced enterprises, then to form a recycling copper industry cluster. And the most important aspect is to establish a technological innovation system based on recycled copper enterprises, bring into full play the research and innovation advantages of research institutes and large enterprises, accelerate the research and development of advanced technologies for scrap copper recycling and the automation of production equipment.

3.5.3 A new model for the development of China's copper industry

In order to occupy a place in the severe international competition, China must find a new way of living that suits its own national conditions and adapts to the rules of international game. Effective integration of the three major industries of copper production, trade and financial capital through equity relations and business cooperation is an inevitable trend for the future copper industry to enhance competitiveness. The complementary and

[38] ICSG [online]: "Global Copper Scrap Flows:Where From, Where To, and How Much?"2012. WWW: <https://www.metalbulletin.com/events/download.ashx/document/speaker/6539/a0ID000000X0jULMAZ/Presentation>

coordinated development of the three pillars of production, trade and finance has gradually become the support for the rapid development of modern large-scale enterprise groups. Production takes the form of value creation, the foundation of trade finance, trade is the process of exchange of goods, the channel of value realization, finance is the exchange process of value, and the carrier of value circulation. Longitudinal integration of industry and finance can carry out industrial chain extension and resource integration. Horizontal integration of industry and finance can carry out strategic mergers and acquisitions to enhance industry concentration and voice.[39] The integration of trade and finance is an essential means to realize the combination of virtual and real operations and diversify the profit model. For one thing, this model can promote the scale of business operations. Large-scale copper enterprises will transform a single copper production enterprise into a comprehensive enterprise group combining production, trade and finance through domestic and foreign reorganization and mergers and business integration, maximize corporate profit and the scale with the advantage of scale. In the international market, through the integration of production, trade and finance, it can realize the multi-industry collaborative operation and the high integration of various resources, thus occupying the dominant position of the market, and even leading the international market price, which is conducive to commodity pricing rights. For another, this model is useful to rational allocation of enterprise resources, regulation of costs, and reduction of corporate risks. For large enterprise groups, a large number of related transactions will be generated between the related enterprises and within the enterprise, through this integration model, it can help enterprises reduce transaction costs and enhance comprehensive competitiveness. In addition, enterprises can diversify their operations while expanding their scale and business areas, effectively reducing overall risks. The development of the corporate financial industry can not only help enterprises to strengthen their financial capabilities, but also effectively use financial means to control risks and ultimately protect the safety of enterprises.

[39] SASAC[online]: “Research on the integration of industry and finance” 2018. WWW: <http://www.sasac.gov.cn/n2588025/n4423279/n4517386/n8658245/c8762203/content.html>

4. Practical part

In this chapter, I will research descriptively and statistically from two parts: One is to determine dependency between the selected variables by employing linear regression analysis in Gretl software. The other one is using Porter five forces analysis model to overall assess and evaluate China's copper industry's competitive strength and position. It helps to identify the most critical aspect that should be improved and form a strategy of how the industry should position itself against competitors.

4.1 Linear regression analysis

The relationship between global copper price and global crude oil price, global gold price, U.S. Industrial production index, China's GDP, global copper consumption, and Shanghai copper futures price need to be identified. I have chosen yearly data from year 2002 to 2016. The reason for choosing the period is the strong fluctuations in the values of the variables that occur during this period, clearly indicating the dependence of global copper price and selected macroeconomic indicators.

All the data are converted into US dollars for pricing, from 2002 to 2016 as listed in Table 1. The global copper price selects the London Metal Exchange Market futures price (LME), the crude oil price selects West Texas Intermediate (WTI), which is the global crude oil pricing benchmark listed by NYMEX, and China's GDP has been converted into US dollars according to the exchange rate of the year.

Table 1 Time Series Data of Selected Variables

YEAR	CP	GGP	IPI	CGDP	GCC	SHFEC
	USD/Ton	USD/ Ounce		Hundreds of millions(USD)	Thousand of tons	USD/Ton
2002	1560.29	309.68	92.9562	14705.5	14900	2218.86
2003	1779.36	363.32	94.1106	16602.88	15230	2253.20
2004	2863.47	409.17	96.5956	19553.47	16800	3440.15
2005	3676.49	444.45	99.7726	22859.66	16580	3882.78

2006	6731.35	603.77	102.0150	27521.32	16950	8795.48
2007	7131.63	695.39	104.5810	35521.83	17910	8486.84
2008	6963.48	871.96	100.9013	45982.05	17730	6599.42
2009	5165.30	972.35	89.2696	51099.54	17010	6002.93
2010	7538.37	1224.52	94.2238	61006.20	19127	8094.53
2011	8823.45	1571.52	97.1387	75725.54	19736	10835.91
2012	7958.92	1668.98	100.0000	85605.47	19799	9223.45
2013	7331.49	1411.23	101.9753	96072.24	20640	8513.73
2014	6863.40	1266.40	105.1294	104823.71	21450	8061.89
2015	5510.46	1160.06	104.3840	110646.65	21849	6361.16
2016	4867.90	1250.80	103.1058	111991.45	22260	5903.61

Source: Own elaboration based on the collected data from FRED data

Note:

CP: Global copper price

WTI: Global crude oil price

GGP: Global gold price

IPI: U.S. Industrial production index

CGDP: China's GDP

GCC: Global copper consumption

SHFEC: Shanghai Copper future price

4.1.1 Selected variables and their trends

In the first part of the analysis, the fluctuation of global copper price and selected macroeconomic indicators over the period 2002 to 2016 are displayed and described. The explained variable is global copper price and the rest are explanatory variables. In other words, the value of global copper price are considered to rise or fall in a straight line according to values of the selected variables.[40] The aim is to spot a pattern of the

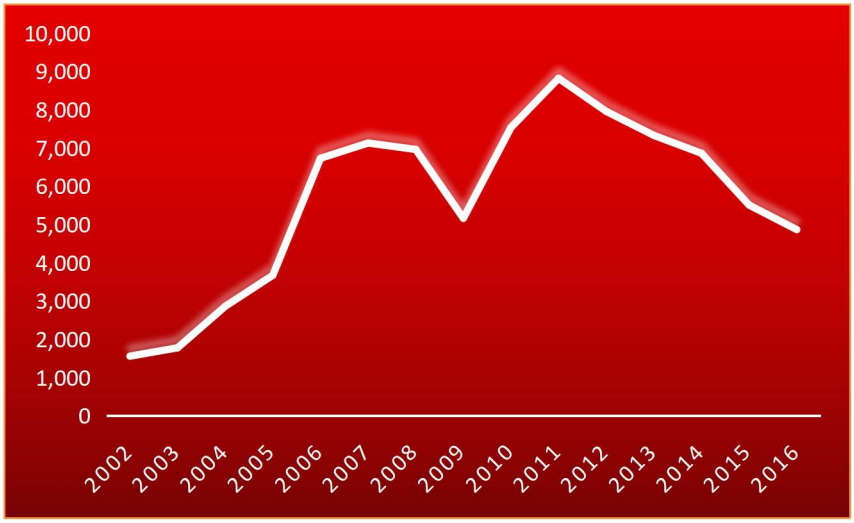
[40] Statistics How To [online]: "Explanatory Variable & Response Variable: Simple Definition and Uses." 2015. WWW: <http://www.statisticshowto.com/explanatory-variable>

relationship between the variables over the selected 15 years, since the experiences in the past have reference value to indicate the influencing factors of global copper price fluctuations. And it will help to avoid risks and better participate in international economic cooperation in the future.

4.1.1.1 Global copper price

Global copper price is the cathode copper futures plus premium or deduct discount. 70% of all copper production in the world is traded on the basis of the official price published by the London Metal Exchange (LME). Therefore, this article mainly uses the LME copper price as the global copper price. The drivers of global copper price including the copper production situation, copper supply, global economic status and so on. Figure 5 shows the global copper price during the period of years 2002 – 2016.

Figure 5 Global Copper Price 2002–2016



Source: Own elaboration based on data from Fred

According to the historical data graph above, we can find its regularity. The price during the examined period had been moving between the values of $1560 to $8823. The monitored period starts at the value of $1560 in 2002, it was followed by a moderate increase. In the following period, the price was decreasing and sharply dropped to a low level at $5165 in 2009 after 6 years increase. Over the next years, the price was increasing and then reach the peak in 2011 with $8823. The factors that cause this kind of fluctuation are various. The specific analysis is as follows:

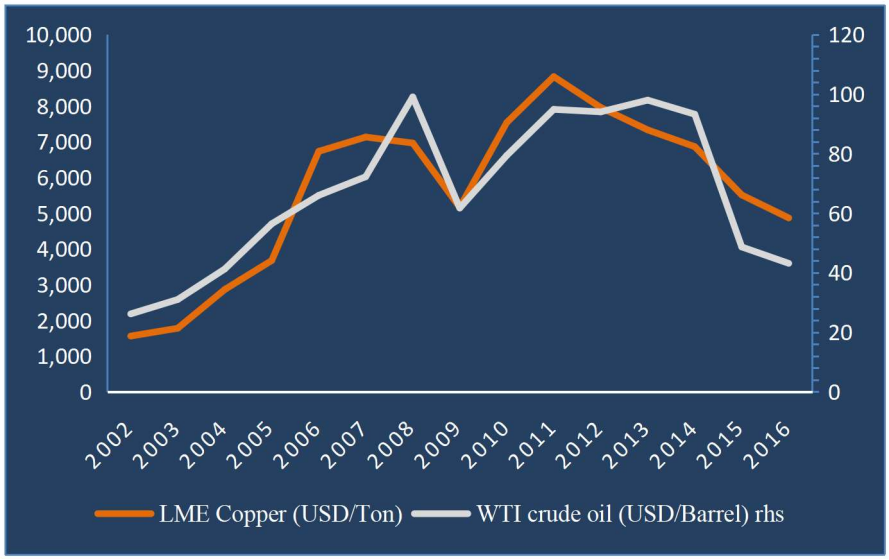
The copper price was depressed before 2000, the rapid development of China's economy has led to a surge in demand for copper, but the supply was seriously insufficient due to lack of investment. After the expansion of mines in 2004, the contradiction between supply and demand of copper concentrates has eased, but the refineries have also expanded and the production capacity is released much faster than the mines. Soon, copper concentrates are insufficiently supplied again. On July 2, 2008, LME copper price hit a historical high level, but owing to the impact of the financial crisis, it fell rapidly at the end of this year. The result of the financial crisis is the refinery shut down, refining demand shrank sharply, refined copper stocks accumulated, TC/RC rose, and the market immediately entered the typical bear market. In 2009, China issued the "four trillion" stimulus plans, and FED also introduced "Quantitative Easing Monetary Policy". The demand for refined copper recovered rapidly, and the bottleneck of mine production capacity once again became prominent, and copper prices returned to the bull market. After 2010, the mine production capacity was gradually released, the copper concentrate market gradually returned to balance, the refined copper stocks accumulated, and the bull market entered the later stage, in 2011, the copper price reach the highest level and after that the copper market enter into a bear market, the overcapacity of mine production and the decline of copper demand are the core factors. Based on the performance records of the past decade, the current copper price trend indicates an impending global economic slowdown.

4.1.1.2 Global crude oil price

From an economic point of view, crude oil is an important industrial raw material, for its terminal demand involves all aspects of the whole economy, whether its demand is strong or not can most reflect the economic quality. The demand for crude oil grows with the growth of the economy, the rise and fall of its price reflects the speed of economic development to a certain extent. Crude oil price is closely related to the degree of inflation, and copper has the function of resisting inflation. Therefore, from the perspective of long-term trend, the price of copper has a positive interaction with the price of global oil. Another important factor as to why the oil price have so large impact upon copper price is

that oil accounts for 7% of the marginal cost of copper production.[41] Figure 6 shows clearly the correlation between them. When the oil price rises, it indicates that the economy is strong and stimulates the price of copper to rise. Oil price decline, reflect the economy is sluggish, and copper price is suppressed.

Figure 6 WTI Crude Oil VS LME Copper Price 2002–2016



Source: Own elaboration based on data from Fred

As demonstrated as above, global crude oil price within the selected years had been moving between the values of $26.17/barrel to $99.06/barrel. Started from 2002, after 6 years of continuous rise, oil price reach highest level in 2008 at $99.06, and then plummeted to $61.73 in 2009, a drop of 37.09%. Then gradually recovered to a steady rise, but in 2015 there was another round of decline, with a drop of 47.82%, and the price reached $48.66, almost returning to the level of 2004.

The fundamental reason for the change in global oil price is supply and demand. During the selected period, the global economy continued to grow, while global oil production growth was slow, seriously lags behind demand growth. It can be seen that strong demand is the main driver of global oil price. But the economic crisis that swept the world in 2008 caused the world's GDP to shrink, it directly cause the sharp drop of global crude oil price. In addition, traditional oil-producing countries such as Libya and Iraq began to recover in

[41] CEO.CA [online]: "What Does Oil have to do with Copper?" 2015 WWW: <http://blog.ceo.ca/2015/01/20/what-does-oil-have-to-do-with-copper/>

2014, the oversupply of crude oil also put pressure on oil price in 2015.[42]

4.1.1.3 Global gold price

Gold price is generally considered to best reflect macroeconomic trend, the fluctuation of gold price indicates two signals: one is the reflection of the value of the US dollar, the US dollar falls, the gold rises. The further one is the signal of inflation, the price rises, the gold rises. The common factors influence the gold price are monetary policy, demand and supply, economic data, inflation, currency movement and ETFs.[43] Generally speaking, gold and copper both belong to non-ferrous metals, and the factors affecting their trend are basically similar, so their trends are also consistent, this can be seen from the Figure 7. The only reverse period is during the economic crisis, gold soars because of its unique investment hedging properties, while copper as an industrial raw material is linked to the real economy at this time, economic pessimism, copper price go down.

Figure 7 Global Gold VS LME Copper Price 2002–2016

Source: Own elaboration based on data from Fred

As is evident from Figure 7, the global gold price during the selected period had been moving between the values of $309/ounce to $1669/ounce, at the beginning of the recorded

[42] Investopedia [online]: "Why the Price of Crude Oil Dropped in 2015" 2018. WWW: <https://www.investopedia.com/articles/investing/102215/4-reasons-why-price-crude-oil-dropped.asp>

[43] TheMotley Fool [online]: "7 Common Factors That Influence Gold Prices" 2016. WWW: <https://www.fool.com/investing/2016/10/13/7-common-factors-that-influence-gold-prices.aspx>

period, global gold price stood at the lowest level $309 and then keep rising to reach $1669 in 2012, an increase of 439% during ten years. After that, a significant decline occurred and the price was reduced by 30% within the next three years.

Looking back on the 10 years of gold bull market, the reasons are manifold: rising inflation and low interest rates, saving becomes unattractive, and concerns about US debt are very obvious. The prospect of the US economy was unclear, lowered the dollar, caused gold price to rise. Another noteworthy aspect is geopolitical factor, the Middle East and the nuclear crisis have intensified concerns about the global economy and once again benefited gold. Gold has been steadily falling since a peak of $1,900 an ounce in September 2011, and then fall down, the main reason is because that the gold price rose too much in the previous period, mainly due to the financial crisis in previous years. Later, the global environment tended to be stable, the US non-agricultural data was gradually improved, the US dollar grew steadily, and the price of gold fell.[44]

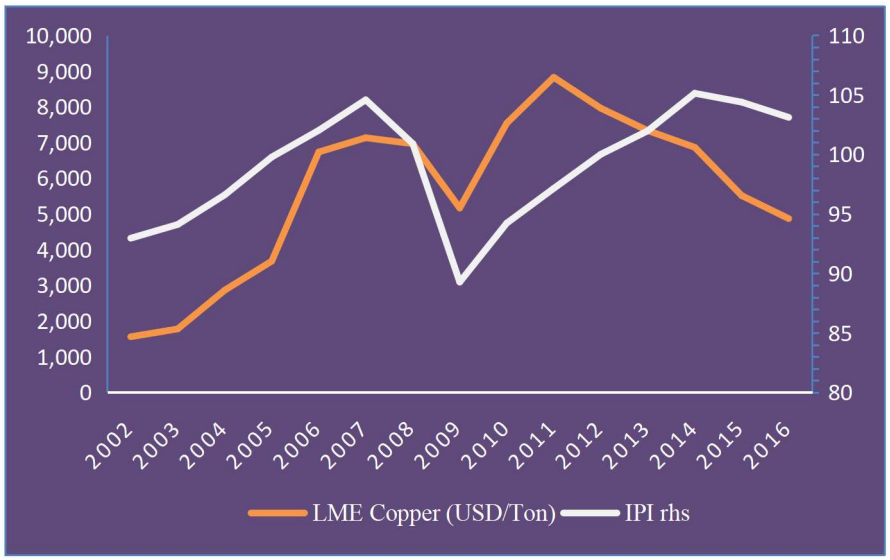
4.1.1.4 U.S. Industrial production index - IPI

The U.S. Industrial Production Index (IPI) is a comprehensive measure of the monthly output of manufacturing companies refer to plants, mines and utilities. 250 companies in the United States were selected as reference samples to represent 27 different industries. The index reflects the economic situation and development trend of the US industrial economy in a certain period of time.[45] When the U.S. IPI went up, the economy boomed and buildings accelerated. As a result, copper demand rose and price rose. However, when the economy slowed down, copper price declined. Figure 8 tells us that there is a positive correlation between IPI and copper price.

[44] Business Today[online]:"Gold prices slip, head for worst weekly drop" 2016.WWW: <https://www.businesstoday.in/markets/commodities/gold-prices-slip-head-for-worst-weekly-drop-since-november-2015/story/238280.html>

[45] Investopedia [online]: "Industrial Production Index - IPI" 2017. WWW: <https://www.investopedia.com/terms/i/ipi.asp>

Figure 8 U.S. IPI VS LME Copper Price 2002–2016



Source: Own elaboration based on data from Fred

As demonstrated, the overall U.S. IPI data showed a steady upward trend, from 92.96 in 2002 to a peak of 104.58 in 2007, followed by a downward trend, reaching a trough of 89.27 in 2009, after that is a long-term slow recovery period. The obvious rapid decline during this selected period was clearly the impact of the U.S. financial crisis in 2007. Bank failures, consumer demand weakened, and unemployment rate hit an eight-year high.[46] All these factors caused heavy damage to US manufacturing, leading IPI data to plummet.

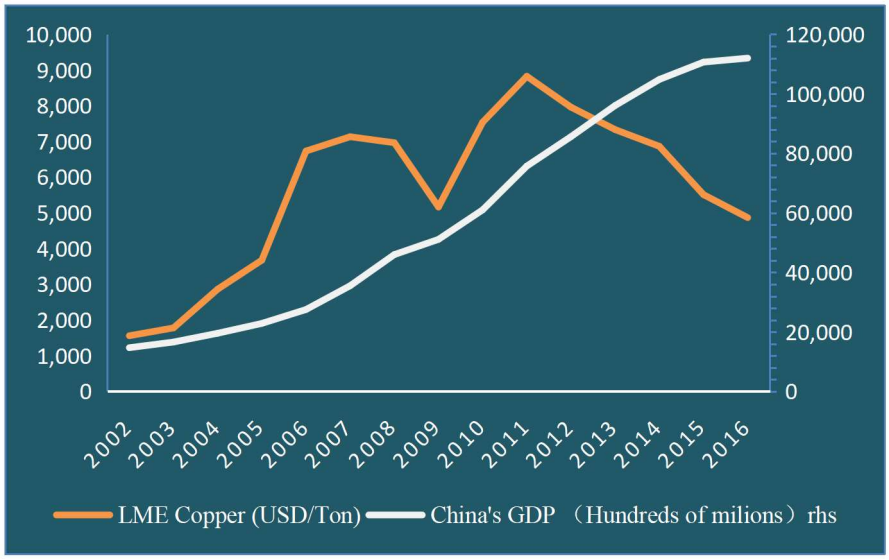
4.1.1.5 China's GDP

China's absolute GDP ranks second, behind the US, but GDP growth is the highest among countries in the world. See Figure 9, the overall trend of China's GDP is continuously rising and the import and export data of most economies in the world are highly correlated with China.[47] China is the largest copper consumer and importer, the relationship between Chin's GDP and global copper price is difficult to be judged solely from the absolute value, but it is much more easier to see the relevancy if we explain it in the form of Chin's GDP growth rate, as it obviously expressed in Figure 10. During the booming period of China's

[46] Timeline [online]: "The U.S.Financial Crisis" 2018.WWW: <https://www.cfr.org/timeline/us-financial-crisis>
[47] Wall Street [online]: "Prospects for the copper market in 2019" 2018 .WWW: <https://wallstreetcn.com/articles/3451828>

economy, copper consumption has increased, driving copper prices up, and vice versa.

Figure 9 China's GDP VS LME Copper Price 2002–2016



Source: Own elaboration based on data from National Bureau of Statistics

Figure 10 China's GDP Growth Rate VS LME Copper Price 2002–2016

Source: Own elaboration based on data from National Bureau of Statistics

From 2002 to 2008, China's GDP basically maintained a double-digit growth, mainly due to the gradual improvement of China's market economic system, the enhancement of the government's macro-control capabilities, the loose monetary policy, the acceleration of urbanization and a large number of infrastructure investment demand, which has promoted the further expansion of China's economic scale. After 2008, China's GDP growth rate has

slowed down noticeably. Although the GDP growth rate has rebounded sharply in 2010, this rebound has not changed the long-term trend of decline. The GDP growth rate during this period has dropped from double-digit growth in the previous period to around 7%[48].On the one hand, it is the negative impact of the international financial crisis, on the other hand, it is also the adjustment of China's production factors after experiencing the rapid development of the previous stage.

4.1.1.6 Global copper consumption

Throughout the 20th century, copper demand has been growing rapidly, and there is no indication that it will slow soon. It has a wide range of applications, mainly because of its unique electrical conductivity, which makes it difficult to replace.[49]

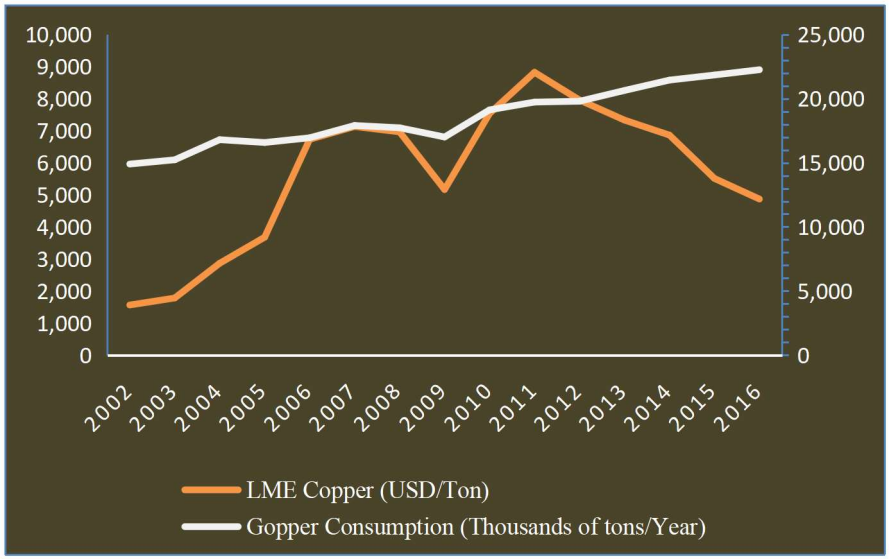
From the perspective of global copper consumption, China, the United States, Germany and Japan are still the major consumers of copper, while China's copper consumption accounts for nearly half of the total, and is the most important copper consumer.[50] Theoretically, rising demand will lead the higher price when supply is constant. As it shows in Figure 10, the relationship between copper price trend and copper consumption is basically in line with economic theory, copper consumption go up, the copper price go up, but after year 2012, the situation reversed, mainly because the global copper output growth in 2014 was higher than the increase in consumption, and the oversupply led to an increase in consumption but a fall in price.

[48] National Information Center [online]: "Analysis of the cyclical factors of GDP trend" 2017 WWW: <http://www.sic.gov.cn/News/455/7665.htm>

[49] ScienceDirect [online]: "Estimating global copper demand until 2100 with regression and stock dynamics" 2018 WWW: <https://www.sciencedirect.com/science/article/pii/S0921344918300041#bib0190>

[50] Agri-Pulse [online]: "The world copper factbook 2017" 2018. WWW: <https://www.icsg.org/index.php/component/jdownloads/finish/170/2462>

Figure 11 Global Copper Consumption VS LME Copper Price 2002 – 2016



Source: Own elaboration based on data from Fred

Depending on the latest data from Statista[51], the world refined copper usage quantity increased by 30% over the 15-year period from 14.9 in 2002 to 22.6 in 2016, quoted in 1,000 metric tons. Global copper consumption showed an overall upward trend. It experienced three declines in 15 years. The first time was in 2005, and the consumption from 16.8 million tons in 2004 to 16.5 million tons. It was followed by a significant decline for two consecutive years, 17.9 million tons in 2007 to 17.7million tons to 17 million tons, occurred in 2008 and 2009.

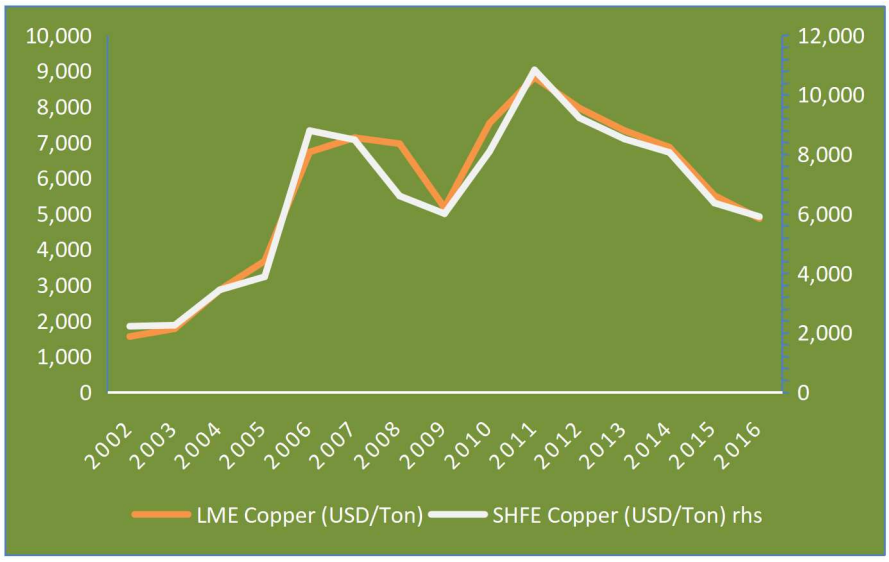
The reasons for the increase of global copper consumption are mainly due to the rapid development of the economy in China and even in Asia and other developing countries, which has a huge demand for copper. The use of copper in the Middle East and North Africa, where the economy is also experiencing rapid growth, has increased by 116%. And the decline of copper consumption in 2005 is related to the soaring price which restrained the consumption. The shrinking of continuous demand in 2008 and 2009 is the impact of the economic crisis, the global economy is weak, and industrial demand is decreasing.

[51] Statista [online]: "Refined copper usage worldwide" 2017. WWW: <https://www.statista.com/statistics/267849/global-consumption-for-copper-in-2006/>

4.1.1.7 Shanghai copper price

Shanghai copper price (SHFE) and London copper price (LME) are closely related and SHFE is said as a shadow of LME.[52]Considering the consistency of the currency, the SHFE is converted into US dollars according to the exchange rate of the current year. The current of SHFE copper and LME copper in selected period is showed in Figure 11, they have almost exactly the same trend.

Figure 12 SHFE VS LME Copper Price 2002–2016



Source: Own elaboration based on data from SHFE

As might be seen, the SHFE copper price fluctuates between $2218 and $10835. In the first three years of the selected period, the price is stable around $2000-$3000. Started from 2005, it sharply increased to reach a high level $8795 in 2006, increased 127% compared to the price of $3800 in 2005. The following three years are the declining period of $6002 in 2009. The peak of the copper price is $10835 in 2011, then slowly falling back. The same reason as the global copper price drop, Chinese copper demand and financial stimulation policy are the main factors for price increase, and financial crisis leads its fall.

4.1.2 Linear Regression Model

[52] OLME [online]: "The Asian connection: How do London and Shanghai market interact? " 2017.WWW: <https://www.lme.com/en-GB/Education-and-events/Online-resources/LME-insight/The-Asian-connection>

Linear regression is used for modelling the relationship between variables, which provides a close-range observation of factors affecting global copper price. The econometric model is based on annual data and represents a time series of 15 observations from 2002 to 2016. The construction of this model consists of following steps:

- Create Economic Model
- Create Econometric Model
- Create Correlation Matrix
- Parameters estimation
- Economic verification
- Statistical verification

4.1.2.1 Economic Model

Generally speaking, the economic model is a mathematical expression of economic theory. By making certain assumptions, many secondary factors can be excluded, and model is established. The economic model for the global copper price with selected variables is compiled as follows:

$$Y_{1t} = f(X_{1t}, X_{2t}, X_{3t}, X_{4t}, X_{5t})$$

Declaration of variables (15 observations)

- Y_{1t} - Global copper price -LME(USD/ton)
- X_{1t} - Unit vector
- X_{2t} - Global crude oil price -WTI (USD/barre)
- X_{3t} - Global gold price - GGP（Dollar/ounce）
- X_{4t} - U.S. Industrial Production Index - IPI
- X_{5t} - China GDP - CGDP (Hundreds of millions USD/year)

The basic assumption of the economic model is the dependence of global copper price on selected variables. Based on the economic theory, the relationship between the variables are assumed:

- An increase in global crude oil price would result in increase in global copper price

- An increase in global gold price would result in increase in global copper price
- An increase in the U.S. IPI would lead to a increase in global copper price
- An increase in China's GDP would result in increase in global copper price

4.1.2.2 Econometric Model

The econometric model reveals the quantitative relationship between various factors in economic activities and describes it by mathematical equations of randomness. As soon as all the related independent variables were selected, the econometric model was finally able to be processed, which would describe how selected factors influence the fluctuations of global copper price. I expect the coefficient estimate to be positive for each of the variables. The econometric model distinguishes itself from the economic model by adding a unit vector(X_{1t}) and a stochastic component(U_{1t}) to the equation.[53] Based on the econometric theory, the variables would be divided into endogenous and exogenous variables.[54] In this paper, the examined model contains one endogenous variable, five exogenous variables, and one stochastic variable. The stochastic variable is a random component or error, it is part of model equation.[55] A linear regression model is written as follows:

$$Y_1t = \gamma_1 X_{1t} + \gamma_2 X_{2t} + \gamma_3 X_{3t} + \gamma_4 X_{4t} + \gamma_5 X_{5t} + U_{1t}$$

Endogenous variable:

Y_{1t} = Global copper price-CP

Exogenous variables:

X_{1t} = Unit vector

X_{2t} = International crude oil prices -WTI (USD/barre)

X_{3t} = Global gold price - GGP（Dollar/ounce）

X_{4t} = U.S. Industrial Production Index - IPI

X_{5t} = China GDP - CGDP (Hundreds of millions USD/year)

[53] Jorgenson, Dale: "Econometrics - Econometric Modeling of Producer Behavior." 2000. p. 20. ISBN: 978-0262100823

[54] Leeflang, Peter: "Advanced Methods for Modeling Markets" 2017. p. 363. ISBN: 978-3-319-53469-5

[55] Studenmund, A. H.:"Using Econometrics - A Practical Guide"2014. p. 9. ISBN: 978-1-292-02127-0

Stochastic variable:

U_{1t} = Residual value

4.1.2.3 Correlation Matrix

Table 2 is a screenshot from Gretl software, and it presents a correlation matrix. The correlation matrix consists paired correlation coefficients of the variables, it is used to check is there high correlation between variables which can lead to multicollinearity in the regression modelling. Multicollinearity means a high dependency between exogenous variables and high correlation coefficients are up to |0.85| regardless are the values positive or negative. Multicollinearity may lead to inaccurate results and mislead the research conclusions.[56] As it can be seen from Table 2, the correlation coefficient of global gold price and China GDP is 0.86, a little bit higher than |0.85|, let me put it aside and wait for the test results.

Table 2 Correlation coefficients of selected variables

Correlation Coefficients, using the observations 2002 - 2016
5% critical value (two-tailed) = 0.5140 for n = 15

WTI	GGP	IPI	CGDP	
1.0000	0.7059	0.3429	0.4362	WTI
	1.0000	0.2841	0.8601	GGP
		1.0000	0.5086	IPI
			1.0000	CGDP

Source: Own calculation and elaboration.

4.1.2.4 Parameters Estimation

The term parameter estimation is the process of using data to estimate the parameters of the chosen distribution.[57] Usually, ordinary least squares(OLS) method will be applied to determine the parameters by minimizing the sum of the squared errors in a linear regression model.[58] Table 3 shows the Gretl output for the estimated parameters of selected variables during 2002 to 2016.

[56] Allen, Michael: "Understanding Regression Analysis." 2004. p. 176. ISBN: 978-0306484339
[57] Business and Economics Journal [online]: "Parameter Estimation" 2017. WWW: <https://www.omicsonline.org/scholarly/parameter-estimation-journals-articles-ppts-list.php>
[58] Carter, Hill: "Principles of Econometrics." 2010. p. 183. ISBN: 978-0470626733.

Table 3 Estimated Parameters of Selected Variables

```
Model 3: OLS, using observations 2002-2016 (T = 15)
Dependent variable: CP

              coefficient      std. error    t-ratio   p-value
  ------------------------------------------------------------
  const      -13480.1         6944.42        -1.941    0.0809  *
  WTI            35.0493        18.2406       1.922    0.0836  *
  GGP             4.64187        1.88740      2.459    0.0337  **
  IPI           146.608         74.4339       1.970    0.0772  *
  CGDP           -0.0365728      0.0206684   -1.770    0.1072

Mean dependent var   5651.025   S.D. dependent var   2277.068
Sum squared resid     7099400   S.E. of regression   842.5793
R-squared            0.902199   Adjusted R-squared   0.863079
F(4, 10)             23.06221   P-value(F)           0.000049
Log-likelihood      -119.2901   Akaike criterion     248.5802
Schwarz criterion    252.1205   Hannan-Quinn         248.5425
rho                  0.302722   Durbin-Watson        1.371491

Excluding the constant, p-value was highest for variable 5 (CGDP)
```

Source: Gretl

The final equation of the econometric model can be expressed as follows:

$$Y1t = -13480.1+35.0493X_{2t} + 4.64187X_{3t} + 146.608X_{4t} - 0.0365728X_{5t} + U_{1t}$$

4.1.2.5 Economic Verification

Economic verification is used to assess the direction and intensity of explanatory variables in explanatory variables, and to compare the results of parameter estimation with economic theory. Under the situation of ceteris paribus, the economic verification of the estimates obtained is as follows:

- The global copper price at zero values of the explanatory variables is at ***-13480.1*** US Dollars per year.
- If the WTI (global crude oil price) increases by one dollar and the rest stay constant (ceteris paribus), the global copper price will increase by ***35.0493*** USD/ton.
- If the GGP (global gold price) increases by one dollar and the rest stay constant (ceteris paribus), the global copper price will increase by ***4.64187*** USD/ton.
- If the IPI (U.S.Industrial Production Index) increases by one dollar and the rest stay constant (ceteris paribus), the global copper price will increase by ***146.608*** USD/ton.
- If the CGDP(China's GDP) increases by one dollar and the rest stay constant (ceteris paribus), the global copper price will decrease by ***0.0365728*** USD/ton.

4.1.2.6 Statistical Verification

The statistical verification identifies the significance of the estimated parameters,which is evaluated by p value. The p value is the level of significance that the test does not matter between rejection and acceptance.[59]

Model Fitness with Data

In general, if the difference between the observed value and the predicted value of the model is small and unbiased, the model fits the data well. The goodness of fit can be measured by determining the coefficient, which is R square, always between 0 and 100%.[60] The goodness of fit is usually measured by determining the coefficient, which is R squared, ranging from 0 to 100%.:

- 0% means that the model does not interpret the variability of response data around its mean.
- 100% means that the model explains all the variability of the response data around its mean.

Usually, the higher the R-squared is, the better the model fits the data selected. From Table 3, we can find the value of coefficient of determination R^2 is equal to 0.902199, which means that the changes in the explained variable are 90.22% dependent on the changes in the explanatory variables changes in the explained variable. Also, we can find the adjusted R-squared, it demonstrates how well terms fit a curve or line, but adjusts for the number of terms in the model. The value of the adjusted R^2 in this model is 0.863079, that means variation of the dependent variable is 86.3% explained by changes in the independent variables.

Parameters Significance

- Ho : γ_i: is not statistically significant

[59] Ramu, Ramanathan: "Introductory Econometrics with Applications" 2001. p. 34. ISBN: 978-0030343421

[60] Minitab [online]: "Regression Analysis - How Do I Interpret R-squared and Assess the Goodness-of-Fit" 2013. WWW: <http://blog.minitab.com/blog/adventures-in-statistics-2/regression-analysis-how-do-i-interpret-r-squaredand-assess-the-goodness-of-fit>

- Ha : γ_i: is statistically significant
- If the P-value > α, do not reject the Ho
- If the P-value < α, reject the Ho
- The level of significance was chosen for the project is $\alpha = 0.05$
- The number of observation is 15
- The model has 5 parameters
- The degree of freedom = 15 – 5 = 10
- Base on level of significance $\alpha = 0.05$; T-table value = 2.228

Table 4 Significance of the test results

Parameters	γ_2	γ_3	γ_4	γ_5
T-ratio	1.922	2.459	1.97	|-1.77|
P value	0.0836	0.0337	0.0772	0.1072
Critical T-value	2.228	2.228	2.228	2.228
Critical P-value	0.05	0.05	0.05	0.05
Comparison of T-value	1.922<2.2228	2.459>2.228	1.97<2.228	1.77<2.228
Comparison of P-value	0.0836>0.05	0.0337<0.05	0.0772>0.05	0.01072>0.05
Verification	IS	S	IS	IS
Hypothesis	Accept H_o	Reject H_o	Accept H_o	Accept H_o

Source: Own elaboration based on the test from Gretl

From the Table 4, we can see that only one parameter (global gold) is statistically significance, U.S. Industrial Production Index and global crude oil price are not statistically significance. The impact of China's GDP on global copper price is small and even can be ignored. The empirical result of this time is not in line with the reality. One reason may be China's GDP is too broad, and it may not directly affect the global copper price, or it may be related to the multicollinearity in this model for the high dependency between China's GDP and global gold price. To modify this model, I adjust the parameters and did another test. This time, I abandon two exogenous variables like IPI and China's GDP, and choose the RMB-denominated China Shanghai copper futures price and global copper consumption which are more directly related to global copper price instead.

4.1.2.7 Economic Model II

After adjusted two variables, the new economic model for the global copper price is compiled as follows:

$$Y_{1t} = f(X_{1t}, X_{2t}, X_{3t}, X_{4t}, X_{5t})$$

Declaration of variables (15 observations)

- Y_{1t} - Global copper price -LME(C)
- X_{1t} - Unit vector
- X_{2t} - Global copper consumption - GCC
- X_{3t} - Global crude oil price -WTI (USD/barre)
- X_{4t} - Global gold price - GGP（Dollar/ounce）
- X_{5t} - Shanghai copper futures price - SHFEC (USD/ton)

Based on the economic theory, the relationship between the variables are assumed:

- If the global copper consumption increase, the global copper price will increase
- If the global crude oil price increase, the global copper price will increase
- If the global gold price increase, the global copper price will increase
- If the Shanghai copper futures price increase, the global copper price will increase

4.1.2.8 Econometric Model II

A new linear regression model can be expressed with the following equation:

$$Y_{1t} = \gamma_1 X_{1t} + \gamma_2 X_{2t} + \gamma_3 X_{3t} + \gamma_4 X_{4t} + \gamma_5 X_{5t} + U_{1t}$$

Endogenous variable:

Y_{1t} = global copper price

Exogenous variables:

X_{1t} = Unit vector

X_{2t} = Global copper consumption

X_{3t} = Global crude oil price

X_{4t} = Global gold price

X_{5t} = Shanghai copper futures price and

Stochastic variable:

U_{1t} = Residual value

4.1.2.9 Correlation Matrix II

As it can be seen from Table 5, there are no such high coefficients, meaning there is no multicollinearity in this model, even though some values are high, all the values are less than |0.85|. Therefore, it is no need to change the variables and the linear regression analysis can then be conducted to study the relationship between the variables.

Table 5 Correlation coefficients of selected variables

Correlation Coefficients, using the observations 2002 - 2016
5% critical value (two-tailed) = 0.5140 for n = 15

GCC	WTI	GGP	SHFEC	
1.0000	0.4529	0.8254	0.5905	GCC
	1.0000	0.7059	0.8332	WTI
		1.0000	0.7819	GGP
			1.0000	SHFEC

Source: Own calculation and elaboration.

4.1.2.10 Parameters Estimation II

Table 6 Estimated Parameters of Selected Variables

Model 2: OLS, using observations 2002-2016 (T = 15)
Dependent variable: CP

	coefficient	std. error	t-ratio	p-value	
const	-1080.49	1220.11	-0.8856	0.3966	
GCC	0.0541780	0.0782992	0.6919	0.5047	
WTI	26.2546	7.42951	3.534	0.0054	***
GGP	-0.0701632	0.528611	-0.1327	0.8970	
SHFEC	0.613309	0.0778081	7.882	1.34e-05	***

Mean dependent var	5651.025	S.D. dependent var	2277.068
Sum squared resid	1357710	S.E. of regression	368.4711
R-squared	0.981296	Adjusted R-squared	0.973815
F(4, 10)	131.1636	P-value(F)	1.35e-08
Log-likelihood	-106.8835	Akaike criterion	223.7670
Schwarz criterion	227.3073	Hannan-Quinn	223.7293
rho	0.126440	Durbin-Watson	1.716555

Excluding the constant, p-value was highest for variable 4 (GGP)

Source: Gretl

Table 6 shows the Gretl output for the estimated parameters of selected variables. The final equation of the econometric model can be compiled as follows:

$$Y_{1t} = -1080.49 + 0.054178X_{2t} + 26.2546X_{3t} - 0.0701632X_{4t} + 0.613309X_{5t} + U_{1t}$$

4.1.2.11 Economic Verification II

Under the situation of ceteris paribus, the economic verification of the estimates obtained is as follows:

The global copper price at zero values of the explanatory variables is at ***-1080.49*** US Dollars per year.

If the global copper consumption increases by one dollar and the rest stay constant (ceteris paribus), the global copper price will increase by ***0.054178***/ton.

If the global crude oil price increases by one dollar and the rest stay constant (ceteris paribus), the global copper price will increase by ***26.2546*** USD/ton.

If the global gold price increases by one dollar and the rest stay constant (ceteris paribus), the global copper price will decrease by ***0.0701632*** USD/ton.

If the China Shanghai copper futures price increases by one dollar and the rest stay constant (ceteris paribus), the global copper price will increase by ***0.613309*** USD/ton.

4.1.2.12 Statistical Verification II

Model Fitness with Data

From Table 7, we can find R^2 is equal to 0.981296, which means that the changes in the explained variable are 98.13% dependent on the changes in the explanatory variables changes in the explained variable. Also, we can find the adjusted R-squared, it demonstrates how well terms fit a curve or line, but adjusts for the number of terms in the model. The value of the adjusted R^2 in this model is 0.973815, that means variation of the dependent variable is 97.38% explained by changes in the independent variables.

Parameters Significance

- Ho : γ_i: is not statistically significant
- Ha : γ_i: is statistically significant
- If the P-value > α , do not reject the Ho
- If the P-value < α , reject the Ho
- The level of significance was chosen for the project is $\alpha = 0.05$
- The number of observation is 15
- The model has 5 parameters
- The degree of freedom = 15 − 5 = 10
- Base on level of significance $\alpha = 0.05$; T-table value = 2.228

Table 7 Significance of the test results

Parameters	γ_2	γ_3	γ_4	γ_5
T-ratio	0.6919	3.534	|-0.1327|	7.882
P value	0.5047	0.0054	0.8970	0.0000134
Critical T-value	2.228	2.228	2.228	2.228
Critical P-value	0.05	0.05	0.05	0.05
Comparison of T-value	0.6919< 2.2228	3.534> 2.228	0.1327< 2.228	7.882> 2.228
Comparison of P-value	0.5047>0.05	0.0054<0.05	0.8970>0.05	0.0000134<0.05
Verification	IS	S	IS	S
Hypothesis	Accept H_o	Reject H_o	Accept H_o	Reject H_o

Source: Own elaboration based on the test from Gretl

From Table 7 above, through both comparison of T-value and P-value, we can see that there are two parameter γ_3 & γ_5 are statistically significance and γ_2, γ_4 are not statistically significance. So, it indicates that the variables global crude oil price, Shanghai copper price in China are statistically significant. And the variables global copper consumption and global gold price are not statically significant according to the test results.

4.2 Porter five forces analysis

Porter five forces analysis is actually an extension of SWOT analysis, which is a very

important tool in today's strategic planning. Through the synthesis and generalization of the internal and external conditions of China's copper industry, then analyze its competitiveness and profitability. Porter five forces analysis can help Chinese copper companies to make strategic adjustments and allocate resources in their strengths and where they have more opportunities.

- Bargaining Power of Suppliers

At present, China's domestic copper resources are relatively scarce, raw materials mainly rely on imports, therefore, the price of China's copper market is highly dependent on the international market, the domestic copper price is synchronized with the international price, and the domestic copper enterprises currently have no pricing power in the national futures market, only the passive recipient of the price, which is greatly affected by the futures price, the bargaining power of suppliers is strong.

- Bargaining Power of Buyers

China has a large number of copper processing enterprises and overcapacity. Domestic buyers have weak bargaining power for copper producers. In terms of copper product export business, since China's copper processing products international business are mostly on the feed processing mold, and only earn a skimpy processing fee and then re-export. Foreign buyers have strong bargaining power for Chinese copper producers.

- Threat of New Entrants

The copper mining and smelting industry ask for large investment funds and a long construction period. It is unlikely that capital will enter this industry on a large scale. Since copper is an important strategic resource of the country, it is of great significance to the security of the country. The Chinese government has strict restrictions on the entry of foreign capital. The current foreign investment is limited to the copper processing industry. Therefore, the potential competitors have little threat and the ability to enter is weak.

- Threat of Substitutes

Copper is a widely used material with special properties. So far, no material has been able to replace copper on a large scale, and only in certain areas which have conditional use of alternatives. Contrary, the application of copper has been further broadened. For example, Microsoft has replaced copper in chips with copper. Therefore, the threat of copper substitutes is almost negligible

- Rivalry among Existing Competitors

Many multinational mining companies in developed countries have tried to expand their scale through mergers, acquisitions, asset restructuring and strategic alliances. The world's top six copper mine producers produce 56% of the world's copper. In contrast, China's mining companies participating in international competition generally have small scale and insufficient competitiveness. So there are intense rivalry among competitors.

5. Discussion and Conclusion

The main objectives of this paper are to identify factors that have a significant impact on global copper price and to find the advantages and disadvantages of China's copper industry, thus constructive suggestions can be provided for China's copper industry. From the first process of building the linear regression model, it shows that global gold price is the main factor affecting the trend of global copper price, followed by global oil price and U.S. Industrial Production Index, but China's GDP have little impact on the global copper price. After modifying the linear regression model with adjusted variables, the result changed, the global oil price and Shanghai futures copper price become the fundamental factors affecting the global copper price in the long run, global copper consumption and gold price are not essential factors determining the copper price anymore. And through the Porter Five Forces Analysis model, we believe that China's copper industry is with few threats from substitute products, high entry barriers which are benefit to be a attractive industry with high profit but suppliers and buyers have strong positions, intense rivalry among competitors which shows this industry is low profit potential.

In view of the fact that the results of these two empirical tests are partially contradictory and inconsistent with reality, the biggest difference lies in the role of gold price in the fluctuation of global copper price, I conducted in-depth research and information review about it. President of Admiral Metals Mr.Jim Burstein[61] in his paper "Copper & oil prices: A look at the correlation" indicates that the top 5 factors most closely related to global copper price are global oil price, global gold price, global copper consumption, GDP China and IPI. My research results prove that there is indeed a strong correlation between global oil price and copper price. In terms of the relationship between gold price and copper price, there is another opinion by Anthony Summers[62] argue that gold and copper price don't seem to bear a direct relationship to each other on the surface. The implicated reason

[61] ADMIRAL METALS [online]: "Copper & oil prices: A look at the correlation" 2015. WWW:<https://www.admiralmetals.com/admiral-metals/copper-oil-prices-a-look-at-the-correlation/ >

[62] IU [online]: "How the Gold-to-Copper Ratio Can Make You a Smarter Investor" 2018. WWW: <https://www.investmentu.com/article/detail/59066/how-gold-to-copper-ratio-make-you-smarter-investor#.XI16mlz0nIU>

should be the difference depends their own attributes. Gold is the most widely recognized safe-haven asset among investors when market pessimism runs high. Copper is the exact opposite, it is a key industrial metal which is used globally in a wide range of industrial applications, the demand for copper reflects whether economy is growing or slowing. So with the increasing financial property of the futures market, the relationship between gold and copper has become complicated. It is impossible to judge the price of copper simply by the trend of gold, but the Gold-to-Copper Ratio has indeed become an important indicator that can predict the future economic development, a rising gold-to-copper ratio shows a weakening economy, while a declining ratio shows a strengthening economy.

As far as U.S IPI was concerned, there are other voices that support its impact of copper price. As the paper "Interpret economic data and analyze copper price trends" in 2002 mentioned that U.S. IPI has a direct relationship with the trend of copper price.[63] The rise in the Industrial Production Index indicates the recovery process of the manufacturing industry, which will stimulate the copper price rise.

With regard to the impact of China's GDP on copper price, my test result shows little significance. It may be due to the multicollinearity of the linear regression model between global gold price and China's GDP. Mr. Mark Burton also agree with Mr.Jim Burstein's standpoint.[64] He published an article in 2007 saying that LME copper price fell after China GDP slowed. In addition, senior analyst Mr. Frik Els said that China accounts for nearly half of global metal demand, and its GDP slowdown is not only the core of the decline in commodity price, but also the core of the global stock market crash. This point of view indirectly shows the important impact of the Chinese economy on global copper price.[65]

According to traditional economic theory, product price should be determined by supply and demand, but from the empirical results, global copper consumption is insignificant to explain changes in copper price, this is inconsistent with the opinion of Mr. Jim Burstein.

[63] My metal.net [online]:"Interpret economic data and analyze copper price trends" 2002. WWW: <https://www.mymetal.net/02/0424/00/188F57FB7C619E03.html>

[64] Fastmarkets MB [online]:"Copper prices weaker after China GDP data" 2013. WWW: <https://www.metalbulletin.com/Article/3231187/LME-OFFICIALS-Copper-prices-weaker-after-China-GDP-data.html>

[65] Mining.com [online]: "The one copper price vs China chart you want to see today" 2016. WWW: <http://www.mining.com/the-one-copper-price-vs-china-chart-you-need-to-see-today/>

Article published by Japanese scholar Tsuyoshi Adachi in 2018 argue that financial speculation amplifies copper price volatility, leading to the demand theory can not explain price trends.[66] This view is currently generally accepted. The hedging property of the futures market has caused the price of commodities to be separated from the traditional supply-demand relationship framework, and is increasingly controlled by financial capital.

The most unexpected finding in this research test is the impact of Shanghai (SHFE) copper futures price on global copper price is so significant, even far more exceeding crude oil, gold and IPI. In response to this conclusion, scholars from different countries have different voices. According to the report from Fusheng Huang[67]who had made the research in 2006 on the interaction between SHFE and LME copper market, it shows that the fluctuation of global copper price (LME) has a greater influence on China's copper market, reaching 40% and increasing, while China's copper market price has less impact on global copper price. Besides this, another report from "LME INSIGHT" also indicates that Shanghai copper market can still be said to follow, rather than to lead, the global copper price, which still retains its home at the LME.[68] I believe that for the issue that how much does the Chinese factor (Shanghai copper price) affect global copper price, it is normal to have different opinions in different stage and position. With the rapid development of China's economy and China's increasing participation in international trade, the impact of China's copper price on global copper prices is increasing, it is a good signal to show that the time for further opening up the Chinese copper market is ripe. China futures market can be integrated into the international market as quickly as possible through openness and internationalization, which will greatly help China obtain "pricing power".

China's copper industry lacks the right to speak in the international copper market and its competitiveness is weak. This conclusion is basically recognized in the international community. The Chinese government and enterprises are also working hard to change this

[66] Redfame [online]: "The Role of Financial Speculation in Copper Prices" 2018.
WWW: < file:///C:/Users/asus/Downloads/3182-16245-1-PB%20(1).pdf>

[67] Sina [online]: " Research and Analysis of Copper Price Correlation in LME and SHFE Markets" 2006.
WWW: <http://finance.sina.com.cn/money/future/20061108/08563059174.shtml>

[68] LME Insight [online] : "How do London and Shanghai markets interact?" 2017. WWW:
<file:///C:/Users/asus/Downloads/LME%20Insight%20The%20Asian%20connection%20how%20do%20LME%20and%20Shanghai%20metal%20markets%20interact%20(1).pdf>

embarrassing situation.

However, this study only proves the key factors affecting the global copper price, but can not draw detailed conclusions on the internal mechanism of how it affects the global copper price, it has limited guidance on the actual operation of the market.

All in all, in the face of fierce global competition, it become more urgent and inevitable for China's copper industry to insists on innovation and vigorously develop the model of integration of production, trade and finance to enhance global competitiveness. Besides these, participating more in global cooperation, learning the advanced experience of other countries and knowing the rules of the international trade become more essential. It is a development direction for China's copper industry in the future.

6. References

6.1 Literature

1. Yining, Li. “Chinese Economy in Dual Transition ” 2013. p.78. ISBN: 9787300181400

2. GALLANT, A R. “An introduction to econometric theory : measure-theoretic probability and statistics with applications to economics” 1997. p. 23. ISBN:0691016453.

3. Krugman,P.R.,Obstfeld,M.,Melitz,M.J. “International Economics” 2012. p. 543. ISBN:9780132146654

4. Greene, William. “Econometric Analysis” 2003. p. 7. ISBN: 0-13-066189-9

5. Todaro,M.P & Smith,S.C. “Economic Development” 2014. p.688 ISBN: 9780133406788

6. T. Elwell & I. R. Scholes. “Analysis of Copper and Its Alloys” 1967. p.14. ISBN: 9781483149509

7. Derviş,K. Publisher: “Center for Global Development” 2005. p. 46. ISBN: 0815717636

8. Vance, Martin. “Econometric Modelling with Time Series - Specification, Estimation and Testing” 2012. p. 161. ISBN: 9780521139816

9. Jorgenson, Dale. “Econometrics - Econometric Modeling of Producer Behavior.” 2000. p. 20. ISBN: 9780262100823

10. Leeflang, Peter: “Advanced Methods for Modeling Markets” 2017. p. 363. ISBN: 9783319534695

11. Studenmund, A. H.:“Using Econometrics - A Practical Guide”2014. p. 9. ISBN: 9781292021270

12. Allen, Michael: “Understanding Regression Analysis.” 2004. p. 176. ISBN: 978-0306484339

13. Carter, Hill: "Principles of Econometrics." 2010. p. 183. ISBN: 978-0470626733.

14. Ramu, Ramanathan: “Introductory Econometrics with Applications” 2001. p. 34. ISBN: 978-0030343421

6.2 Internet sources

1. Investopedia [online]:“Econometrics Definition” 2018. [Cited: 18.02.2019].Available at: https://www.investopedia.com/terms/e/econometrics.asp
2. Statistics Solutions [online]: “Assumptions of Linear Regression” 2017. [Cited: 18.02.2019].Available at: http://www.statisticssolutions.com/assumptions-of-linear-regression
3. Lumen Learning [online]: “Economic Models” 2009. [Cited: 18.02.2019]. Available at: https://courses.lumenlearning.com/boundlesseconomics/chapter/economic-models
4. Statistics How to [online]: “Endogenous Variable and Exogenous Variable: Definition and Classifying” . [Cited: 18.02.2019]. Available at: https://www.statisticshowto.datasciencecentral.com/endogenous-variable/
5. Encyclopedia.com[online]: “Ordinary Least Squares Regression” 2008. [Cited: 18.02.2019].Available at: https://www.encyclopedia.com/social-sciences/applied-and-social-sciences-magazines/ordinary-least-squares-regression
6. Investopedia: [online]: “Porter's 5 Forces” 2018. [Cited: 18.02.2019]. Available at: https://www.investopedia.com/terms/p/porter.asp
7. Asia Metal [online]:“Copper: smelting and classification” 2016. [Cited: 18.02.2019]. Available at: http://metalpedia.asianmetal.com/metal/copper/extraction.shtml
8. IISD.ORG [online]:“Sustainable Development and the Global Copper Supply Chain: International research team report”2011. [Cited: 18.02.2019].Available at: https://www.iisd.org/sites/default/files/publications/sus_dev_chinese_copper.pdf

9. ICSG [online]: “The world copper factbook 2018” 2019. [Cited: 18.02.2019]. Available at: https://www.icsg.org/index.php/component/jdownloads/finish/170/2876
10. Statista [online]: “Global copper reserves as of 2017, by country” 2018. [Cited: 18.02.2019]. Available at: https://www.statista.com/statistics/273637/copper-reserves-by-country/
11. Statista [online]: “Total copper mine production worldwide from 2006 to 2017” 2018. [Cited: 18.02.2019]. Available at: https://www.statista.com/statistics/254839/copper-production-by-country/
12. OEC [online]: “Copper ores and concentrates” 2018. [Cited: 11.03.2019]. Available at: https://atlas.media.mit.edu/en/profile/hs92/260300/
13. ICSG [online]: “Copper: Preliminary Data for 1st Half 2018”2018. [Cited: 11.03.2019]. Available at: https://www.icsg.org/index.php/component/jdownloads/finish/114/2869?Itemid
14. Statista [online]: “Distribution of refined copper production worldwide in 2017” 2018.[Cited: 11.03.2019]. Available at: https://www.statista.com/statistics/605555/distribution-of-global-refined-copper-production-by-select-country/
15. Geology.com [online]: “Facts About Copper” 2018. [Cited: 11.03.2019].Available at: https://geology.com/usgs/uses-of-copper/
16. Atlantis Press [online]: “Study on Copper Consumption in China and Abroad” 2016. [Cited: 11.03.2019].Available at: file:///C:/Users/asus/Downloads/25861271%20(1).pdf
17. DBS[online]:“Copper And Its Electrifying Future”2018.[Cited:11.03.2019].Available at: file:///C:/Users/asus/Downloads/181004_insights_copper_and_its_electrifying_future.pdf
18. World Bureau of Metal Statistics[online]:“News and announcements” 2018. [Cited: 11.03.2019]. Available at: http://www.world-bureau.com/readnews.asp?id=63
19. Statista [online]: “Major countries in copper mine production worldwide from 2010 to 2018”2019. [Cited: 15.03.2019].Available at: https://www.statista.com/statistics/264626/copper-production-by-country/
20. Freedonia[online]:“World Copper” 2019. [Cited: 11.03.2019].Available at:

https://www.freedoniagroup.com/industry-study/world-copper-3274.htm

21. Green car congress [online]: “BNEF forecasts EVs to hit 54% of new car sales by 2040; decreasing importance of PHEVs” 2017. [Cited: 15.03.2019]. Available at: https://www.greencarcongress.com/2017/07/20170706-bnef.html
22. Mining-technology [online]: “Belt and Road: how China’s global plans will affect copper” 2018. [Cited: 11.03.2019].Available at: https://www.mining-technology.com/features/how-chinas-global-plans-will-affect-copper/
23. Aurubis[online]: “LME / Hedging” 2017.[Cited: 15.03.2019].Available at: https://belgium.aurubis.com/fileadmin/media/pdf/CH/Hedging_at_Aurubis.pdf
24. Unrisd [online]: “Valueworks: Effects of Financialization along the Copper Value Chain” 2018. [Cited: 15.03.2019].Available at: http://www.unrisd.org/unrisd/website/projects.nsf/(httpProjects)/E340375ACE363D36C12580B2004C8053?OpenDocument
25. Independent Australia [online]: “Who owns corporate Australia?” 2013. [Cited: 11.03.2019]. Available at: https://independentaustralia.net/business/business-display/who-owns-corporate-australia,5033
26. Marketscreener [online]: “Shareholders” 2018. [Cited: 11.03.2019].Available at: https://www.marketscreener.com/GLENCORE-29423547/company/?iCStream=1
27. Mitsui [online]: “Major Activities” 2018. [Cited: 15.03.2019]. Available at: https://www.mitsui.com/ap/en/business/1216135_9193.html
28. The New York Times [online]: “Glencore to Sell Peruvian Mine to Chinese Group for $6 Billion” 2014 [Cited: 15.03.2019]. Available at: https://dealbook.nytimes.com/2014/04/14/chinese-consortium-buys-peru-mine-for-6-billion/
29. Mining.com [online]: “China's CITIC to be Ivanhoe Mine’s top shareholder in $548m-deal” 2018. [Cited: 11.03.2019]. Available at: http://www.mining.com/chinas-citic-ivanhoe-mines-top-shareholder-548m-deal/
30. IMF NEWS [online]: “IMF Adds Chinese Renminbi to Special Drawing Rights Basket” 2016.[Cited: 15.03.2019]. Available at: https://www.imf.org/en/News/Articles/2016/09/29/AM16-NA093016IMF-Adds-Chinese-Renminbi-to-Special-Drawing-Rights-Basket

31. Copper Development Association [online]:“Copper: Properties and Applications” 2018. [Cited: 22.03.2019]. Available at: https://copperalliance.org.uk/knowledge-base/education/education-resources/copper-propertie s-applications/
32. Metalbulletin [online]:“Copper substitutes caused by high copper price”2011. [Cited: 22.03.2019]. Available at: https://www.metalbulletin.com/events/download.ashx/document/speaker/6513/a0ID000000X0jLpMAJ/Presentation
33. ICSG [online]: “Global Copper Scrap Flows:Where From, Where To, and How Much?”2012.[Cited: 22.03.2019]. Available at: https://www.metalbulletin.com/events/download.ashx/document/speaker/6539/a0ID000000X0jULMAZ/Presentation
34. SASAC[online]: “Research on the integration of industry and finance” 2018. [Cited: 22.03.2019]. Available at: http://www.sasac.gov.cn/n2588025/n4423279/n4517386/n8658245/c8762203/content.html
35. Statistics How To [online]: “Explanatory Variable & Response Variable: Simple Definition and Uses.” 2015. [Cited: 22.03.2019]. Available at: http://www.statisticshowto.com/explanatory-variable
36. CEO.CA [online]: “What Does Oil have to do with Copper?” 2015 [Cited: 22.03.2019]. Available at: http://blog.ceo.ca/2015/01/20/what-does-oil-have-to-do-with-copper/
37. Investopedia [online]: “Why the Price of Crude Oil Dropped in 2015” 2018. [Cited: 22.03.2019]. Available at: https://www.investopedia.com/articles/investing/102215/4-reasons-why-price-crude-oil-dropped.asp
38. TheMotley Fool [online]: “7 Common Factors That Influence Gold Prices” 2016. [Cited: 22.03.2019]. Available at: https://www.fool.com/investing/2016/10/13/7-common-factors-that-influence-gold-prices.aspx
39. Business Today[online]:“Gold prices slip, head for worst weekly drop” 2016.[Cited: 22.03.2019]. Available at: https://www.businesstoday.in/markets/commodities/gold-prices-slip-head-for-worst-w

eekly-drop-since-november-2015/story/238280.html

40. Investopedia [online]: “Industrial Production Index - IPI” 2017. [Cited: 22.03.2019]. Available at: https://www.investopedia.com/terms/i/ipi.asp
41. Timeline [online]: “The U.S.Financial Crisis” 2018.[Cited: 22.03.2019]. Available at: https://www.cfr.org/timeline/us-financial-crisis
42. Wall Street [online]: “Prospects for the copper market in 2019” 2018 .[Cited: 22.03.2019]. Available at: https://wallstreetcn.com/articles/3451828
43. National Information Center [online]: “Analysis of the cyclical factors of GDP trend” 2017 [Cited: 22.03.2019]. Available at: http://www.sic.gov.cn/News/455/7665.htm
44. ScienceDirect [online]: “Estimating global copper demand until 2100 with regression and stock dynamics” 2018 [Cited: 22.03.2019]. Available at: https://www.sciencedirect.com/science/article/pii/S0921344918300041#bib0190
45. Agri-Pulse [online]: “The world copper factbook 2017” 2018. [Cited: 22.03.2019]. Available at: https://www.icsg.org/index.php/component/jdownloads/finish/170/2462
46. Statista [online]: “Refined copper usage worldwide” 2017. [Cited: 22.03.2019]. Available at: https://www.statista.com/statistics/267849/global-consumption-for-copper-in-2006/
47. OLME [online]: “The Asian connection: How do London and Shanghai market interact? ” 2017 [Cited: 22.03.2019]. Available at: https://www.lme.com/en-GB/Education-and-events/Online-resources/LME-insight/The-Asian-connection
48. Business and Economics Journal [online]: “Parameter Estimation” 2017. [Cited: 22.03.2019]. Available at: https://www.omicsonline.org/scholarly/parameter-estimation-journals-articles-ppts-list.php
49. Minitab [online]: “Regression Analysis - How Do I Interpret R-squared and Assess the Goodness-of-Fit” 2013. [Cited: 22.03.2019]. Available at: http://blog.minitab.com/blog/adventures-in-statistics-2/regression-analysis-how-do-i-interpret-r-squaredand-assess-the-goodness-of-fit
50. ADMIRAL METALS [online]: “Copper & oil prices: A look at the correlation” 2015. [Cited: 22.03.2019]. Available at: https://www.admiralmetals.com/admiral-metals/copper-oil-prices-a-look-at-the-correla

tion/

51. IU [online]: “How the Gold-to-Copper Ratio Can Make You a Smarter Investor” 2018. [Cited: 22.03.2019]. Available at: https://www.investmentu.com/article/detail/59066/how-gold-to-copper-ratio-make-you-smarter-investor#.XI16mlz0nIU
52. My metal.net [online]:“Interpret economic data and analyze copper price trends” 2002. [Cited: 22.03.2019]. Available at: https://www.mymetal.net/02/0424/00/188F57FB7C619E03.html
53. Fastmarkets MB [online]:“Copper prices weaker after China GDP data” 2013. [Cited: 22.03.2019]. Available at: https://www.metalbulletin.com/Article/3231187/LME-OFFICIALS-Copper-prices-weaker-after-China-GDP-data.html
54. Mining.com [online]: “The one copper price vs China chart you want to see today” 2016. [Cited: 22.03.2019]. Available at: http://www.mining.com/the-one-copper-price-vs-china-chart-you-need-to-see-today/
55. Redfame [online]: “The Role of Financial Speculation in Copper Prices” 2018. [Cited: 22.03.2019]. Available at: file:///C:/Users/asus/Downloads/3182-16245-1-PB%20(1).pdf
56. Sina [online]: “ Research and Analysis of Copper Price Correlation in LME and SHFE Markets” 2006. [Cited: 22.03.2019]. Available at: http://finance.sina.com.cn/money/future/20061108/08563059174.shtml
57. LME Insight [online] : “How do London and Shanghai markets interact?” 2017. [Cited: 22.03.2019]. Available at: file:///C:/Users/asus/Downloads/LME%20Insight%20The%20Asian%20connection%20how%20do%20LME%20and%20Shanghai%20metal%20markets%20interact%20(1).pdf