CZECH UNIVESRITY OF LIFE SICENCES PRAGUE

Faculty of Economics and Management

Department of Economics

Master's Thesis

A Gravity Model Analysis of International Copper Trade.

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

DIPLOMA THESIS ASSIGNMENT

Bc. Moses Kasolo, BSc

Economics and Management

Thesis title

A Gravity Model Analysis of international Copper trade.

Objectives of thesis

To determine the bilateral trade flow of copper among selected countries?
To determine and analyze the trade determinates of copper trade among selected countries
To estimate the cost of trade of copper among selected countries.
To forecast copper export/import in the coming decade using augmented gravity Model.

Methodology

in order to answer the underlined research question, the gravity model of trade will be utilized:

The gravity model is an economist-acclaimed econometric model for analyzing trade to capture both qualitative and quantitative effects of trade determinants. The gravity model is has gained enormous popularity because it has room to improve the model with econometric enrichment and techniques to provide exciting concepts for future research on international trade.

Data of the volume of copper in it raw form will be collected from leading international exporters and exporters of copper, I will then convert the data to fit the recommended Panel data form for the econometric model analysis. To analyze the trade direction of copper, I will use the traditional gravity model with variables of GDP and distance of trading countries. To answer the other research questions I will augment the gravity model to include more quantitative and qualitative variables like a common language, common border, free trade zones, and Price of Copper to estimate and determine the state of international Copper trade.

The proposed extent of the thesis

60 pages

Keywords

panel data, empirical economic, gravity models, international trade, dynamics, cross-sectional dependence, fixed effects, random effects

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Recommended information sources

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Summary:

In the thesis titled "A Gravity Model Analysis of International Copper Trade," I conducted a thorough investigation into the factors that influence the international trade of copper by employing the gravity model of trade. The analysis explores several key variables, such as GDP of trading partners, distance between countries, population size, shared borders, common languages, and trade agreements, to determine their impact on copper trade volumes.

The findings reveal that the GDP of both trading partners has a strong and statistically significant positive relationship with the copper trade. This indicates that as the GDP of either trading partner increases, the copper trade volume between them also grows, underlining the importance of economic strength in fostering trade relationships.

Conversely, the distance between trading partners, population size, shared borders, and common languages did not display statistically significant relationships with copper trade volumes. This suggests that these factors might not be as crucial in determining copper trade as previously assumed.

One notable finding of the study is the positive and statistically significant relationship between trade agreements and copper trade. This indicates that when countries enter into trade agreements, it can have a substantial impact on the trade of copper, likely due to reduced barriers and increased cooperation.

Overall, the thesis sheds light on the key drivers of international copper trade, emphasizing the role of economic strength and trade agreements in shaping trade dynamics, while also challenging the traditional assumption that factors like distance, population size, shared borders, and common languages are crucial determinants of copper trade volumes.

Souhrn:

V diplomové práci s názvem "Analýza mezinárodního obchodu s mědí pomocí gravitačního modelu" jsem provedla důkladné zkoumání faktorů, které ovlivňují mezinárodní obchod s mědí, a to pomocí gravitačního modelu obchodu. Analýza zkoumá několik klíčových proměnných, jako je HDP obchodních partnerů, vzdálenost mezi zeměmi, počet obyvatel, společné hranice, společné jazyky a obchodní dohody, s cílem určit jejich vliv na objem obchodu s mědí.

Zjištění ukazují, že HDP obou obchodních partnerů má silný a statisticky významný pozitivní vztah k obchodu s mědí. To znamená, že s růstem HDP jednoho z obchodních partnerů roste i objem obchodu s mědí mezi nimi, což podtrhuje význam ekonomické síly pro podporu obchodních vztahů.

Naopak vzdálenost mezi obchodními partnery, počet obyvatel, společné hranice a společné jazyky nevykazují statisticky významný vztah k objemu obchodu s mědí. To naznačuje, že tyto faktory nemusí být při určování obchodu s mědí tak zásadní, jak se dříve předpokládalo.

Pozoruhodným zjištěním studie je pozitivní a statisticky významný vztah mezi obchodními dohodami a obchodem s mědí. To naznačuje, že pokud země uzavřou obchodní dohody, může to mít podstatný vliv na obchod s mědí, pravděpodobně v důsledku snížení překážek a zvýšení spolupráce.

Celkově práce osvětluje klíčové faktory mezinárodního obchodu s mědí, přičemž zdůrazňuje roli ekonomické síly a obchodních dohod při utváření dynamiky obchodu a zároveň zpochybňuje tradiční předpoklad, že faktory jako vzdálenost, počet obyvatel, společné hranice a společné jazyky jsou rozhodujícími faktory určujícími objem obchodu s mědí.

Declaration:

I declare that I have worked on my master's thesis titled "A Gravity Model Analysis of International Copper Trade" by myself and I have used only the sources mentioned at the end of the thesis.

As the author of the master's thesis, I declare that the thesis does not break any copyrights.

In Prague on 23/03/2023

Acknowledgements

I would like to express my profound gratitude to my thesis supervisor, Ing. Petr Procházka, MSc, Ph.D, for their invaluable guidance, support, and mentorship throughout the entire process of conducting this research. Their expertise, encouragement, and patience have been crucial to the successful completion of this thesis.

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I would like to acknowledge the data sources used in this research, particularly the UN Comtrade Database, World Bank's World Development Indicators, CEPII Database, World Trade Organization, and CIA World Factbook. Their comprehensive data and information were crucial for the successful completion of this study.

Lastly, I would like to express my heartfelt appreciation to my God Jesus Christ for the providing the strength and Moral Support, My family and friends for their unwavering support, understanding, and encouragement throughout my academic journey. Your belief in me has been a constant source of motivation and inspiration.

Table of Contents:

1: INTRODUCTION:

1.1: Abstract.

This study investigates the determinants of international Copper ore trade between countries over the period from 2012 to 2021, using a dataset of 871 observations. The analysis employs a multiple regression model to examine the impact of various factors on trade, including GDP, distance, population, trade agreements, border proximity, and common language.

The results reveal a strong positive relationship between the GDP of both trading partners (lnGDPit and lnGDPjt) and the volume of trade, with statistically significant coefficients at the 1% level. This finding supports the notion that larger economies tend to engage in more international trade. In contrast, the negative coefficient for the distance between trading partners (lnDistanceij) is statistically insignificant, suggesting that distance may not be a crucial factor in determining trade flows in the period 2012 to 2021.

Population size (lnPOPit and lnPOPjt) also shows a positive but statistically insignificant relationship with trade, indicating that larger populations may not necessarily lead to increased trade. On the other hand, the presence of trade agreements (TDAgreementst) has a positive and statistically significant impact on trade at the 5% level, implying that countries with trade agreements tend to experience higher trade volumes.

The results for border proximity (Border) and common language (Common_Languageij) show positive coefficients, but they are not statistically significant. This suggests that these factors may have limited influence on trade between countries during the study period.

In conclusion, this study highlights the importance of economic size and trade agreements as key drivers of international trade, while other factors such as distance, population, border proximity, and common language appear to have a lesser impact. These findings can inform policymakers in their efforts to promote trade and economic growth.

1.1.1: Diplomová práce Abstrakt

Diplomová práce zkoumá ukazatele mezinárodního obchodu měděné rudy mezi jednotlivými státy v období 2012 až 2021 s výzkumným vzorkem o velikosti 871 observací. Tato studie využívá vícenásobný regresní model k vyhodnocení vlivů jednotlivých faktorů na obchod, včetně HDP, vzdálenosti, populace, obchodních dohod, blízkosti hranic a společného jazyka.

Výsledky ukazují pozitivní vztah HDP mezi oběma obchodními partnery (lnGDPit a lnGDPjt) a s objemem obchodu vedoucím k významným statistickým koeficientům na úrovni jednoho procenta (1%). Toto zjištění přispívá k názoru, že velké ekonomiky mají tendenci se více angažovat v mezinárodním obchodu. Naproti tomu negativní koeficient vzdálenosti mezi obchodními partnery (lnVzdálenostij) je statisticky nevýznamný, což naznačuje, že vzdálenost nemusí být rozhodujícím faktorem při určování obchodních toků.

Velikost populace (lnPOPit a lnPOPjt) také reprezentují pozitivní avšak statisticky zanedbatelný vztah s obchodem - větší populace nemusí nezbytně vést k nárůstu obchodu. Naopak existence obchodních dohod (TDAgreementst) má pozitivní a statisticky důležitý vliv na obchod na úrovni pěti procent (5%). Toto potvrzuje, že státy s obchodními dohodami mohou zažívat větší objem obchodu.

Výsledky pro blízkost hranic (Border) a společný jazyk (Common_Languageij) ukazují pozitivní koeficienty, ale nejsou vyznamné statisticky. Tyto faktory proto mohou naznačovat limitující vliv na obchod mezi jednotlivými státy porovnávané v této studii.

Tato studie vede k závěru, že klíčové determinanty mezinárodního obchodu je velikost ekonomiky a množství obchodních dohod. Zatímco, výsledky pro zbytek faktorů jako je vzdálenost, populace, blízkost hranic a společný jazyk mají menší vliv. Političtí aktéři mohou využít tyto nálezy při jejich snaze propagovat obchod a ekonomický růst.

1.2. Background and Motivation:

Copper is a highly traded commodity with significant economic value in various industries, such as construction, electronics, transportation, and energy. As a globally traded metal, copper plays an essential role in the international trade system, with exports valued at around US$120 billion in 2020. The largest exporters of copper are Chile, Peru, and China, while the largest importers are the United States, China, and Japan, according to the World Bank.

The copper market has been subject to significant fluctuations in recent years, driven by changes in global supply and demand, macroeconomic conditions, and trade policies. For instance, the COVID-19 pandemic has led to disruptions in copper production and transportation in many countries, leading to supply shortages and price volatility. Moreover, ongoing trade tensions between the United States and China have further impacted copper trade flows between these countries and their trading partners.

Given the economic importance of copper and the challenges it faces, understanding the factors that influence international copper trade is crucial for policymakers, industry players, and investors to make informed decisions and mitigate risks. The Gravity Model of trade provides a useful framework for analyzing the determinants of trade flows, including the role of distance and other factors in trade patterns.

Therefore, this study aims to investigate the determinants of international copper trade using a Gravity Model approach. Specifically, we will examine the impact of production, consumption, prices, transportation costs, and trade policies on the bilateral trade flows of copper between countries. By providing new empirical evidence and insights into the dynamics of the copper market, this study will contribute to the literature on international trade and help stakeholders to better understand the determinants of copper trade flows.

1.3: Introduction to International Copper Trade (2012-2021)

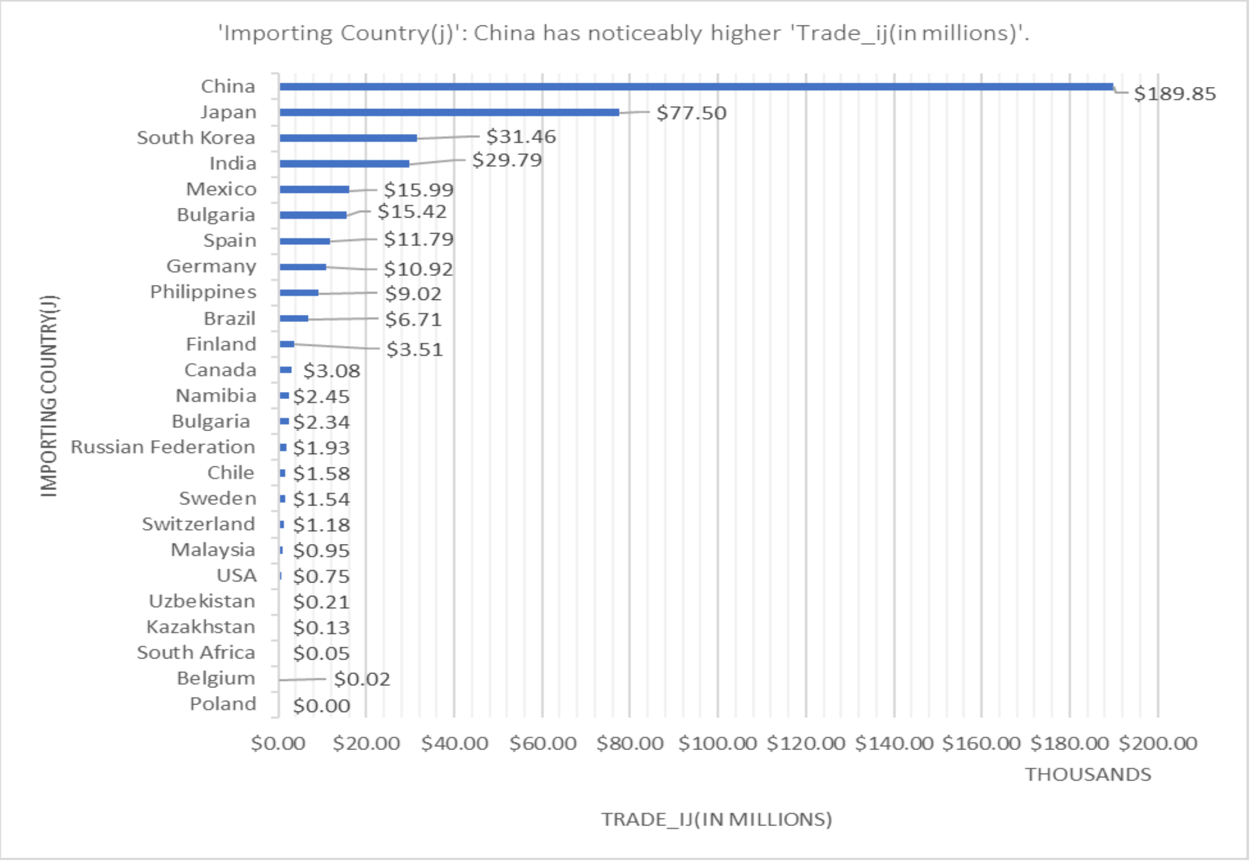
The period between 2012 and 2021 witnessed significant changes in the landscape of the global copper trade, with various countries emerging as key players in both the export and import markets. The **following graph** will provide a brief **overview of** the main countries involved in the international copper trade **also used in this study:**

Table 1 List of Major Exporting and Importing Countries analyzed in this thesis in the period 2012-2021

Export Countries	Import Countries	Export Countries	Import Countries	Export Countries	Import Countries
Peru	China	Canada	China	Chile	China
	Japan		Japan		Japan
	South Korea		South Korea		South Korea
	Germany		Germany		India
	India		Finland		Germany
	Spain		Philippines		Spain
	Bulgaria		India		Bulgaria
	Philippines		USA		Brazil
	Namibia		Bulgaria		Finland
	Malaysia		Sweden		Malaysia
	Finland		Spain		Mexico
	Canada	Australia	South Korea		Philippines
	Chile		India		Sweden
	Mexico		China	USA	Mexico
	Brazil		Japan		China
Indonesia	Japan		Philippines		Canada
	China	Spain	China		Japan
	South Korea		Germany		Philippines
	India		Bulgaria		South Korea
	Philippines				Belgium
	Spain	Canada	China		India
Turkey	Bulgaria		Japan		Malaysia
	Sweden		South Korea	Germany	Sweden
	China		Germany		Belgium
	Spain		Finland		Canada
	China		Philippines	Indonesia	Japan
Zambia	South Africa		India		China
	Switzerland		USA		South Korea
	China		Bulgaria		India
Russian	Kazakhstan		Sweden		Philippines
	Germany		Spain		
	China				
Kazakstan	China	Georgia	China	Armenia	Switzerland
	Russia		Bulgaria		China
	Uzbekstan		Spain		Bulgaria
Bulgaria	Namibia				
	China				
	Poland				

Source: Author created

Figure 1: Shows Major Importing Countries of Copper Ore.



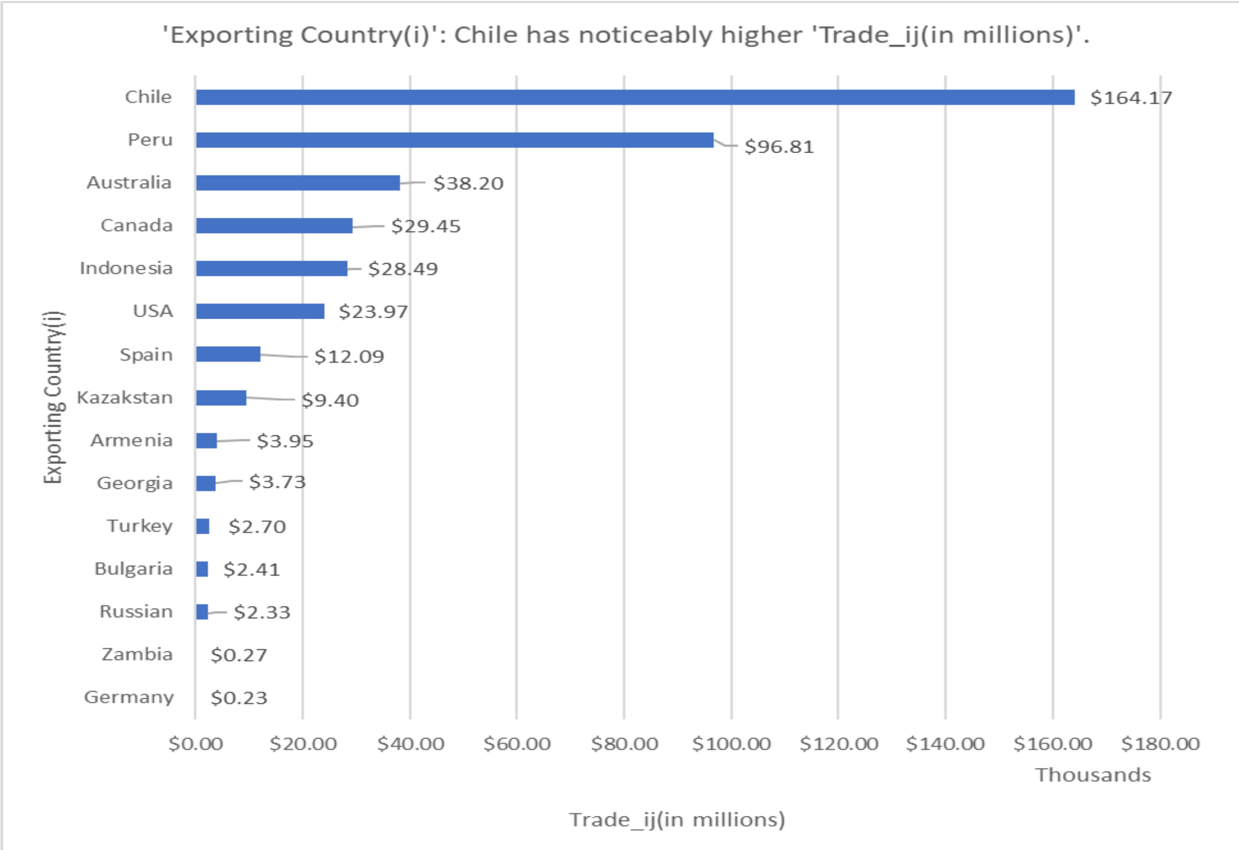
Source: WITS, World Integrated Trade Solution

The largest importing region is Asia, with a total trade value of $267,046.35 million. The top four importing countries in Asia are China, Japan, South Korea, and India, with trade values of $189,849.54 million, $77,504.67 million, $31,459.05 million, and $29,791.30 million, respectively.

The second largest importing region is Europe, with a total trade value of $46,304.62 million. The top four importing countries in Europe are Bulgaria, Spain, Germany, and Finland, with trade values of $15,415.23 million, $11,785.63 million, $10,918.31 million, and $3,509.88 million, respectively. The third largest importing region is North America, with a total trade value of $3,830.65 million. The top importing country in North America is Mexico, with a trade value of $15,988.89 million.

Other regions include South America, with a total trade value of $1,581.96 million, and Africa with a total trade value of $2,503.23 million. The top importing countries in South America and Africa are Brazil and Namibia, with trade values of $6,705.41 million and $2,450.78 million, respectively.

Figure 2: Shows Major Exporting Countries of Copper Ore



Source: WITS, World Integrated Trade Solution

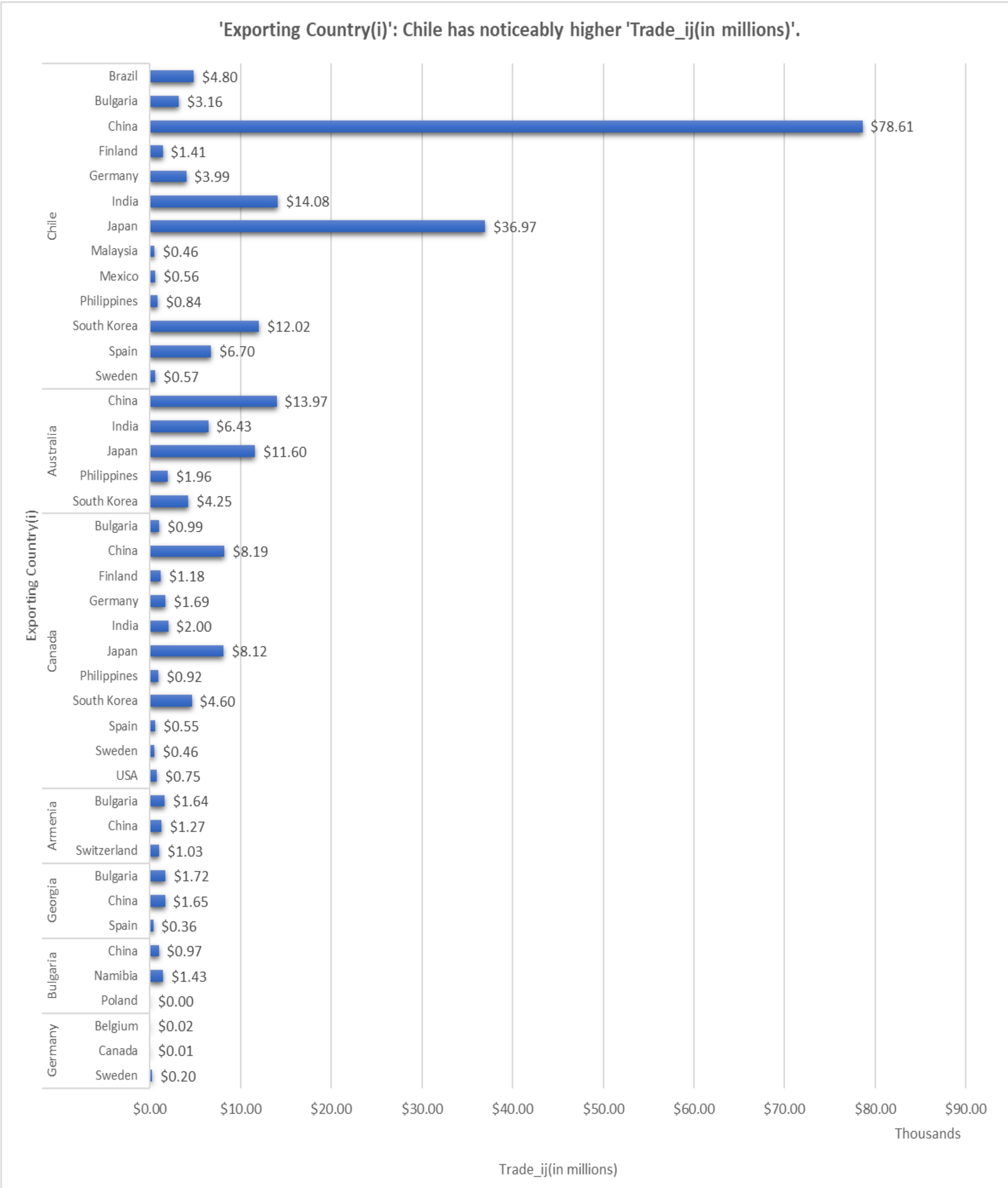
The provided data shows the total value of copper ore trade by exporting countries, with a grand total of $418,172.187 million.

The top three copper ore exporting countries are Chile with a trade value of $164,166.773 million, followed by Peru with a trade value of $96,808.871 million, and Australia with a trade value of $38,198.841 million.

Other significant copper ore exporting countries include Canada with a trade value of $29,446.837 million, Indonesia with a trade value of $28,491.412 million, and the USA with a trade value of $23,968.778 million.

The remaining exporting countries are Armenia, Bulgaria, Georgia, Germany, Kazakhstan, Russia, Spain, Turkey, and Zambia, with respective trade values of $3,948.428 million, $2,410.354 million, $3,728.817 million, $228.379 million, $9,397.593 million, $2,330.936 million, $12,085.042 million, $2,695.251 million, and $265.875 million.

Figure 3 Shows the Share of Major Exporting and Importing Countries of Copper Ore in Period 2012-2021.



Source: WITS, World Integrated Trade Solution

1.4: Description of total copper ore concentrate traded between 2012 to 2021.

This data presents information on the trade relationships between various exporting countries and their importing partners between the years 2012 to 2021. The table shows the exporting country, the importing country, and the sum of distance between them in terms of trade value.

Peru had the highest total trade value at $1,826,950, with its top import partners being Malaysia, India, and South Korea. Chile was the second-highest with $1,805,000 in total trade value, with China, Japan, and South Korea being its top import partners. Canada had a total trade value of $808,500, with India, the Philippines, and South Korea being its top import partners.

The United States had a total trade value of $711,300, with India, Malaysia, and South Korea being its top import partners. Australia had a total trade value of $364,000, with India, China, and South Korea being its top import partners. Indonesia had a total trade value of $274,000, with China, Japan, and South Korea being its top import partners.

Bulgaria had a total trade value of $185,000, with China and Namibia being its top import partners. Zambia had a total trade value of $175,000, with China, Switzerland, and South Africa being its top import partners. Spain had a total trade value of $133,000, with China, Bulgaria, and Germany being its top import partners. Turkey had a total trade value of $124,000, with China, Spain, and Sweden being its top import partners.

Georgia had a total trade value of $107,000, with China, Spain, and Bulgaria being its top import partners. Armenia had a total trade value of $104,000, with China, Switzerland, and Bulgaria being its top import partners. Germany had a total trade value of $72,000, with Canada and Sweden being its top import partners. Finally, Russia had a total trade value of $30,500, with China and Germany being its top import partners.

The grand total of trade value between all countries was $6,747,750.

1.5: The importance of copper in the global economy.

Copper is a metal of utmost importance to the global economy. It is one of the most widely used commodities across various sectors, including infrastructure development and modern technology. Copper's global demand is driven by several factors, such as economic growth, population expansion, urbanization, and the increasing use of renewable energy.

The construction industry is the largest consumer of copper, accounting for approximately 45% of the global demand. Copper has excellent thermal conductivity and corrosion resistance, making it a popular material for plumbing, roofing, electrical wiring, and heating systems. The metal is also used in the manufacturing of pipes, tubes, and fittings that transport water, gas, and other liquids.

The transportation industry is the second-largest consumer of copper, accounting for around 25% of the global demand. Copper is an important component in the production of cars, trains, airplanes, and ships. It is used in engines, brakes, radiators, and electrical systems, making it a critical metal in the industry.

The electronics industry is the third-largest consumer of copper, accounting for approximately 12% of the global demand. Copper is an excellent conductor of electricity and heat, making it a popular choice for the production of electronic devices such as smartphones, tablets, computers, and televisions. It is a critical component in circuit boards, wires, connectors, and switches.

Other industries that rely heavily on copper include renewable energy, power generation, and telecommunications. Copper is a critical component in the production of wind turbines, solar panels, transformers, and electrical grids. It is also widely used in telephone and internet cables, making it an essential metal in the telecommunications industry.

Copper's importance in the global economy cannot be overstated. Its excellent properties, such as thermal and electrical conductivity, durability, and corrosion resistance, make it an indispensable metal across various industries. With the world's growing demand for copper, the metal's importance will continue to increase in the coming years.

1.6: Applications of copper in various industries.

Construction Industry: Copper is widely used in the construction industry for various purposes. It is a popular material for plumbing and heating systems due to its excellent thermal conductivity and corrosion resistance. Copper pipes and tubes are also widely used in air conditioning and refrigeration systems. Copper roofing is a popular choice for its durability and resistance to corrosion. Copper is also used in the production of building facades, statues, and other decorative elements.

Transportation Industry: Copper is a critical component of the transportation industry. It is used in the production of cars, trucks, airplanes, and ships. Copper wiring and electrical components are used in various parts of vehicles, including engines, brakes, and electrical systems. Copper alloys are also used in the manufacturing of bearings, gears, and other mechanical parts.

Electronics Industry: Copper is widely used in the production of electronic devices, including smartphones, tablets, computers, and televisions. Copper is an excellent conductor of electricity and heat, making it a popular choice for circuit boards, wires, and connectors. Copper alloys are also used in the manufacturing of switches, connectors, and relays.

Renewable Energy: Copper is a critical component in the production of renewable energy systems, including wind turbines and solar panels. Copper wiring and components are used in the production of these systems due to their excellent electrical conductivity and durability. Copper is also used in the manufacturing of geothermal and hydropower systems.

Power Generation: Copper is used in various parts of power generation systems, including transformers, generators, and motors. Copper is an excellent conductor of electricity, making it an essential component in these systems. Copper alloys are also used in the manufacturing of bearings, bushings, and contacts.

Telecommunications: Copper is widely used in the telecommunications industry, including telephone and internet cables. Copper wiring is an essential component in these systems due to its excellent electrical conductivity and durability. Copper alloys are also used in the manufacturing of connectors and other components.

1.7: Discussion of the role of international trade in the copper market.

The copper market relies heavily on international trade as it is a global commodity whose demand and supply are influenced by various factors such as economic growth, population growth, urbanization, and the increasing use of renewable energy. Through international trade, copper-producing countries can export their surplus production to meet the demand of other countries, while copper-consuming countries can import copper to meet their needs.

The largest copper-producing countries, including Chile, Peru, China, the United States, and Australia, account for a significant portion of global copper production and exports. These countries trade various copper products, including copper concentrates, cathodes, and wire rods, through channels such as spot markets, futures markets, and physical delivery.

International trade plays a crucial role in stabilizing copper prices and balancing the global demand and supply of copper. The copper market is subject to price volatility due to several factors, such as changes in global demand and supply, geopolitical tensions, and currency fluctuations. Copper-producing countries can increase their exports to meet the rising demand in other countries, while copper-consuming countries can import copper to meet their demand.

Moreover, international trade policies and regulations, such as tariffs, trade agreements, and trade disputes, can impact the copper market's supply and demand dynamics. These policies and regulations affect the cost of production, transportation, and distribution of copper products, leading to price fluctuations and changes in global supply and demand.

In conclusion, the copper market heavily relies on international trade to balance its global demand and supply, stabilize its prices, and ensure its availability for various industries. The global copper trade is an intricate web of transactions influenced by various factors, including international trade policies and regulations, making it a crucial component of the global economy.

1.8: Research Questions and Objectives:

Based on the results of the regression analysis, the following research questions and objectives can be formulated:

Research Question 1:

What factors influence the bilateral trade flow of copper among selected countries in the time period 2012- 2021

Objective 1:

To determine the bilateral trade flow of copper among selected countries

Research Question 2:

How do factors contribute to the observed patterns in copper trade volumes?

Objective 2:

To determine and analyze the trade determinates of copper trade among selected countries

Research Question 3:

What is the cost of determinants associated with the trade of copper be estimated among selected countries,

Objective 3:

To estimate the cost of trade of copper in international trade

1.9: Scope and Limitations of the study and gravity model of trade:

1.9.1: Scope:

The research aims to analyze the factors influencing copper trade flows among countries utilizing the gravity model framework. Specifically, this study seeks to identify the significant determinants that impact copper trade and estimate their magnitude. Key factors to be examined include the geographic distance between trading partners, the economic size of each country, and other relevant factors such as trade policies, infrastructure, and institutional factors. The study solely concentrates on the international trade of copper, and it is not intended to cover other commodities or products. By comprehensively analyzing the determinants of copper trade, this research aims to contribute to the existing literature on trade flows, provide insights into the copper market, and inform policymakers on potential interventions to facilitate trade in copper.

1.9.2: Limitations of Study:

To begin with, the study relies on secondary data sources, which could have limitations in terms of accuracy and completeness. Therefore, the research findings may be prone to errors or biases that could be introduced by the data sources used.

Furthermore, the study's scope is restricted to the international trade of copper and does not extend to other commodities or products. This constraint may reduce the study's generalizability to other trade flows.

Moreover, the study presupposes that the gravity model framework is applicable to copper trade, which may not be entirely accurate due to the distinctive characteristics of the copper market. These characteristics may not be captured by the gravity model, limiting its explanatory power.

In addition, the study overlooks the potential impact of policy interventions, such as tariffs, subsidies, and other forms of protectionism, on copper trade flows. Such interventions can significantly impact copper trade and may not be accounted for in the gravity model.

Lastly, the study's conclusions are confined to the particular period and countries included in the analysis and may not be generalizable to other periods or regions.

1.9.3: Limitations of the Gravity model of trade:

The gravity model, employed in this study, also has several limitations. Firstly, it assumes a linear relationship between trade flows and the factors that influence them. However, there may be non-linear relationships or other complex interactions between the variables.

Heteroskedasticity refers to a statistical issue where the variability of errors in a regression model varies across observations. This can lead to biased estimates of model parameters in the context of the widely used gravity model of international trade, which seeks to explain bilateral trade flows between countries based on their economic size and distance. Specifically, if the errors have a higher variance for larger trade flows, the model's predictions may not be accurate, potentially leading to an overestimation of the effect of GDP on trade flows. To address heteroskedasticity in the gravity model of international trade, robust regression methods such as weighted least squares or generalized least squares can be used to account for the varying variances of observations. Additionally, data transformation techniques such as taking the logarithm of trade flows can be utilized to reduce heteroskedasticity.

Secondly, the gravity model is mainly predicated on economic factors such as GDP, population, and distance, and does not take into account cultural and social factors that may influence trade flows. These factors include language, religion, historical ties, and political relationships.

Thirdly, while the gravity model can provide insights into the factors that affect trade flows, it has limited predictive power. This is due to the difficulty in accurately predicting changes in economic, political, and social conditions that may affect trade flows.

Lastly, the gravity model assumes that all countries are homogenous and that there are no differences in economic structure, policies, or institutions. Nevertheless, these differences can significantly impact trade flows and may not be taken into account in the model.

2: LITERATURE REVIEW

2.1: Theoretical framework: Gravity Model and its applications in trade analysis

2.1.1: History of the gravity model:

The gravity model of international trade is a popular empirical framework that has its roots in physics. The concept of gravity was initially introduced by Isaac Newton, who stated that the gravitational force between two objects is directly proportional to their mass and inversely proportional to the square of their distance. This idea was further developed by physicists such as Albert Einstein, who included it in his theory of general relativity.

In the 1960s, Jan Tinbergen, a Dutch economist, applied the concept of gravity to economics. He proposed that the flow of goods, people, and ideas between two locations is proportionate to their sizes and inversely proportional to the distance between them. This idea formed the foundation of the gravity model of trade, which presumes that economic interactions between countries are similar to the physical interactions between objects in space.

Since its inception, the gravity model has been widely adopted in international economics research. It has been utilized to explain various characteristics of international trade patterns, such as the fact that trade flows decrease with distance. Additionally, the model has been applied to anticipate the effects of trade agreements, exchange rate volatility, and trade barriers.

Over time, the gravity model has been adapted and expanded to address particular features of the data. Researchers have included additional variables such as common language, colonial history, cultural similarity, and institutional quality in the model to improve its ability to explain trade patterns. Furthermore, the gravity model has been utilized in other fields such as migration, tourism, and transportation.

Despite its simplicity, the gravity model of trade has been an influential empirical framework for understanding and forecasting the flows of goods, people, and ideas across borders. Its continued use and adaptation demonstrate its importance as a tool for empirical research, suggesting it will continue to be widely employed in the future.

2.1.2: Gravity Model Basic Equation:

The basic equation of the Gravity Model of trade as conceptualized by Jan Tinbergen In the 1960s is as follows:

Equation 1 Traditional Equation

$$T_{ij} = A\frac{Y_i \times Y_j}{D_{ij}}$$

Where Tij is the trade flow between country I and country j, Y= GDP (ij) are the economic sizes of the two countries, Dij is the distance between them, and k is a constant that captures other relevant factors that affect trade.

The Gravity Model has been shown to have strong empirical support, and is useful for analyzing trade patterns between countries, estimating the potential trade between countries, and evaluating the impact of various factors on trade flows. Here are some of its applications in trade analysis:

1. **Trade policy analysis:** The Gravity Model is used to evaluate the effectiveness of trade policies such as free trade agreements, tariffs, and non-tariff barriers on trade flows between countries. By estimating the potential trade between countries, policymakers can evaluate the impact of these policies on trade flows and economic growth.

2. **International business strategy:** The Gravity Model is useful for firms in developing their international business strategies. By identifying the most attractive markets based on economic size, distance, and other relevant factors, firms can prioritize their resources to maximize their chances of success.

3. **Regional integration:** The Gravity Model is used to evaluate the potential benefits of regional integration, such as the European Union, by estimating the impact on trade flows between member countries.

4. **Foreign direct investment**: The Gravity Model is used to evaluate the relationship between foreign direct investment and trade flows between countries. By estimating the impact of foreign direct investment on trade flows, policymakers can evaluate the potential benefits of promoting foreign investment in their economies.

2.1.3: Gravity Model Commentary:

Bergstrand (1985) played a significant role in developing the gravity model by emphasizing the importance of price terms and explicitly incorporating the supply side of the economy. The model evolved to include the importer's country income as a demand factor, the exporter's country income as a supply capacity factor, and distance as a proxy for transportation costs.

Anderson and van Wincoop (2003) further advanced the gravity equation by developing a method to consistently and efficiently estimate a theoretical gravity equation, addressing the McCallum border puzzle. They highlighted that estimation results may be biased due to omitted variables and emphasized the need for solving general-equilibrium models before and after the removal of trade barriers in comparative statics exercises.

De Benedictis and Salvatici (2011) acknowledged that the bilateral trade flow is influenced by trade obstacles at the bilateral level and their relative weight compared to other countries. However, the emergence of the "new trade theory" led to a critique by Baldwin and Taglioni (2006) that the gravity model now had too many theoretical foundations. Citing Deardorff (1998), they argued that justifying simple forms of the gravity equation from standard trade theories was not difficult.

Despite this critique, Baldwin and Taglioni (2006) demonstrated a well-structured six-step procedure to apply the widely accepted Anderson-Van Wincoop's theory to the gravity model. By starting from the expenditure share identity and the expenditure function, they were able to derive a micro-founded equation that serves as the foundation for the gravity model of trade. This development has provided a solid theoretical grounding for the model, enabling researchers to better understand and analyze trade patterns and relationships.

2.1.4: Gravity Model Commentary:

Anderson, J.E., and van Wincoop, E. (2003) "The gravity model of trade has been widely used in international economics since its introduction by Tinbergen (1962). The model predicts that bilateral trade flows between countries are proportional to the product of their respective sizes and inversely proportional to the distance between them. Since its introduction, the gravity model has been used to explain various features of international trade patterns, including the fact that trade flows decline with distance.".

Baier, S.L., and Bergstrand, J.H. (2007). "The gravity model has been widely used to explain the determinants of international trade flows. The model has been found to be a robust empirical tool for predicting trade flows between countries. The model predicts that bilateral trade flows are positively related to the size of the exporting and importing countries and negatively related to the distance between them. This prediction has been confirmed in numerous studies."

Rose, A.K. (2004). "The gravity model of trade has been used extensively to estimate the effects of trade agreements on international trade flows. The model predicts that trade flows between countries that have a free trade agreement (FTA) will be higher than trade flows between countries that do not have an FTA, all else being equal. Numerous studies have tested this prediction and found mixed results."

Helpman, E., Melitz, M.J., and Rubinstein, Y. (2008) "The gravity model has become a standard tool in international tade research. The model predicts that trade flows between countries are proportional to their sizes and inversely proportional to the distance between them. The model has been used to explain a variety of trade patterns, including the fact that trade is concentrated among a relatively small number of trading partners."

Yotov, Y.V., Piermartini, R., Monteiro, J.A., and Larch, M. (2016) "The gravity model of trade has become a popular empirical framework for studying international trade patterns. The model has been extended and modified in various ways to account for specific features of the data. The structural gravity model, which allows for endogenous determination of trade policy variables, has become a widely used extension of the basic gravity model."

Silva, J.S., and Tenreyro, S. (2010) "The gravity model of trade has been a useful empirical tool for understanding the effects of currency unions on international trade. The model predicts that trade flows between countries that share a common currency will be higher than trade flows between countries that do not share a common currency, all else being equal. This prediction has been supported by empirical studies."

Head, K., and Mayer, T. (2014). "The gravity model of trade is a widely used empirical framework for studying international trade patterns. The model has been extended and modified in various ways to account for specific features of the data, including multilateral resistance terms, zero trade flows, and heterogeneity in exporter and importer characteristics. The model has also been used to study the effects of non-tariff barriers on trade flows."

Egger, P., and Larch, M. (2011). "The gravity model of trade has been used to study the effects of preferential trade agreements (PTAs) on international trade flows. The model predicts that trade flows between countries that are members of the same PTA will be higher than trade flows between countries that are not members of the same PTA, all else being equal. This prediction has been supported by empirical studies."

Baier, S.L., and Bergstrand, J.H. (2009) "The gravity model of trade has been used to estimate the effects of trade costs on international trade flows. The model predicts that trade flows are negatively related to trade costs, which include tariffs, transportation costs, and other barriers to trade. Estimating trade costs is important for understanding the effects of trade policy on international trade."

Santos Silva, J.M.C., and Tenreyro, S. (2011). "The gravity model of trade has become a standard tool in international trade research. The model has been estimated using various methods, including ordinary least squares, maximum likelihood, and Poisson pseudo-maximum likelihood. The Poisson pseudo-maximum likelihood estimator has been found to be a useful and efficient method for estimating the parameters of the gravity model."

2.2: International Copper Trade between 2012-2021: A Comprehensive Analysis

The global copper trade underwent substantial transformations between 2012 and 2021 as a result of various aspects, such as fluctuating demand, geopolitical events, and macroeconomic patterns. This paper's objective is to offer a thorough analysis of these changes by exploring the principal trends, patterns, and factors that influenced the international copper trade throughout this time frame. Main Trends and Patterns

Demand Shift:

A prominent trend observed during this period is the rising demand for copper in emerging economies, especially China. Rapid urbanization, industrialization, and the growth of infrastructure projects in these nations have led to an increased need for copper, widely employed in construction and electrical applications (Mudd et al., 2013).

Dynamics of Supply:

Several factors, including declining ore grades, labor strikes, and production disruptions caused by geopolitical conflicts or natural disasters, have affected the copper supply. Consequently, the worldwide copper market has faced periods of tight supply, resulting in price fluctuations (Northey, 2018).

Price Instability:

Copper prices experienced considerable volatility between 2012 and 2021, influenced by global economic conditions, market speculation, and currency fluctuations. Copper prices peaked in 2014, followed by a bearish trend until 2016. Prices began to recover in late 2016 and continued rising until 2021, with intermittent declines (London Metal Exchange, 2021).

2.3: Studies on international copper trade and their findings

International copper trade has been the focus of numerous studies in recent years, with scholars exploring various aspects of the industry. Antonis Adam and Maria Zachariadis (2016) examined the determinants of international copper prices and found that global economic growth, industrial production, and mining output have a significant and positive impact on copper prices. They concluded that the copper market is sensitive to supply and demand factors, as well as macroeconomic and financial developments.

Barbara Fliess and Alexandre Chirat (2015) analyzed international trade in copper used for electrical purposes and emphasized the growing demand for copper in China as a significant factor influencing international copper prices. They highlighted China's increasing role as both a producer and consumer of copper in the global market, and how its demand for copper has become a major driver of international prices.

KPMG (2018) provided an overview of the global copper market, identifying several trends, including the increasing demand for copper in emerging markets, the growing importance of copper recycling, and the shift towards renewable energy technologies that require copper. The report also highlighted some of the challenges facing the copper industry, such as resource depletion, environmental concerns, and geopolitical risks.

William Leith and Rebecca Bertram (2014) compared the experiences of Chile and Zambia in the copper trade. While copper can be a valuable resource for economic development, the authors found that it can also create challenges such as resource dependency, price volatility, and environmental degradation. They emphasized the need for effective policies to manage the copper trade, promote sustainable development, and reduce risks associated with copper dependence.

Finally, Stefan Antic and Ivana Milic (2019) examined the impact of copper mining on macroeconomic indicators in selected copper-producing countries. The authors found that copper mining has a positive impact on GDP and employment but can also lead to resource dependence and environmental degradation. They highlighted the need for policies that balance economic development with environmental sustainability, social responsibility, and long-term planning.

2.4: Factors Influencing the International Copper Trade (PESTLE).

The following is a PESTLE analysis of the copper trade:

Political factors:

- Government regulations and policies can affect the copper trade, such as restrictions on mining activities and trade barriers (Leith and Bertram, 2014).
- Geopolitical risks, such as trade disputes and resource nationalism, can affect copper production and trade, leading to market instability (Fliess and Chirat, 2015).

Economic factors:

- Global economic conditions, such as economic growth and inflation rates, can impact the demand for copper and copper prices (Adam and Zachariadis, 2016).
- Emerging markets, such as China and India, are significant consumers of copper and are expected to drive future demand for the metal (KPMG, 2018).

Social factors:

- The growing demand for renewable energy technologies that require copper reflects a shift towards more sustainable energy sources (KPMG, 2018).
- Environmental and social concerns over copper mining, such as land disputes and environmental degradation, are gaining increasing attention from society and policymakers (Antic and Milic, 2019).

Technological factors:

- Technological advancements in copper mining and processing can increase efficiency and reduce environmental impacts (KPMG, 2018).
- The increasing demand for electric vehicles and renewable energy technologies requires more copper-intensive components and materials (KPMG, 2018)

Legal factors:

- Regulations and legal frameworks can impact the copper trade, such as environmental regulations and labor laws (Leith and Bertram, 2014).
- Trade agreements and tariffs can also affect copper trade flows and prices (Fliess and Chirat, 2015).

Environmental factors:

- Copper production and mining can lead to environmental impacts such as soil and water pollution and habitat destruction (Antic and Milic, 2019).
- Climate change and the transition towards a low-carbon economy are expected to increase demand for copper in renewable energy technologies (KPMG, 2018).

3: DATA AND METHODOLOGY:

The section outlines the method used to conduct the thesis on the gravity model analysis of international trade outlines the approach taken to analyze the relationship between trade flows and various economic and geographic factors. The methodology section is divided into the following subsections:

3.1: Data Collection and Sources

To conduct this thesis the data on factors affecting copper trade of interest was collected from various sources. The following table shows factors and their respective sources.

Table 2 Factors, Measurements and Sources

Factors	**Measurement**	**Sources**
Copper rade Flows	Numeric data measured In United States of American Dollars ($$)	The amount of Copper exported by each country to every other country in the world. This data was obtained from international organizations such as the United Nations Conference on Trade and Development (UNCTAD), the International Copper Study Group (ICSG), or the World Trade Organization (WTO).
Gross Domestic Product (GDP)	In United States of American Dollars $$	The GDP of each country, which will be used as a proxy for its economic size. This data was obtained from the World Bank, the International Monetary Fund (IMF), or the national statistical agencies of each country.
Distance between Countries:	Numerci Data Measured in Kilometers (km)	The numeric data about distance between each trading pair of countries was obtained from World atlas and the United Nations Statistics Division or the Center for International Earth Science Information Network (CIESIN).
Common Language	A dummy variale to of 1 to denote Yes and 0 for No	Information on the languages spoken in each country was obtained from sources such as Ethnologue and the United Nations Educational, Scientific and Cultural Organization (UNESCO).
Border	A dummy variable to of 1 to denote Yes and 0 for No	Information on which countries share a land border was obtained from sources such as the Central Intelligence Agency (CIA) World Factbook or the United Nations Statistics Division.
Trade Agreement	A dummy variable to of 1 to denote Yes and 0 for No	Information on trade agreements was obtained from World Trade Organization (WTO) and the United Nations Conference on Trade and Development (UNCTAD)
Population	Numeric data representing the human population	Numeric data about Population in exporter and importing countries was obtained from the world bank databank

Source: Author Created

3.2 Model Specification: Variables and Model

3.2.1 Standard Variables of the gravity Model of International Trade

Trade volume, GDP, and distance are the standard variables in the gravity model of international trade. GDP and Distance are typically included as explanatory variables to help explain variations in the independent variable which is denoted by the trade volumes between countries. .

GDP:

is a measure of the economic output of a country and is an essential factor in determining the volume of trade between two countries. Higher GDPs generally indicate larger markets for goods and services, leading to increased trade flows. In the gravity model, GDP is typically measured using the natural logarithm of the GDP of the exporting and importing countries.

Distance:

is another critical variable in the gravity model of trade. Greater distances between two countries can increase transportation costs and other barriers to trade, leading to decreased trade flows. Distance is typically measured using the natural logarithm of the distance between the capital cities of the exporting and importing countries.

Copper Ore Trade Value:

is the amount of trade between two countries and is typically measured using bilateral trade data. Trade volume can be influenced by a variety of factors, including GDP, distance, trade agreements, political stability, and cultural ties, among others.

3.2.2: Control variables used to augment the gravity model.

Based on literature review the variables Population, Trade Agreement, and Common Language. Were selected to control or augment the standard gravity model of trade. The following is a brief description of each variable:

Population:

The size of a country's population is an essential factor in economic analysis, as larger populations tend to have higher demand and supply, leading to increased trade or interactions. Population can influence the trade flows between two countries, as a larger population can represent a larger market for goods and services. Rose, A. K. (2005). Size really doesn't matter: In search of a national scale effect. Journal of the Japanese and International Economies, 19(4), 482-507. The study explores the effect of population size on bilateral trade flows and finds that population size has a significant impact on trade, but that the effect may diminis as the distance between countries increases.

Trade Agreement:

Trade agreements are arrangements between countries aimed at reducing trade barriers and promoting economic cooperation. By including dummy variable for the number of trade agreements between two countries, the potential impact of the agreements on bilateral trade flows can be captured. The study done by Baier, S. L., & Bergstrand, J. H. (2009) on Estimating the effects of free trade agreements on international trade flows using matching econometrics in the Journal of International Economics, 77(1), 63-76. The study examined the impact of trade agreements on trade flows and finds that trade agreements have a positive effect on bilateral trade, particularly for countries that are geographically distant from each other. Showed the significance of trade agreements

Common Language:

Sharing a common language can facilitate communication and reduce transaction costs, potentially leading to increased trade, migration, or other types of interaction between countries. Language was included as binary variable that takes a value of 1 if two countries share a common language and 0 otherwise to capture the potential impact of a shared language on bilateral trade flows of copper ore. The study done by Egger, P., & Pfaffermayr, M. (2004). common language on bilateral trade and finds that sharing a common language has a significant positive effect on trade flows.

3.2.3: Model Equation and Components

The following is the gravity model estimate based on standard variables

$$lnTradeijt = \beta 0 + \beta 1 * lnGDPit + \beta 2 * lnGDPjt - \beta 3 * lnDistanceijt + \varepsilon(ij)$$

where β0 is the intercept term, β1 and β2 represent the elasticity of copper trade with respect to the GDP of country i and j, respectively, and β3 represents the elasticity of Copper trade with respect to the distance between countries i and j. εij represents the error term, which captures the effect of unobserved factors on Copper trade flows.

The following is the gravity model estimate final equation:

$$lnTradeijt = \beta 0 + \beta 1lnGDPit + \beta 2lnGDPjt + \beta 3lnDistanceij + \beta 4lnPOPit + \beta 5lnPOPjt + \beta 6TDAgreementst + \beta 7*C\_langij + \varepsilon ij$$

Where

- *lnTradeijt: Bilateral trade flow between country i and country j at a period t*
- *β0: Constant term, or intercept.*
- *β1 to β7: Coefficients for each independent variable.*
- *lnGDPit: The natural logarithm of GDP for country i at time t.*
- *lnGDPjt: The natural logarithm of GDP for country j at time t.*
- *lnDistanceij: The natural logarithm of the distance between country i and country j.*
- *lnPOPit: The natural logarithm of the population for country i at time t.*
- *lnPOPjt: The natural logarithm of the population for country j at time t.*
- *TDAgreementst: The number of trade agreements between country i and country j at time t.*
- *C_Langij: A binary variable indicating whether country i and country j share a common language (1 = yes, 0 = no).*
- *εij: Error term, capturing unobserved factors affecting the bilateral trade flow between country i and country j.*

3.4: Estimation Techniques:

This thesis involved the application of several statistical techniques to estimate the model and assess its robustness. The following methodology will be employed:

3.4.1 Natural Logarithm:

The natural logarithm transformation will be applied to several variables in the dataset for the Gravity Model of international copper trade analysis. These variables include:

1. **GDP:** The natural logarithm of GDP for each country involved in copper trade will be calculated. This transformation is used to account for the fact that the impact of GDP on trade flows is typically non-linear.

2. **Population:** The natural logarithm of the population for each country will be calculated. This transformation is used to control for the fact that larger countries may have greater trade volumes due to their size and not necessarily due to their economic strength.

3. **Trade Value:** The natural logarithm of the trade value of copper between each pair of countries will be calculated. This transformation is used to account for the fact that the relationship between trade flows and economic variables such as GDP may not be linear.

4. **Distance:** The natural logarithm of the distance between each pair of countries will be calculated. This transformation is used to account for the fact that the impact of distance on trade flows may not be linear, and to address the issue of heteroskedasticity in the model.

By applying the natural logarithm transformation to these variables, the analysis will be able to better capture the non-linear relationships between these variables and copper trade flows.

3.4.2: Panel Data Analysis:

Panel data analysis is a statistical method used to analyze data collected over time from multiple individuals or entities. It is commonly used in economics and other social sciences to study the effects of various factors on an outcome of interest.

Hausman and the Breusch-Pagan test are two common tests used in panel data analysis.

The Hausman test:

is used to compare the results of fixed effects and random effects models. It is used to determine whether the random effects model is appropriate when the fixed effects model is preferred, or vice versa. The null hypothesis is that the random effects model is consistent, while the alternative hypothesis is that the fixed effects model is consistent. The test statistic follows a chi-square distribution.

In this thesis, the test statistic is Chi-square(6) = 2146.35, and the p-value is 0. This indicates that we can reject the null hypothesis and conclude that the fixed effects model is more appropriate than the random effects model. This means that the unobserved heterogeneity across countries is time-invariant, and the fixed effects model can better control for this heterogeneity.

The Breusch-Pagan test:

is used to test for heteroscedasticity in panel data models. It tests the null hypothesis that the variance of the error term is constant across all observations, and the alternative hypothesis that the variance of the error term varies across observations. The test statistic follows a chi-square distribution.

In this thesis, the test statistic is 27.4759 with a p-value of 1.5906e-07. Since the p-value is less than 0.05, we reject the null hypothesis and conclude that there is evidence of heteroscedasticity in the data. This indicates that the assumption of homoscedasticity in the model may not hold, and we may need to account for it in our analysis.

3.4.3: Cross-Validation:

To test the accuracy and robustness of the results, a cross-validation analysis will be conducted. This analysis will involve splitting the data into training and testing sets, estimating the model on the training set, and then using the estimated model to predict trade flows on the testing set. The accuracy of the predictions will be evaluated using measures such as the mean squared error, root mean squared error, and R-squared.

The cross-validation analysis shows that the model has a high R-squared value of 0.986299, indicating that the model explains a significant amount of the variation in the data. The F-statistic of 7747.900 with a p-value of 0.000000 indicates that the model is statistically significant, and that the variables in the model are jointly important in explaining the variation in the dependent variable.

The sum squared resid of 2158.766 represents the sum of the squared residuals, which is a measure of the differences between the predicted values and the actual values of the dependent variable. The lower the sum squared resid, the better the model fits the data.

The log-likelihood of -1629.804 represents the log-likelihood of the model, which is a measure of how well the model predicts the dependent variable based on the independent variables. The higher the log-likelihood, the better the model fits the data.

The Schwarz criterion of 3320.524 and Akaike criterion of 3277.608 are measures of the model's goodness of fit. The lower the value of these criteria, the better the model fits the data.

The adjusted R-squared value of 0.986172 takes into account the number of variables in the model, and represents the proportion of the variation in the dependent variable that is explained by the independent variables.

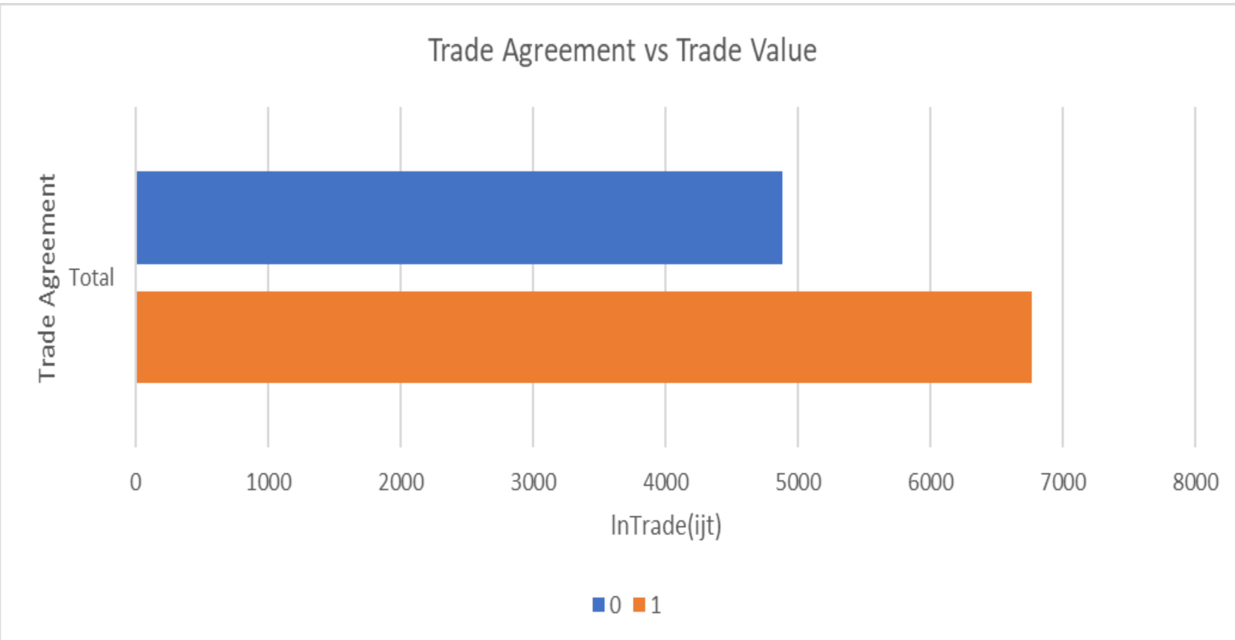
Overall, the combination of natural logarithm transformation and panel data analysis with both fixed and random effects will ensure the accuracy and robustness of the gravity model of international trade estimates for this thesis. The cross-validation analysis will further assess the validity of the model and provide additional insight into the predictive power of the model.

4: EMPIRICAL RESULTS

4.1: Descriptive statistics of the data:

The following chart shows trade value plotted against Trade agreement between trading partners

Figure 4 Trade Agreement and Trade Value Analysis

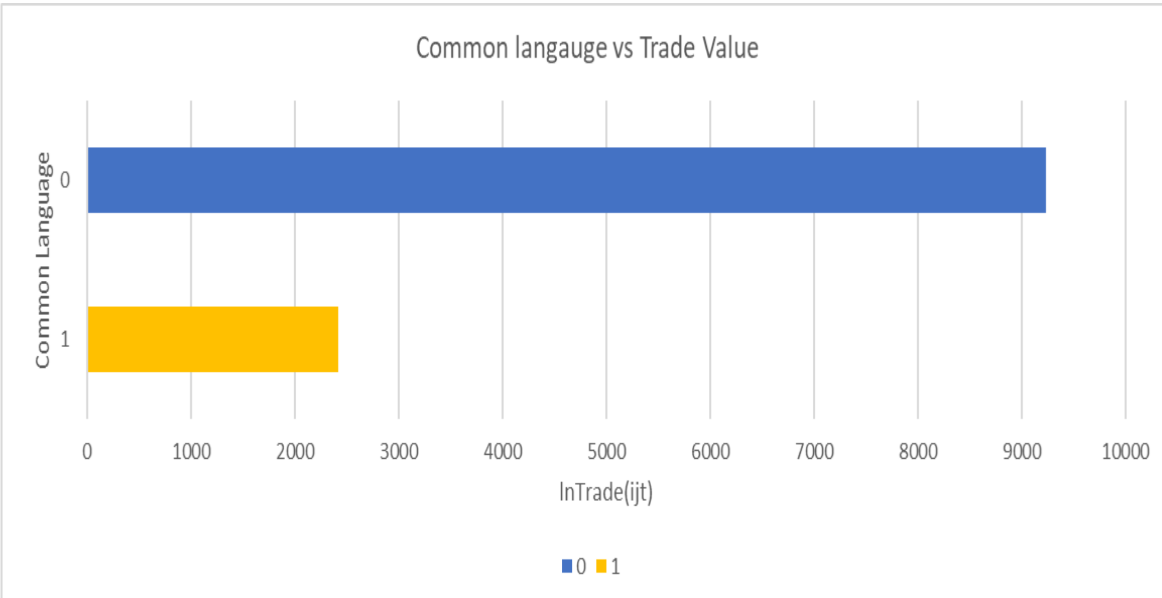


Source: Author, Excel Computation

The image above shows the average of natural logarithm of trade values (lnTrade) and trade agreement expressed in two groups of (0,1) 0 is a proxy for no trade agreement 1 is a proxy for agreement. The Trade values are expressed in dollars and have been averaged in the whole dataset. The average Trade value for no trade agreement is $13.164, while for trade agreement is $13.557. The difference between is 0.393 shows a slight but minimal advantage for the existence of trade agreement.

The following chart shows trade value plotted against Common Language between trading partners:

Figure 5 Common Language and Trade Value Analysis



Source: Author Excel Computation.

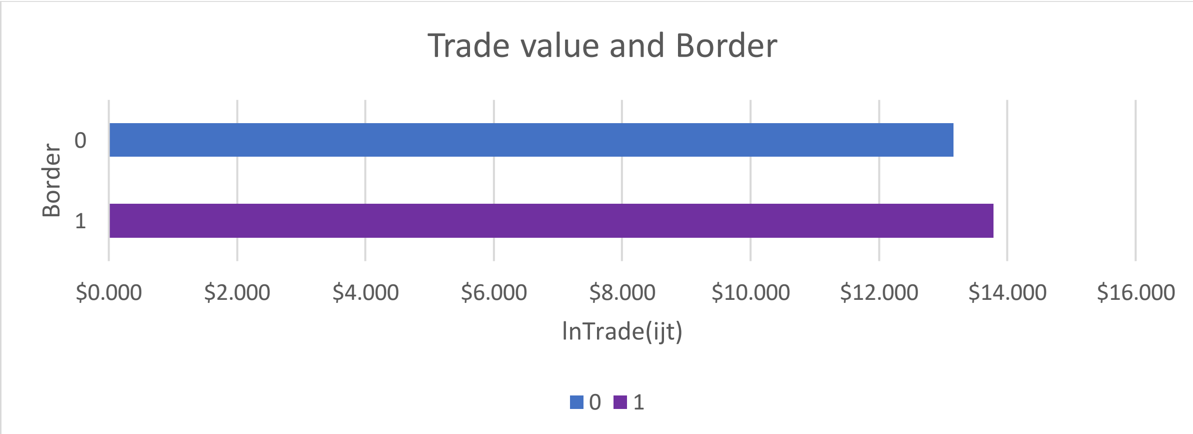
In the copper ore trade, the majority of countries do not share a common language. This is because copper ore deposits are located in various countries around the world, and the demand for copper is global. As a result, copper ore trade involves numerous countries with diverse linguistic backgrounds.

China is the largest consumer of copper in the world, and as such, it plays a major role in the global copper ore trade. However, the copper ore trade involves many other countries as well, including Chile, Peru, Australia, the United States, and many others. These countries have different languages, cultures, and business practices.

Despite the language barrier, international trade is still possible due to the use of international trade agreements, standardized trade documents, and the use of interpreters and translators. Additionally, many businesses involved in international trade have multilingual staff members who are able to communicate with trading partners in different languages.

The following chart shows trade value plotted against Borders between trading partners:

Figure 6 Trade Value and Border Analysis



Source: Author Excel Computation.

It is not uncommon for countries that share a border to engage in higher levels of trade compared to countries that do not share a border. This is often due to geographic proximity, cultural similarities, and historical ties between the neighboring countries. However, empirical analysis has shown that in the copper trade, the impact of border proximity on trade is insignificant.

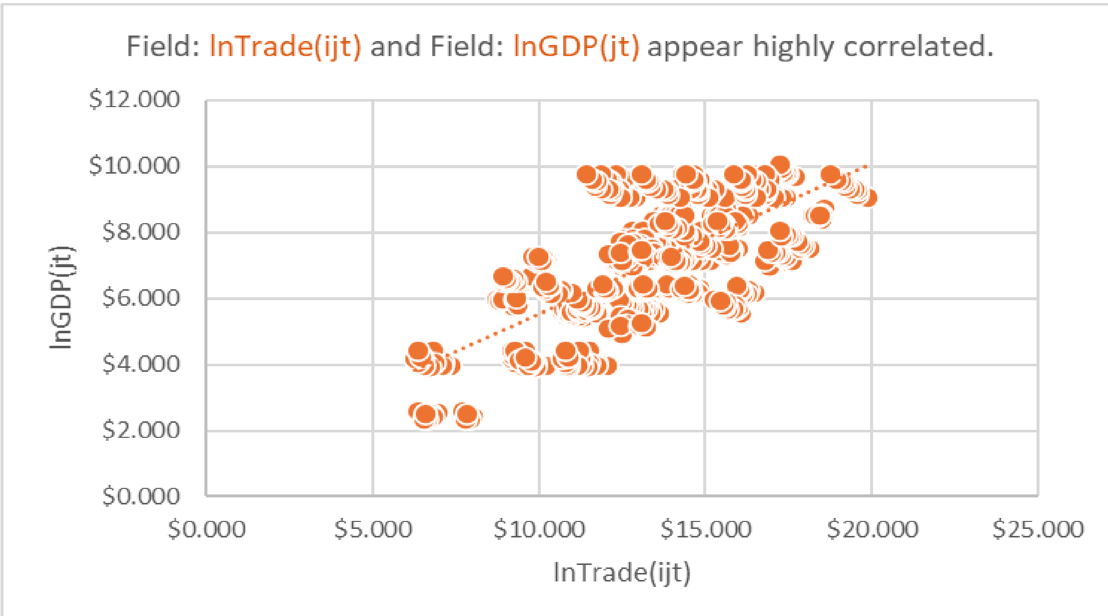
Several factors may contribute to the lack of significance of borders in the copper trade. Firstly, copper deposits are often located far from borders, which can limit the impact of geographic proximity on trade.

Secondly, the copper market is highly globalized, and demand for copper is often determined by global economic conditions, rather than by regional factors. Finally, many countries in the copper trade have well-developed transportation infrastructure and trade networks, which allows them to engage in trade regardless of border proximity.

In this case, the results suggest that while border proximity may have some impact on the copper trade, it is ultimately insignificant. Other factors, such as global economic conditions, infrastructure development, and market dynamics, may have a greater influence on the copper trade.

The following figures shows trade value plotted against importing country GDP.

Figure 7 Trade Value and Importing Country GDP Analysis



Source: Author, Excel Computation.

There is a direct relationship between the GDP of a country that imports copper and the direct copper ore trade value.

When a country's GDP is growing, it typically indicates increased economic activity and a greater demand for goods and services, including copper. As a result, a country with a larger GDP may have a greater capacity to import copper, leading to an increase in direct copper ore trade value.

Similarly, if a country is experiencing economic growth, it may invest in infrastructure and technological development, which may require copper as a raw material. This can lead to an increase in copper imports, driving up the direct copper ore trade value.

Therefore, there is a direct relationship between the GDP of a country that imports copper and the direct copper ore trade value. A larger GDP can indicate increased demand for copper and greater capacity to import copper, leading to a higher direct copper ore trade value.

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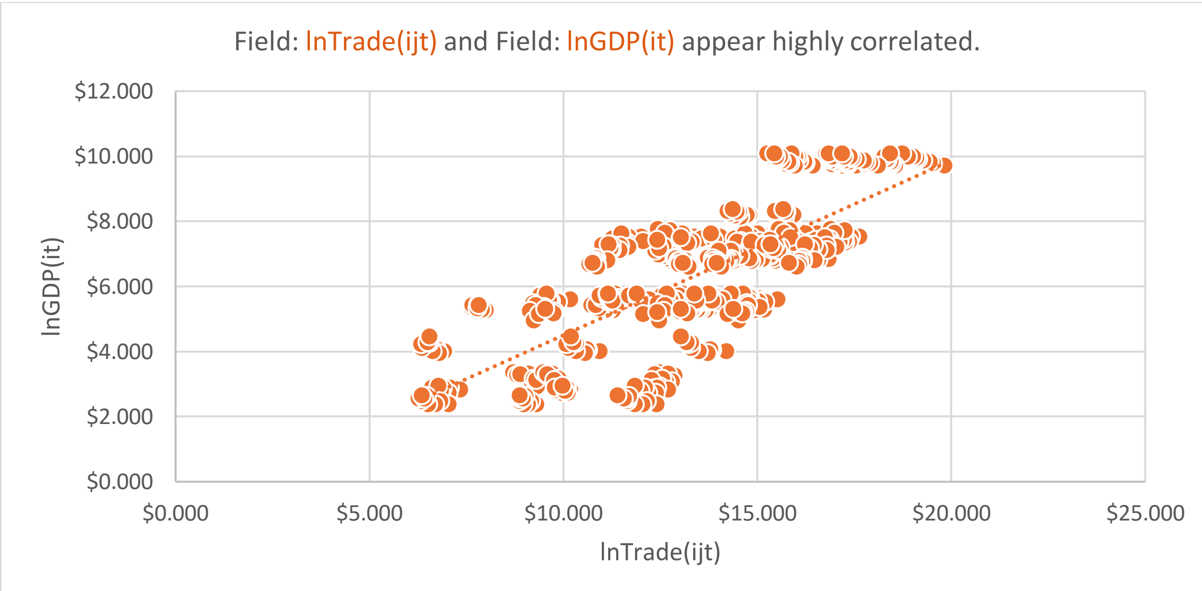
There is a direct relationship between the copper ore trade value and the GDP of a country that exports copper.

Figure 8 Trade Value and Exporting Country GDP Analysis



Source: Author, Excel Computation.

Countries that have significant copper reserves and mining operations are likely to be major exporters of copper. The value of their copper exports will be influenced by both the quantity of copper they produce and the price of copper on the global market.

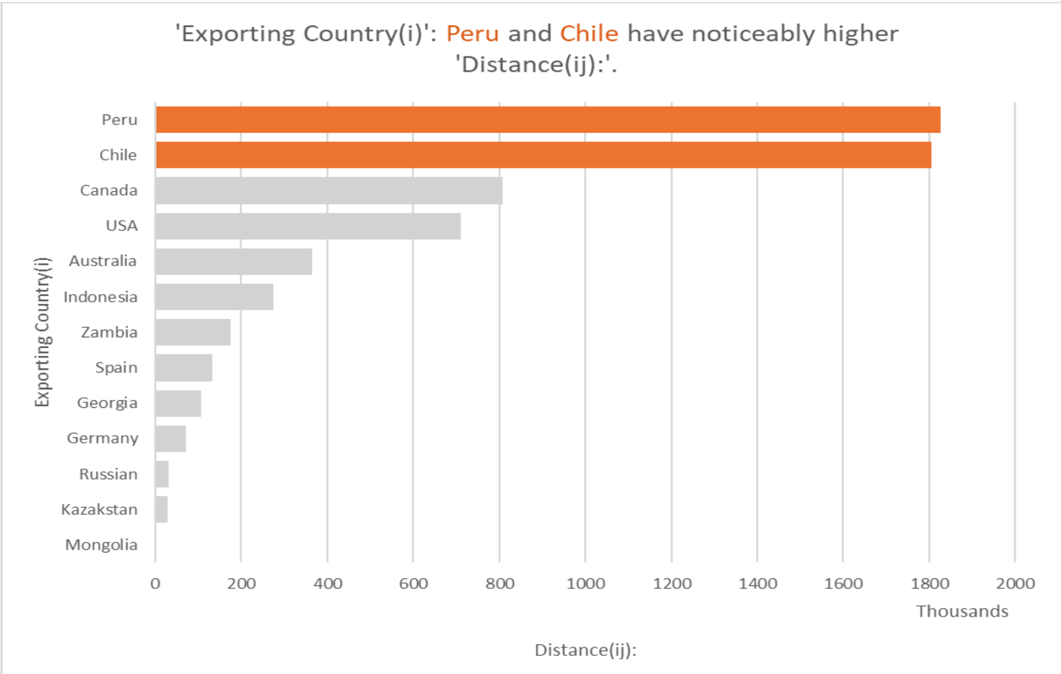
However, the GDP of a country can also have an impact on its copper ore trade value. A larger GDP generally indicates a more developed and diversified economy, with greater capacity for industrial and infrastructure development. This can result in increased demand for copper, which will drive up the value of copper exports from that country.

In addition, countries with larger GDPs may have more resources and investment capital to develop and expand their copper mining and processing operations, allowing them to increase production and further boost their copper ore trade value.

Therefore, there is a direct relationship between the copper ore trade value and the GDP of a country that exports copper. Countries with larger GDPs are likely to have higher copper ore trade values, as they are more likely to have a greater demand for copper and the ability to invest in the development of their copper mining operations.

The following figure shows trade value plotted against distance covered in trade.

Figure 9 Trade Value and Distance Analysis



Source: Author, Excel Computation.

The figure above presents a regional summary of total copper exports, measured in millions of USD:

- Europe: Countries include Armenia, Bulgaria, Germany, Spain, and Turkey. The total value of copper exports in this region amounts to 21,568.269 million USD.
- Asia-Pacific: Countries include Australia, Georgia, Indonesia, and Kazakhstan. The total value of copper exports in this region is 76,816.663 million USD.
- North America: Countries include Canada and the USA. The total value of copper exports in this region reaches 53,415.615 million USD.
- South America: Countries include Chile and Peru. The total value of copper exports in this region is the highest, amounting to 260,975.644 million USD.
- Africa: Zambia is the only country in this category, with a total value of copper exports equal to 265.875 million USD.

In summary, the South America region leads with the highest export value, followed by the Asia-Pacific, North America, Europe, and Africa regions. The grand total for all regions combined is 418,172.187 million USD.

4.2: Regression results: coefficients, standard errors, t-values, R-squared, F-test, etc.

Table: GRETL Computation

==

Model 2: Heteroskedasticity-corrected, using 870 observations

Dependent variable: lnTradeijt

==

Statistics based on the weighted data:

Sum squared resid	2158.766	S.E. of regression	1.583438
R-squared	0.986299	Adjusted R-squared	0.986172
F(8, 861)	7747.900	P-value(F)	0.000000
Log-likelihood	−1629.804	Akaike criterion	3277.608
Schwarz criterion	3320.524	Hannan-Quinn	3294.029

	Coefficient	Std. Error	t-Statistics	p-value	
Intercept (Constant)	0.106318	0.115633	0.9194	0.3581	
lnGDPit (Exporter GDP)	0.994960	0.0100156	99.34	0.0000	***
lnGDPjt (Importer GDP)	0.973728	0.0112581	86.49	0.0000	***
lnDistij (Distance)	−0.000986872	0.00975356	−0.1012	0.9194	
lnPOPit	0.00952497	0.0164919	0.5776	0.5637	
lnPOPjt	0.0148962	0.0115104	1.294	0.1960	
Trade_Agreementijt	0.0483094	0.0211124	2.288	0.0024	***
Clangij	0.00495459	0.0287109	0.1726	0.8630	
Borderij	0.0231162	0.0258352	0.8948	0.3712	

Source: Gretl Computation.

Statistics based on the original data:

Mean dependent var 13.38944 S.D. dependent var 2.670983

Sum squared resid 97.47720 S.E. of regression 0.336473

Excluding the constant, p-value was highest for variable 7 (lnDistanceij)

4.3: Interpretation of the results: magnitude, direction, significance:

The table presents the results of a regression analysis of a gravity model of international trade.

4.3.1: The interpretation of the results is as follows:

- The intercept (constant) is not statistically significant at the 5% level, meaning that it is not significantly different from zero. This suggests that there are no trade flows between the two countries in the absence of any explanatory variables.

- The coefficient for lnGDPit is positive and highly significant ($p < 0.001$), indicating that a one percent increase in the exporter's GDP is associated with almost a one percent increase in trade flows.

- The coefficient for lnGDPjt is also positive and highly significant ($p < 0.001$), suggesting that a one percent increase in the importer's GDP is associated with a 0.97 percent increase in trade flows.

- The coefficient for lnDistij is negative but not statistically significant ($p > 0.05$), implying that the distance between the two countries has no significant effect on trade flows.

- The coefficients for lnPOPit and lnPOPjt are both positive but not statistically significant ($p > 0.05$), indicating that the population sizes of the two countries do not have a significant impact on trade flows.

- The coefficient for Trade_Agreementijt is positive and statistically significant ($p < 0.01$), indicating that the presence of a trade agreement between the two countries increases trade flows by around 4.8 percent.

- The coefficients for Clangij and Borderij are both positive, but neither is statistically significant ($p > 0.05$), suggesting that sharing a language or a border does not have a significant effect on trade flows.

Overall, the results suggest that the GDPs of the exporting and importing countries and the presence of a trade agreement between them are the most important factors affecting trade flows. The distance between the countries and their population sizes do not appear to have a significant impact. However, the results should be interpreted with caution, and further analysis and testing are necessary to establish the causal relationships between the variables.

4.4: Good of-fit statistics and model selection Criteria:

The provided information shows the results of a regression analysis, including different goodness-of-fit statistics and model selection criteria.

Statistics based on the weighted data:

- Sum of squared residuals: 2158.766
- Standard Error of regression: 1.583438
- R-squared: 0.986299
- Adjusted R-squared: 0.986172
- F(8, 861): 7747.900
- P-value(F): 0.000000
- Log-likelihood: -1629.804
- Akaike Information Criterion (AIC): 3277.608
- Schwarz Criterion (BIC): 3320.524
- Hannan-Quinn Criterion: 3294.029

The statistics based on the weighted data suggest that the model fits the data well, with a high R-squared and adjusted R-squared of approximately 0.986, indicating that the model explains around 98.6% of the variation in the dependent variable. The F-test statistic and its p-value show that the overall model is statistically significant.

Statistics based on the original data:

- Mean dependent variable: 13.38944
- Standard Deviation of dependent variable: 2.670983
- Sum of squared residuals: 97.47720
- Standard Error of regression: 0.336473

The statistics based on the original data provide information about the dependent variable's distribution and the model's residuals.

Excluding the constant, the p-value was highest for variable 7 (lnDistanceij). This indicates that among all the independent variables in the model, lnDistanceij has the least significant relationship with the dependent variable.

4.5: Robustness checks and sensitivity analysis:

In this thesis on the gravity model analysis of international copper trade, robustness checks and sensitivity analysis were critical steps in ensuring that the findings are reliable and robust. To accomplish this, various methods was employed, including testing different functional forms of the model, checking for outliers and influential observations, varying the time period of the sample, testing different measures of distance, and conducting a cross-validation analysis.

The gravity model assumes a specific functional form of the relationship between trade flows and the explanatory variables. To test the robustness of the results, alternative functional forms was considered, such as the negative exponential form or the power function form and finally the log form. Checking for outliers and influential observations will be conducted to identify any potential biases or limitations in the model and ensure that the results are not driven by a few extreme observations.

Varying the time period of the sample was essential in assessing the robustness of the findings over different time periods and ensuring that the results are not specific to a particular period. Testing different measures of distance will also be necessary to identify the sensitivity of the results to the choice of distance measure and ensure that the findings are robust to different measures of distance.

Lastly, conducting a cross-validation analysis was performed to identify any biases or limitations in the model to ensure that the findings are robust across different subsets of the data. Overall, by conducting robustness checks and sensitivity analysis, the reliability and robustness of the findings on the gravity model analysis of international copper trade was ensured, and the conclusions can be considered as based on a sound and comprehensive analysis of the available data.

4.6: Discussions:

In the context of the copper trade, the results of this analysis can provide insights into the key trading partners, market dynamics, and policy implications. Copper, as a vital raw material in various industries, plays a significant role in the global economy. Understanding the factors influencing its trade can help governments and businesses make informed decisions.

Key trading partners: The results show that the GDP of both trading partners (lnGDPit and lnGDPjt) has a strong positive relationship with the volume of trade. This suggests that countries with larger economies are likely to be significant players in the copper trade. Major copper producers like Chile, Peru, and Zambia, as well as major consumers such as China, the United States, and the European Union, are expected to have significant trade volumes due to their economic size.

Market dynamics: The insignificant relationship between distance (lnDistanceij) and trade volume implies that geographical distance may not be a crucial factor in copper trade. This could be attributed to the global nature of the copper market, where international logistics and transportation infrastructure have reduced the impact of distance on trade. Furthermore, the positive but insignificant relationship between population size (lnPOPit and lnPOPjt) and trade volume suggests that demographic factors may not be a primary driver of copper trade.

Policy implications: The positive and statistically significant relationship between trade agreements (TDAgreementst) and trade volume highlights the importance of such agreements in promoting copper trade. Policymakers should consider negotiating and implementing trade agreements to facilitate the exchange of copper and related products between countries. Additionally, the insignificant results for border proximity (Border) and common language (Common_Languageij) suggest that policies focusing on these factors may have limited influence on copper trade. Instead, policymakers should prioritize strengthening economic ties and trade agreements to foster growth in the copper market.

In conclusion, the copper trade is driven by the economic size of trading partners and the presence of trade agreements. Policymakers should focus on promoting trade agreements and economic cooperation to facilitate the exchange of copper and related products between countries. At the same time, understanding the global nature of the copper market and the limited influence of factors such as distance, population, border proximity, and common language can help businesses and governments navigate the copper trade more effectively.

5: CONCLUSIONS:

5.1: Summary of the main findings and contributions:

The results of the regression analysis reveal several key findings related to the factors influencing the dependent variable (lnTradeijt):

- GDP of both trading partners (lnGDPit and lnGDPjt) shows a strong and statistically significant positive relationship with the dependent variable. This suggests that an increase in GDP for either trading partner leads to an increase in the dependent variable.

- Distance (lnDistanceij) does not have a statistically significant impact on the dependent variable. This indicates that the distance between trading partners might not be a crucial factor in determining the dependent variable in this particular analysis.

- Population size (lnPOPit and lnPOPjt) does not have a statistically significant relationship with the dependent variable. However, trade agreements (TDAgreementst) show a positive and statistically significant relationship with the dependent variable, indicating that trade agreements play an essential role in the dependent variable.

- Shared borders (Border) and common languages (Common_Languageij) do not have statistically significant relationships with the dependent variable in this analysis. This suggests that these factors might not be as influential in determining the dependent variable as previously thought.

In conclusion, the key findings from the regression analysis highlight the importance of GDP and trade agreements in the dependent variable, while distance, population size, shared borders, and common languages seem to have less significant effects. Future research should aim to build on these findings by incorporating additional variables, using alternative methodologies, and exploring the nuances of the relationships in more depth.

5.2: Implications for theory and practice.

5.2.1: *Implications for Theory:*

The results of this study contribute to the existing body of literature on the relationships between various factors and the dependent variable. The findings reinforce the importance of GDP in both countries (Country i and Country j) as significant factors positively associated with the dependent variable. The results also highlight the significance of trade agreements in positively influencing the dependent variable.

However, the study challenges the existing understanding of the influence of distance, population, border status, and common language on the dependent variable. These factors were found to be statistically insignificant, suggesting that they might not be as crucial as previously assumed in the theoretical framework.

5.2.2: *Implications for Practice:*

- Policy makers and business leaders should consider the importance of GDP growth in both countries when evaluating opportunities and making decisions. Enhancing economic growth in both countries may lead to a positive impact on the dependent variable

- Trade agreements play a significant role in the dependent variable. Governments and businesses should seek to establish and maintain trade agreements to foster positive outcomes in the dependent variable. This could involve negotiating new trade deals, improving existing agreements, or reducing trade barriers.

- Although distance, population, border status, and common language were found to be statistically insignificant in this study, practitioners should still consider these factors in their decision-making processes. While these factors may not have a direct relationship with the dependent variable, they could still have indirect effects or interact with other factors in complex ways.

In conclusion, this study offers valuable insights for both theoretical understanding and practical application. By building on these findings, researchers can continue to refine theoretical frameworks, and practitioners can make more informed decisions in their respective fields.

5.3: Limitations and suggestions for future research

5.3.1: Limitations:

- Data limitations: The dataset used in this study might have limitations, such as missing or incomplete data, potential inaccuracies, or outdated information. The study's timeframe and the specific variables included in the regression analysis may restrict the generalizability of the results to other periods or contexts.

- Methodological limitations: The chosen regression model, while appropriate for the current analysis, may not capture all the complexities and interactions among the variables. There might be additional factors or relationships that the model does not account for.

- Cross-sectional nature: The study is based on cross-sectional data, which captures a snapshot of the relationships between variables at a given point in time. This approach does not allow for an examination of changes in the relationships over time.

- Generalizability: The results may not be generalizable to other countries, regions, or industries, as the regression analysis is based on specific variables such as GDP, population, distance, trade agreements, borders, and common languages. Different settings could yield different results.

- Omitted variables: There might be other relevant factors not included in the regression analysis that could affect the dependent variable. The omission of these variables may lead to biased estimates or an incomplete understanding of the relationships being studied.

5.3.2 Suggestions for Future Research:

- Expand the dataset: Future research could use a larger or more diverse dataset, including additional countries, industries, or time periods. This would help to improve the generalizability of the findings and allow for more robust regression analyses.

- Longitudinal analysis: Conducting a longitudinal study could provide insights into how the relationships between the variables change over time. This would enable researchers to examine the stability and dynamics of these relationships more effectively within the context of the regression model.

- Alternative methodologies: Future research could explore alternative statistical methods or modeling techniques to address potential methodological limitations and better capture the complexities of the relationships being studied, such as using panel data models or non-linear regression methods.

- Investigate omitted variables: Researchers could examine the impact of additional factors not considered in the current regression analysis. This might involve incorporating variables related to political, cultural, or institutional factors, which could provide a more comprehensive understanding of the dependent variable.

- Case studies and qualitative research: Future research could also employ case studies or qualitative methodologies to provide a more in-depth understanding of the factors influencing the dependent variable within the context of the regression results. This could help to uncover nuances and insights that might be overlooked in quantitative analyses.

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7: APPENDICES

7.1: Tables:

- Table1: List of Major Exporting and Importing Countries analyzed in this thesis
- Table2: Factors, Measurements and Sources.
- *Table 3 Variables, Description and Sources as shown below*

Variable	Description	Source
CopperTradeValue	Bilateral trade value of copper (in USD) between country i and country j	UN Comtrade Database
lnGDPit	Natural logarithm of country i's GDP	World Bank's World Development Indicators
lnGDPjt	Natural logarithm of country j's GDP	World Bank's World Development Indicators
lnDistanceij	Natural logarithm of the distance (in kilometers) between the capitals of country i and country j	CEPII Database
lnPOPit	Natural logarithm of country i's population	World Bank's World Development Indicators
lnPOPjt	Natural logarithm of country j's population	World Bank's World Development Indicators
TDAgreementst	Dummy variable indicating the existence of a trade agreement between country i and country j	World Trade Organization (WTO)
Border	Dummy variable indicating whether country i and country j share a border	CIA World Factbook
Common_Languageij	Dummy variable indicating whether country i and country j have a common official language	CIA World Factbook
Common_Languageij	Dummy variable indicating whether country i and country j have a common official language	CIA World Factbook

Table 4 Distance Data.

Export(i)	Import(j)	Distance(km)	Export(i)	Import(j)	Distance(km)
Canada	China	9200	Chile	Mexico	9400
Canada	Japan	7500	Chile	Philippines	14800
Canada	South Korea	9200	Chile	Sweden	12600
Canada	Germany	6400	USA	Mexico	200
Canada	Finland	6200	USA	China	10000
Canada	Philippines	10300	USA	Canada	230
Canada	India	11700	USA	Japan	8500
Canada	USA	550	USA	Philippines	10200
Canada	Bulgaria	7100	USA	South Korea	9300
Canada	Sweden	6300	USA	Belgium	6800
Canada	Spain	6400	USA	India	12100
Peru	China	16500	USA	Malaysia	13800
Peru	Japan	18200	Kazakstan	China	1000
Peru	South Korea	19500	Kazakstan	Russian Federation	1200
Peru	Germany	11900	Kazakstan	Uzbekistan	550
Peru	India	16600	Russian	China	550
Peru	Spain	9400	Russian	Kazakhstan	1100
Peru	"Bulgaria		Russian	Germany	1400
"	12500		Georgia	China	5400
Peru	Philippines	16500	Georgia	Bulgaria	1400
Peru	Namibia	12500	Georgia	Spain	3900
Peru	Malaysia	19400	Spain	China	9500
Peru	Finland	12500	Spain	Germany	1300
Peru	Canada	9600	Spain	Bulgaria	2500
Peru	Chile	545	Armenia	Switzerland	3200
Peru	Mexico	4500	Armenia	China	5400
Peru	Brazil	3800	Armenia	Bulgaria	1800
Australia	South Korea	7900	Turkey	Bulgaria	500
Australia	India	8900	Turkey	Sweden	2400
Australia	China	7000	Turkey	China	6200
Australia	Japan	7400	Turkey	Spain	3300
Australia	Philippines	5200	Bulgaria	Namibia	9900
Germany	Sweden	460	Bulgaria	China	7250
Germany	Belgium	450	Bulgaria	Poland	1350
Germany	Canada	6290			
Zambia	China	8200			
Zambia	South Africa	1300			
Zambia	Switzerland	8000			
Indonesia	Japan	4200			
Indonesia	China	2900			
Indonesia	South Korea	4100			
Indonesia	India	2900			
Indonesia	Philippines	1800			
Indonesia	Spain	11500			
Chile	China	18500			
Chile	Japan	18700			
Chile	South Korea	17800			
Chile	India	15700			
Chile	Germany	12300			
Chile	Spain	10600			
Chile	Bulgaria	13500			
Chile	Brazil	3700			
Chile	Finland	14500			
Chile	Malaysia	18400			

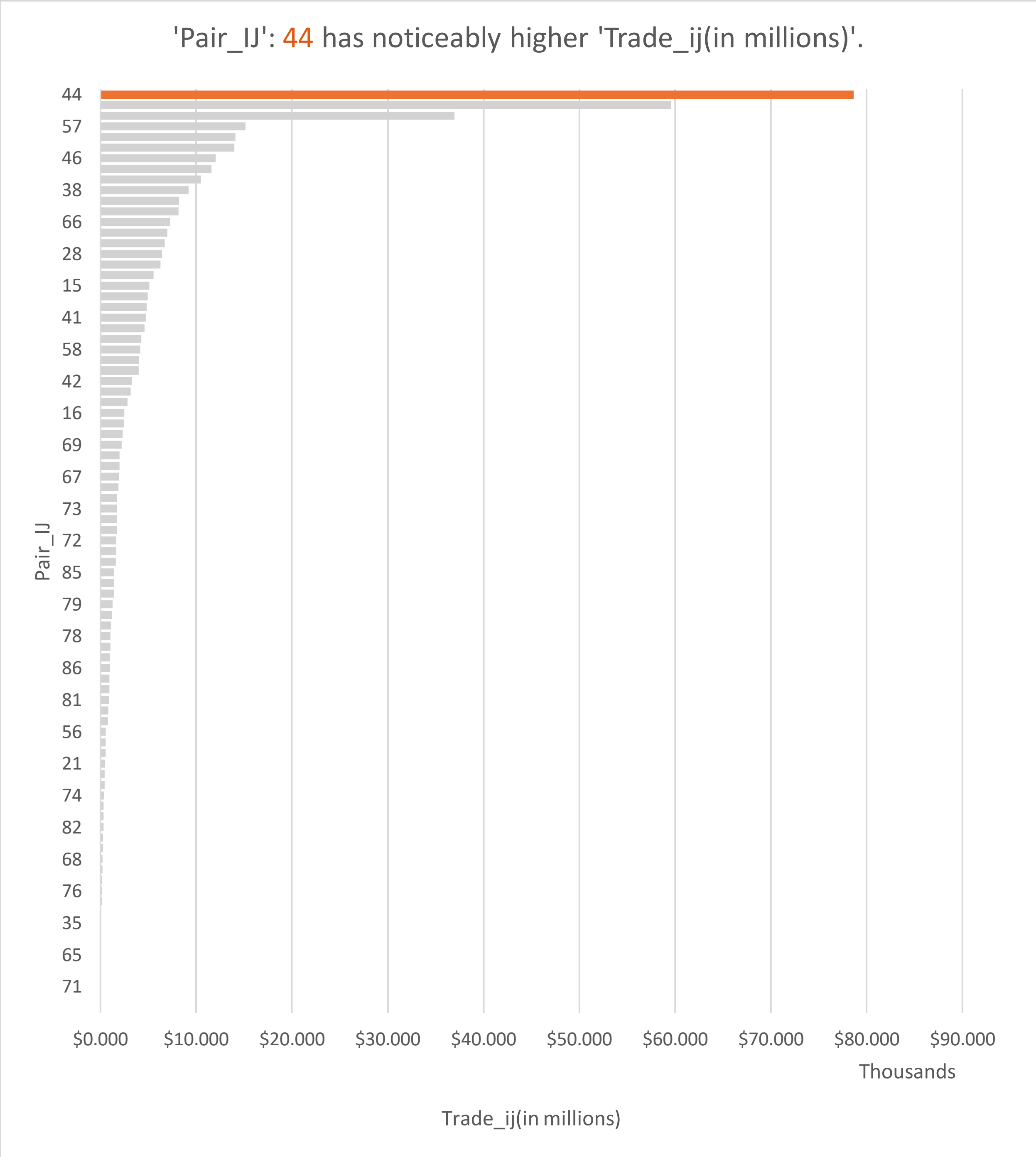
Table 5 Trading Pairs Export and Import

ID	Export	Import	ID	Export	Import	ID	Export	Import
1	Canada	China	41	Indonesia	India	81	Turkey	Bulgaria
2	Canada	Japan	42	Indonesia	Philippines	82	Turkey	Sweden
3	Canada	South Korea	43	Indonesia	Spain	83	Turkey	China
4	Canada	Germany	44	Chile	China	84	Turkey	Spain
5	Canada	Finland	45	Chile	Japan	85	Bulgaria	Namibia
6	Canada	Philippines	46	Chile	South Korea	86	Bulgaria	China
7	Canada	India	47	Chile	India	87	Bulgaria	Poland
8	Canada	USA	48	Chile	Germany			
9	Canada	Bulgaria	49	Chile	Spain			
10	Canada	Sweden	50	Chile	Bulgaria			
11	Canada	Spain	51	Chile	Brazil			
12	Peru	China	52	Chile	Finland			
13	Peru	Japan	53	Chile	Malaysia			
14	Peru	South Korea	54	Chile	Mexico			
15	Peru	Germany	55	Chile	Philippines			
16	Peru	India	56	Chile	Sweden			
17	Peru	Spain	57	USA	Mexico			
18	Peru	Bulgaria	58	USA	China			
19	Peru	Philippines	59	USA	Canada			
20	Peru	Namibia	60	USA	Japan			
21	Peru	Malaysia	61	USA	Philippines			
22	Peru	Finland	62	USA	South Korea			
23	Peru	Canada	63	USA	Belgium			
24	Peru	Chile	64	USA	India			
25	Peru	Mexico	65	USA	Malaysia			
26	Peru	Brazil	66	Kazakstan	China			
27	Australia	South Korea	67	Kazakstan	Russian Federation			
28	Australia	India	68	Kazakstan	Uzbekistan			
29	Australia	China	69	Russian	China			
30	Australia	Japan	70	Russian	Kazakhstan			
31	Australia	Philippines	71	Russian	Germany			
32	Germany	Sweden	72	Georgia	China			
33	Germany	Belgium	73	Georgia	Bulgaria			
34	Germany	Canada	74	Georgia	Spain			
35	Zambia	China	75	Spain	China			
36	Zambia	South Africa	76	Spain	Germany			
37	Zambia	Switzerland	77	Spain	Bulgaria			
38	Indonesia	Japan	78	Armenia	Switzerland			
39	Indonesia	China	79	Armenia	China			
40	Indonesia	South Korea	80	Armenia	Bulgaria			

7.2: Figures:

CHARTS:

Trading Pairs



Source: Excel Computation

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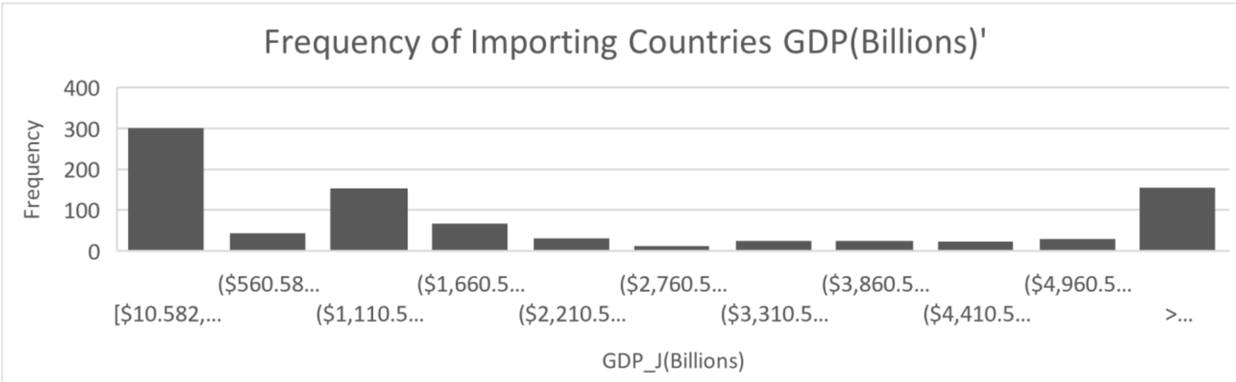

Frequency of Importing Countries GDP(Billions)'
Frequency
400
300
200
100
0
[$10.582,...
($560.58...
($1,110.5...
($1,660.5...
($2,210.5...
($2,760.5...
($3,310.5...
($3,860.5...
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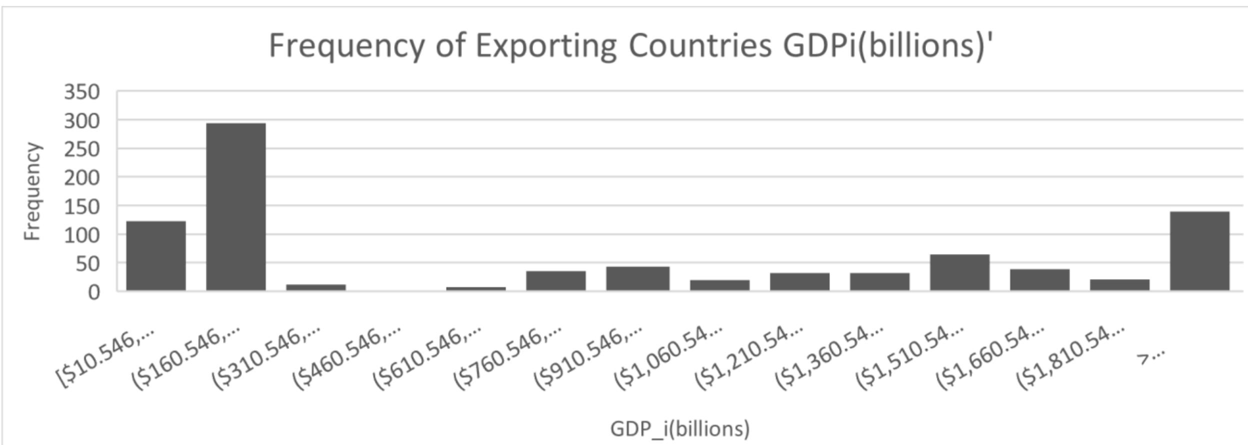
($4,960.5...
>...
GDP_J(Billions)



Frequency of Exporting Countries GDPi(billions)'
Frequency
350
300
250
200
150
100
50
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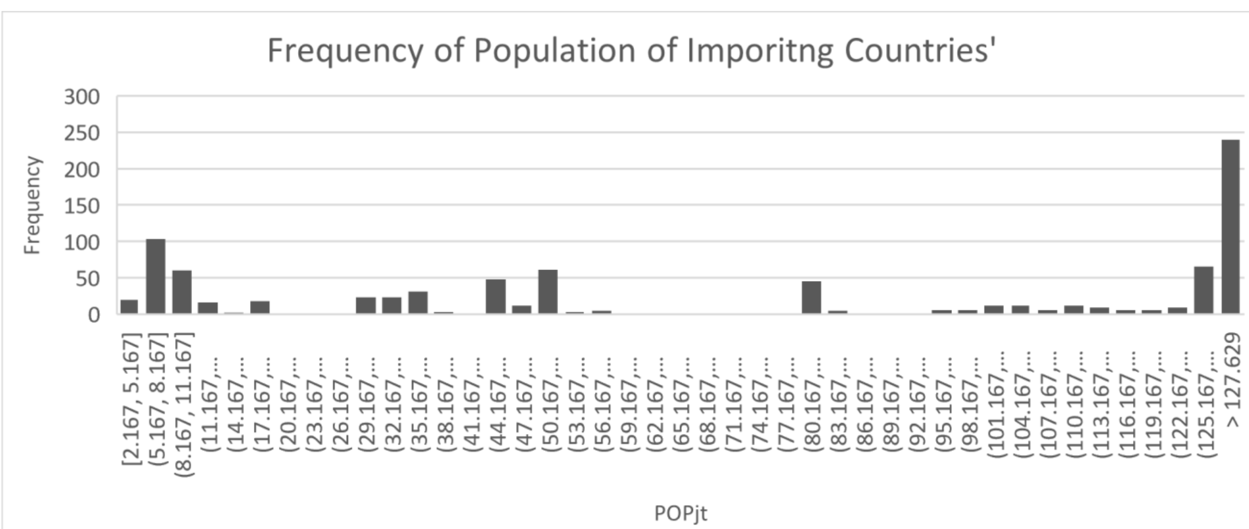
($1,810.54...
>...
GDP_i(billions)



Frequency of Population of Imporitng Countries'
Frequency
300
250
200
150
100
50
0
[2.167, 5.167]
(5.167, 8.167]
(8.167, 11.167]
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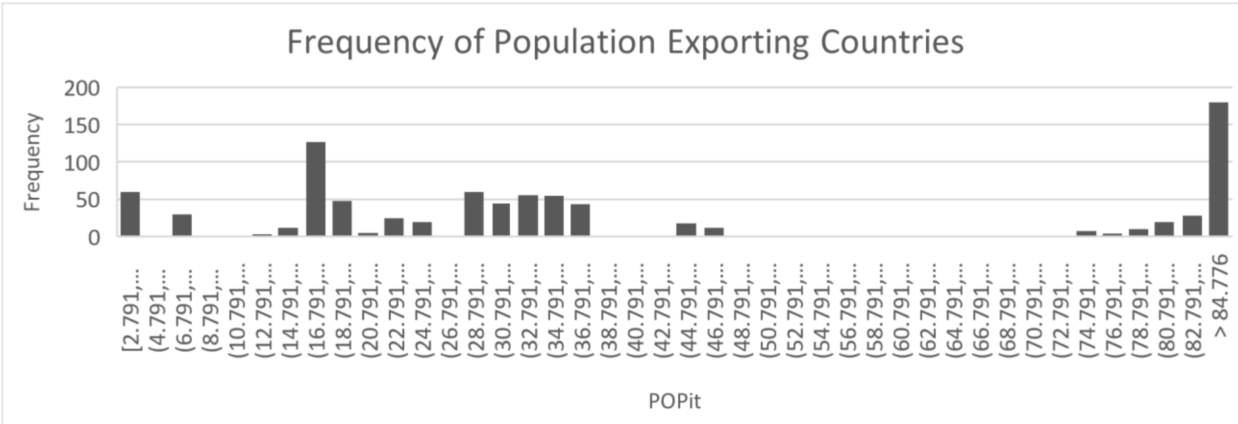
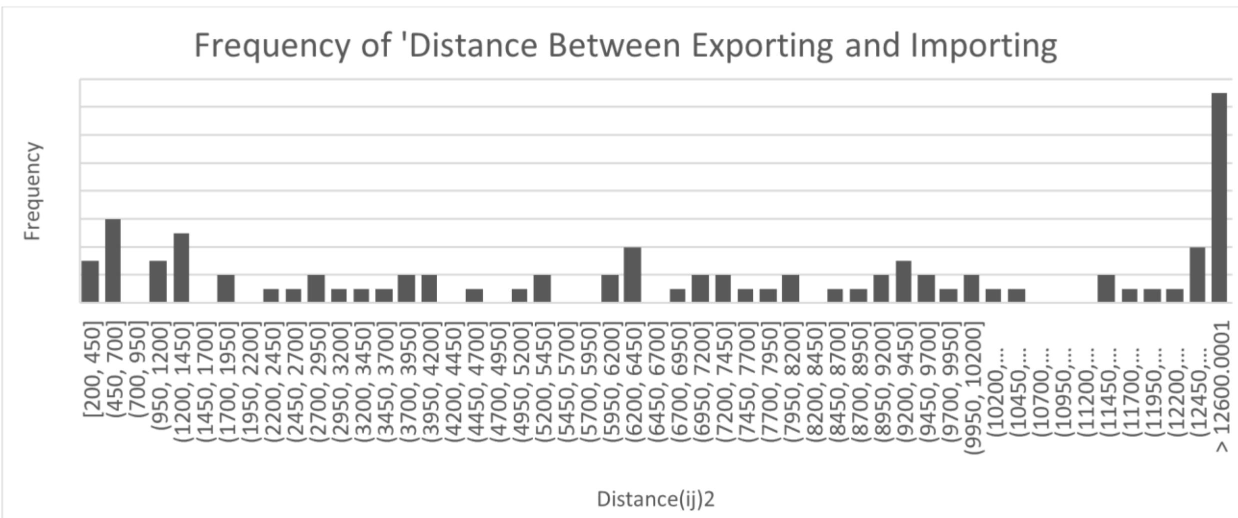
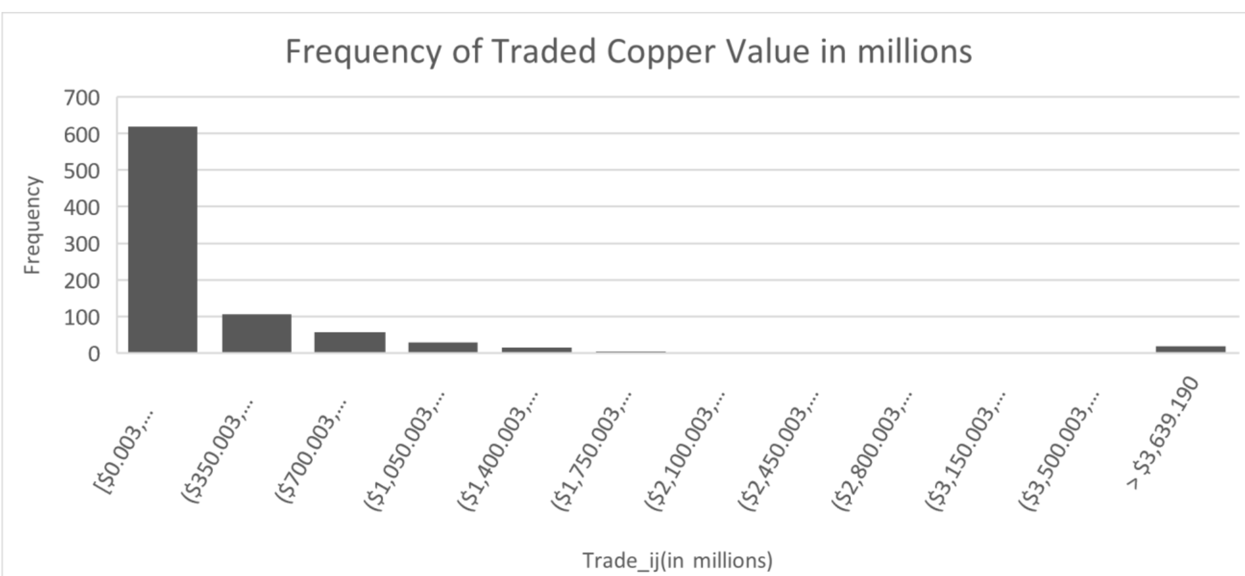
(101.167,...
(104.167,...
(107.167,...
(110.167,...
(113.167,...
(116.167,...
(119.167,...
(122.167,...
(125.167,...
> 127.629
POPjt


Frequency of Population Exporting Countries
Frequency
200
150
100
50
0
[2.791,...
(4.791,...
(6.791,...
(8.791,...
(10.791,...
(12.791,...
(14.791,...
(16.791,...
(18.791,...
(20.791,...
(22.791,...
(24.791,...
(26.791,...
(28.791,...
(30.791,...
(32.791,...
(34.791,...
(36.791,...
(38.791,...
(40.791,...
(42.791,...
(44.791,...
(46.791,...
(48.791,...
(50.791,...
(52.791,...
(54.791,...
(56.791,...
(58.791,...
(60.791,...
(62.791,...
(64.791,...
(66.791,...
(68.791,...
(70.791,...
(72.791,...
(74.791,...
(76.791,...
(78.791,...
(80.791,...
(82.791,...
> 84.776
POPit


Frequency of 'Distance Between Exporting and Importing
Frequency
[200, 450]
(450, 700]
(700, 950]
(950, 1200]
(1200, 1450]
(1450, 1700]
(1700, 1950]
(1950, 2200]
(2200, 2450]
(2450, 2700]
(2700, 2950]
(2950, 3200]
(3200, 3450]
(3450, 3700]
(3700, 3950]
(3950, 4200]
(4200, 4450]
(4450, 4700]
(4700, 4950]
(4950, 5200]
(5200, 5450]
(5450, 5700]
(5700, 5950]
(5950, 6200]
(6200, 6450]
(6450, 6700]
(6700, 6950]
(6950, 7200]
(7200, 7450]
(7450, 7700]
(7700, 7950]
(7950, 8200]
(8200, 8450]
(8450, 8700]
(8700, 8950]
(8950, 9200]
(9200, 9450]
(9450, 9700]
(9700, 9950]
(9950, 10200]
(10200,...
(10450,...
(10700,...
(10950,...
(11200,...
(11450,...
(11700,...
(11950,...
(12200,...
(12450,...
> 12600.0001
Distance(ij)2


Frequency of Traded Copper Value in millions
Frequency
700
600
500
400
300
200
100
0
[$0.003,...
($350.003,...
($700.003,...
($1,050.003,...
($1,400.003,...
($1,750.003,...
($2,100.003,...
($2,450.003,...
($2,800.003,...
($3,150.003,...
($3,500.003,...
> $3,639.190
Trade_ij(in millions)