THE CO-MOVEMENT BETWEEN COPPER PRICES AND THE EXCHANGE RATE OF FIVE MAJOR COMMODITY CURRENCIES

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Abstract

In this study, the relationship between movements in the exchange rates of five commodity currencies (Australia, Canada, Chile, China, and South Africa) in terms of the United States Dollar (USD) and the spot USD copper price was analysed. Correlation and regression analysis (including the use of lagged variables) was used to investigate these relationships. It was found that four of the five commodity currency exchange rates have a strong co-movement relationship with copper price (i.e. the Australian Dollar, Canadian Dollar, Chilean Peso, and the South African Rand). The only exchange rate that does not have a co-movement relationship with copper prices is the Chinese Yuan. This article is based on a master's minor dissertation study.

Keywords

Commodities, commodity currencies, copper, co-movement, exchange rates, correlation

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1. INTRODUCTION

"Though we see a world of change and contrast all about, it's one of the ancient esoteric insights that all is One. That is: everything is intimately connected, from Divine to mortal. From heaven to earth. From black to white" (Anon, 2011).

The law of one price, as described by Isard (1977:942), states that "... in the assumed absence of transport costs and trade restrictions, perfect commodity arbitrage ensures that each good is uniformly priced (in common currency units) throughout the world – the 'law of one price' prevails". Yang, Bessler and Leatham (2000) define the law of one price as the commodity price that is adjusted by exchange rates and allowances for transportation costs will be the same for all countries. Chance (2009) states that the law of one price is a condition in a financial market where two identical or equivalent financial instruments sell for the same price. The principle where no arbitrage opportunities exist is the same as the law of one price. If the law of one price is followed, it means that there should be no differences in prices between countries for the same commodity, taking into consideration the bilateral exchange rate involving a currency pair.

In the field of economics, the law of one price is underpinned by supply and demand with an equilibrium price (Copeland, 2008). The inclination of a specific product's prices to converge to one price is influenced by the supply of and demand for that product. The law of supply and demand shows that, as demand for a product decreases, the price decreases, and this is followed by a decrease in supply. If demand were to increase for a product, the price would also increase, which is then followed by an increase in supply. These changes in demand and supply occur until a level of equilibrium is achieved, which supports the principle of the law of one price (Copeland, 2008).

As the law of one price and the law of supply and demand are the underlying economic principles that influence the supply and demand for products, they should also apply in the currency market, as exchange rates are financial products (Copeland, 2008). Exchange rates are determined by supply and demand based on information that is disseminated to the market. As information becomes available to the market, market users interpret the information, and the equilibrium price changes according to the interpretation of the information (Bukenya & Labys, 2005).

From what we know about the law of one price and the law of supply and demand, commodity prices should work exactly the same way as the economics behind exchange rates, as commodities are products traded globally between buyers and sellers. It can therefore be argued that there is a relationship between commodity prices and exchange rates based on the underlying economic principles of the law of one price and the law of supply and demand. The equal relationships found in exchange rates and commodity prices indicate an interlinking relationship between commodity prices and exchange rates.

In this study the overall research question was to identify the relationship, if any, between movements in copper prices and movements in specific exchange rates and, if such a relationship were found, to determine its extent.

The study thus investigated the relationship between movements in the spot United States Dollar (USD) copper price and movements in the spot exchange rate of five commodity currencies that produce and export copper. The five commodity currencies included are the Australian Dollar (AUD), the Canadian Dollar (CAD), the Chilean Peso (CLP), the Chinese Yuan

(CNY), and the South African Rand (ZAR). The five currencies' USD exchange rates were used for the purpose of this study.

The rationale for the selection of these countries and the copper price will be explained in the next section. The research methodology applied in the study was of a quantitative nature, using secondary data. The primary quantitative methodology used was correlation and regression analysis to identify any co-movement relationships.

All data collected for use in the study was secondary data obtained from I-Net Bridge from June 2006 to August 2011. The data was cleaned up by removing data points that were blank due to public holidays. Once the data was cleaned, line graphs and scatterplots were drawn to identify any visual relationships between the data sets. Thereafter, correlation and regression analyses were completed on the data sets to identify the strength of the relationships.

The hypotheses of the research question, which is to identify the relationship, if any, between the movements in commodity prices and exchange rates (the commodity price is copper and the exchange rates are AUD/USD, CAD/USD, CLP/USD, CNY/USD, and ZAR/USD) are provided below. There are two sets of hypotheses, one on correlation and one on regression.

The hypotheses for the correlation analysis were:

- H_0: There is no statistically significant co-movement relationship between the copper price and the exchange rate.
- H_1: There is a statistically significant co-movement relationship between the copper price and the exchange rate.

The aim of these hypotheses was to determine if there is a co-movement relationship between the copper price and the exchange rates of the five commodity currencies.

The hypotheses for the second set were:

- H_0: There is no co-movement relationship between the copper price and the exchange rate shown by the regression value.
- H_1: There is a co-movement relationship between the copper price and the exchange rate shown by the regression value.

2. LITERATURE REVIEW

2.1 Introduction

In the introduction to this paper it was shown that the law of one price and the law of supply and demand in economics underpin the concept of commodity prices and the exchange rates between currencies.

The various concepts that will be reviewed in this paper are interlinked by the law of one price and the law of supply and demand. A commodity, which is the first concept that will be discussed, is a type of asset that either stores value or can be used to create an object of value (Anson, 2009).

The second concept that will be reviewed is commodity currencies, together with the corresponding commodity currency country. The discussion will be limited to Australia, Canada,

Chile, China, and South Africa, as these countries are classified as commodity countries according to Cashin, Céspedes and Sahay (2002). Although China's currency cannot be officially classified as a commodity currency, it was included in this study, as China is the largest global user of copper. China also controls over 95% of the world's total production of rare earth minerals (Tse, 2011). To simplify reporting of the results, all five currencies will be referred to as commodity currencies.

The third concept that will be reviewed is copper, which will be followed by the fourth concept – the co-movement relationships between commodity currency/USD exchange rates and the spot USD copper prices.

The final two concepts that will be reviewed are the exchange rate classifications of the five currencies, followed by the financial crisis of 2007 to 2009. The financial crisis of 2007 to 2009 is included as it has a significant impact on the results of this study. The exchange rates and commodity prices move in a distinct opposite direction during the financial crisis period.

2.2 Commodities and currencies

According to Geman (2005:XV) a commodity is "... a consumption asset whose scarcity, whether in the form of exhausting underground reserves or depleted stock, has a major impact on the world and country specific economic development". 'Commodity' is the term used to describe a tangible, marketable resource that is traded and used globally. Commodities can be classified into two categories, namely hard and soft commodities (Fabozzi, Füss & Kaiser, 2008).

Soft commodities are products that are organic and perishable, are grown rather than mined (Chatnani, 2010), and split into livestock and agriculture, with agriculture being split into softs as well as grains and seeds (Fabozzi et al., 2008). Examples of soft commodities are live cattle, orange juice, wheat, coffee, and sugar. Hard commodities are mined or extracted from the earth's surface or natural resources, and are non-perishable (Chatnani, 2010); these are split into energy and metals, with metals split into industrial metals and precious metals (Fabozzi et al., 2008). Examples of hard commodities are Brent oil, copper, and gold.

Hard and soft commodities trade on a global commodities market, generally with a single currency-denominated price (USD), which allows investors the opportunity to gain economic exposure to commodities in different forms. There are six ways in which commodities are traded, namely:

- purchasing the underlying commodity;
- purchasing shares in a natural resource company;
- purchasing commodity futures contracts;
- purchasing commodity swaps and forward contracts;
- purchasing commodity-linked notes; and
- purchasing commodity exchange-traded funds (Anson, 2009).

The medium of exchange that is used to pay for any commodity is a currency. Currencies are the store of value used around the world to trade goods and services. Modern currencies are found in the physical form of notes and coins (Tavlas & Ozeki, 1992).

Currencies date back many centuries and have evolved from grain and shells to coins made of silver and gold, to today's paper money (Rosenstreich, 2005). Currencies are found throughout

the world, and are unique to each country or region (e.g. the Euro in the European Union). The majority of currencies can be classified into two major types, namely reserve currencies (also known as safe haven currencies) and commodity currencies.

A reserve or safe haven currency is defined as a currency that increases in value if market risk and illiquidity increase and if the currency benefits when exposed negatively to risky assets. The United States Dollar and the Swiss Franc are examples of reserve or safe haven currencies. A reserve or safe haven currency is popular in times of volatility, as investors seek currencies that will maintain their value (Ranaldo & Söderland, 2009).

2.3 Commodity currencies and countries

A country that produces and exports a large amount of commodities is known as a commodity country, and its currency is known as a commodity currency. A commodity currency is thus "... a currency whose behaviour is largely related to the one of the price of the exported commodity" (Bova, 2009:2). Cashin et al. (2002) describe a commodity currency as a currency of commodity-exporting countries, whose real exchange rate movements are influenced by commodity exports' real price movements. Examples of commodity currencies are the Australian Dollar, Canadian Dollar, New Zealand Dollar, South African Rand, and the Chilean Peso (Chen, Rogoff & Rossi, 2010). For many countries around the world, especially emerging economies such as South Africa and Chile, the export of commodities is a vital part of the country's earnings (Cerda, 2007).

Commodities are vital to many countries, as the export of the commodity significantly contributes to the total income of the country (Sapsford & Morgan, 1994). Countries that depend on the income from commodity exports, such as Australia, Canada, Chile, China, and South Africa, produce a wide range of minerals for use around the world. The term 'commodity currency country' is used to identify countries whose income is largely from commodities produced in that country.

Australia has a rich source of natural resources, such as bauxite, coal, copper, iron ore, tin, gold, silver, uranium, nickel, tungsten, rare earth elements, mineral sands, lead, zinc, and diamonds (United States Geological Survey, 2009). Australia's exports total an estimated USD266 billion, and the country is ranked the 22nd-largest exporter in the world (CIA World Factbook, 2011). Australia exports commodities such as coal, copper, iron ore, gold, meat, wool, alumina, and wheat. Some 60% of Australia's total exports consist of commodities (Chen & Rogoff, 2002).

Similar to Australia, Canada is also rich in natural resources but is a highly developed country that utilises its resources very efficiently. Some of the natural resources produced by Canada are iron ore, nickel, zinc, copper, gold, lead, rare earth elements, molybdenum, potash, silver, coal, and diamonds (United States Geological Survey, 2009). Canada's exports total an estimated USD405 billion, and the country is the 12th-largest exporter in the world (CIA World Factbook, 2011). Canada exports commodities such as wood pulp, timber, crude petroleum, natural gas, electricity, copper, and aluminium. Just over 25% of Canada's total exports consist of commodities (Chen & Rogoff, 2002).

Even though Chile has the best sovereign bond rating in South America, as well as strong financial institutions and stable policies, it is still an emerging country that is highly dependent on its exports. In Chile, more than one quarter of the total Gross Domestic Product (GDP) is generated through exports, with commodities totalling about three quarters thereof. Some of the natural resources produced by Chile are copper, iron ore, nitrates, molybdenum, and zinc (United States Geological Survey, 2009). Copper is Chile's largest contributor of foreign

currency, as it provides about one-third of the government's revenue (World Trade Organisation 2011; International Monetary Fund 2011). Chile's exports total an estimated USD86 billion, and the country is ranked as the 45th-largest exporter (CIA World Factbook, 2011).

China is currently the world's largest exporter in total exports and also the largest economy. Some of the natural resources produced by China are coal, copper, iron ore, mercury, tin, tungsten, antimony, manganese, molybdenum, vanadium, magnetite, aluminium, lead, zinc, rare earth elements, and uranium (United States Geological Survey, 2009). Gross exports in China total an estimated USD1.898 trillion (CIA World Factbook, 2011). It exports commodities such as aluminium, iron, copper, and steel. China is also one of the largest consumers of primary commodities (Streifel, 2006).

Compared to Australia, Canada, Chile, and China, South Africa is the second-smallest commodity country included in the current study. South Africa produces numerous natural resources such as gold, chromium, antimony, coal, iron ore, manganese, nickel, phosphates, tin, rare earth elements, uranium, diamonds, platinum, copper, vanadium, and salt (United States Geological Survey, 2009). South Africa's exports total an estimated USD94 billion, and the country is ranked as the 42nd-largest exporter. Exports include gold, copper, diamonds, platinum, other metals, and minerals.

2.4 The choice of copper

Commodities play an important role in the five commodity countries mentioned in the previous section. Copper was chosen as the commodity as its production is common to all five countries, with Chile being the largest producer of copper and China being the largest consumer of copper in the world (International Copper Study Group, 2010; International Trade Centre, 2011).

Copper is widely used as a conducting metal. Applications of copper vary widely, ranging from electronics, structural engineering, household products, coinage, and biomedical and chemical applications. Within these main categories, specific uses of copper include electromagnets, electrical relays, magnetrons in microwave ovens, roofing, household fixtures, frying pans, coins (such as the United States quarter and nickel), medical equipment (as a biostatic surface to reduce the spread of disease), as well as for converting carbon monoxide to carbon dioxide. In Africa, the main use of copper is copper wires (Copper Africa, n.d.; Dunsby, Eckstein, Gaspar & Mulholland, 2008; Fabozzi et al., 2008).

Copper is traded on exchanges such as the London Metal Exchange, the Commodities Exchange division of the New York Mercantile Exchange, and the Shanghai Exchange. On the London Metal Exchange, copper contracts are quoted in USD per imperial ton (ton), and each contract comprises 25 tons (London Metal Exchange, 2012).

On the Commodities Exchange division of the New York Mercantile Exchange, copper contracts are quoted in United States cents per pound, and each contract comprises 25 000 pounds (CME Group, 2012). On the Shanghai Metal Exchange, copper contracts are quoted in CNY (Renminbi) per ton, and each contract comprises of 5 tons of copper (Basemetals.com, 2012). The types of contracts that are traded on exchanges are futures contracts and options contracts (Copper Info, 2011).

Copper is also traded actively in the over-the-counter market, i.e. directly between two counterparties, using forward contracts that are customised for every contract (CME Group, 2009). The underlying principle of the law of one price and the law of supply and demand links

the prices of copper to the exchange rates of the countries supplying copper, which leads to a possible relationship between movements in the copper price and movements in the exchange rates of commodity currencies (Chen et al., 2010).

The amounts of copper exported by Australia, Canada, Chile, and South Africa have increased annually between 2005 and 2011. Copper is a vital part of these countries' export accounts and will continue to be important, as the uses of copper are vast. The top twenty copper-producing countries are listed in TABLE 1, with Chile producing more than four times the quantity of copper produced in Peru and China respectively. As can be seen from this table, Chile has the largest production volume at 5 968 000 metric tons (tonnes) per year (International Copper Study Group, 2010).

TABLE 1: Copper production per country

Rank	*Country*	*Tonnes ('000)*
1	Chile	5 968
2	Peru	1 375
3	China	1 313
4	United States	1 223
5	Indonesia	962
6	Australia	922
7	Zambia	865
8	Russian Federation	775
9	Canada	575
10	Poland	469
11	Kazakhstan	419
12	Congo	376
13	Mexico	288
14	Iran	283
15	Brazil	232
16	Papua New Guinea	176
17	Argentina	155
18	Mongolia	139
19	Bulgaria	116
20	South Africa	112

Source: *International Copper Study Group (2010)*

From TABLE 2 it can be seen that Chile is the largest exporter of copper, with Australia and China not being among the top twenty copper-exporting countries.

TABLE 2: Top 20 copper-exporting countries ranked by USD value

Rank	*Country*	*USD*
1	Chile	2 393 085
2	Netherlands	606 023
3	Belgium	337 402
4	Finland	271 476
5	Bulgaria	233 799
6	Slovakia	230 921
7	Spain	169 756
8	Canada	157 728
9	Peru	151 109
10	Poland	120 875
11	United States of America	99 504
12	Armenia	92 644
13	Dominican Republic	61 594
14	South Africa	50 390
15	Italy	39 940
16	Mexico	38 684
17	France	16 343
18	Singapore	9 269
19	Turkey	5 912
20	United Kingdom	4 478

Source: *International Trade Centre (2011)*

TABLE 3 shows that China imports the largest amount of copper (USD2 930 779). China imports just under twice the amount of copper (in USD) imported by Belgium. The remaining countries import only a fraction of the imports of China and Belgium.

TABLE 3: Top 20 copper-importing countries ranked by USD value

Rank	*Country*	*US Dollar*
1	China	2 930 779
2	Belgium	1 539 397
3	Netherlands	605 821
4	Australia	420 818

Rank	*Country*	*US Dollar*
5	Canada	324 768
6	Republic of Korea	300 723
7	Mexico	290 908
8	Austria	259 995
9	Poland	233 365
10	Germany	216 415
11	United States of America	201 384
12	Japan	159 790
13	Turkey	43 732
14	Russian Federation	31 374
15	Sweden	24 611
16	Chinese Taipei	21 383
17	United Kingdom	12 308
18	Hungary	10 111
19	South Africa	9 805
20	Brazil	8 943

Source: *International Trade Centre (2011)*

As previously mentioned, the spot USD copper price and the five commodity currencies (Australian Dollar, Canadian Dollar, Chilean Peso, Chinese Yuan, and South African Rand) with respect to their USD exchange rates were the variables used in the present study.

In FIGURE 1, the spot USD copper price per tonne and the AUD/USD exchange rate from June 2006 to August 2011 are shown. Before August 2008, the copper price ranged between USD5 000 per tonne and USD9 000 per tonne. After August 2008, the copper price fell drastically to below USD3 000 per tonne. The price of copper increased steadily after this drastic fall. The exchange rate decreased steadily in the period from June 2006 to August 2008. In August 2008, the exchange rate increased sharply, followed by a fluctuation around the AUD/USD 1.45 level due to the financial crisis. In the first quarter of 2009, the AUD/USD exchange rate fell steadily and continued the downward trend.

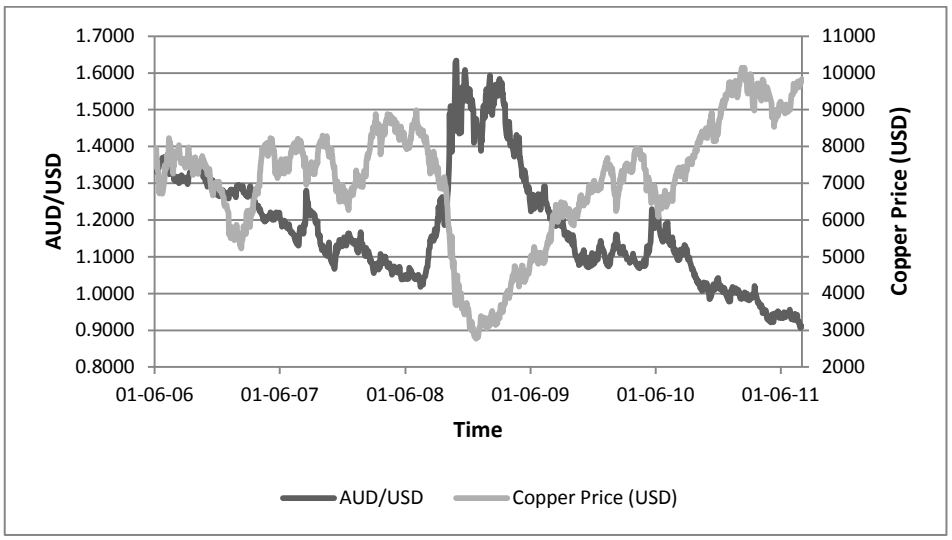

FIGURE 1: Movements of the copper price and the AUD/USD exchange rate

Source: *I-Net Bridge (2011)*

The difference in the movement of the copper price and the movement of the AUD/USD exchange rate is clearly seen in August 2008, where the copper price fell drastically and the AUD/USD exchange rate increased drastically. A clear opposite reaction was observed.

In FIGURE 2, the spot USD copper price per tonne and the CAD/USD exchange rate is shown. The exchange rate increased slightly between June 2006 and April 2007. Between April 2007 and September 2007, the exchange rate fell significantly, followed by a steady increase in the period leading to August 2008. In August 2008, the exchange rate increased significantly. The exchange rate fluctuated around the 1.25 level, and then started falling, up until August 2011.

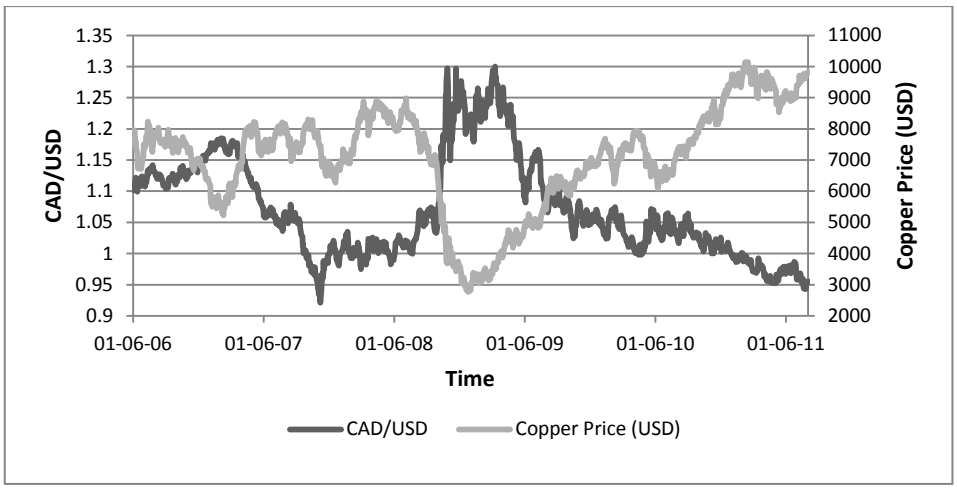

FIGURE 2: Movements of the copper price and the CAD/USD exchange rate

Source: *I-Net Bridge (2011)*

In line with the observed relationship between the copper price and the AUD/USD exchange rate, there is also a clear difference between the copper price and the CAD/USD exchange rate during August 2008.

FIGURE 3 displays the spot USD copper price per tonne and the CLP/USD exchange rate. The exchange rate fluctuated between the 500 and 550 levels in the period of June 2006 to October 2007. Between October 2007 and August 2008, the exchange rate fell significantly, followed by a sharp increase in the period leading up to August 2008. In August 2008, the exchange rate started falling, up until August 2011.

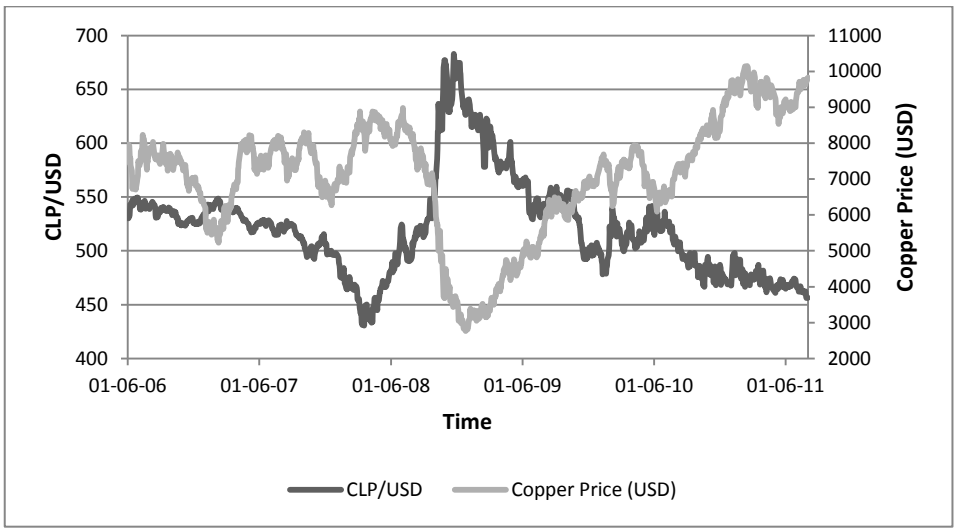

FIGURE 3: Movements of the copper price and the CLP/USD exchange rate

Source: *I-Net Bridge (2011)*

In August 2008, there is a clear difference in the relationship between the copper price and the CLP/USD exchange rate, similar to that of the relationship between the movement of the copper price and the movement of the AUD/USD exchange rate.

The spot USD copper price per tonne and the CNY/USD exchange rate is shown in FIGURE 4. Initially the exchange rate decreased from CNY/USD 8 to CNY/USD 6.8, followed by a period of no movement. In the last half of 2010, the exchange rate started decreasing slightly, up until August 2011.

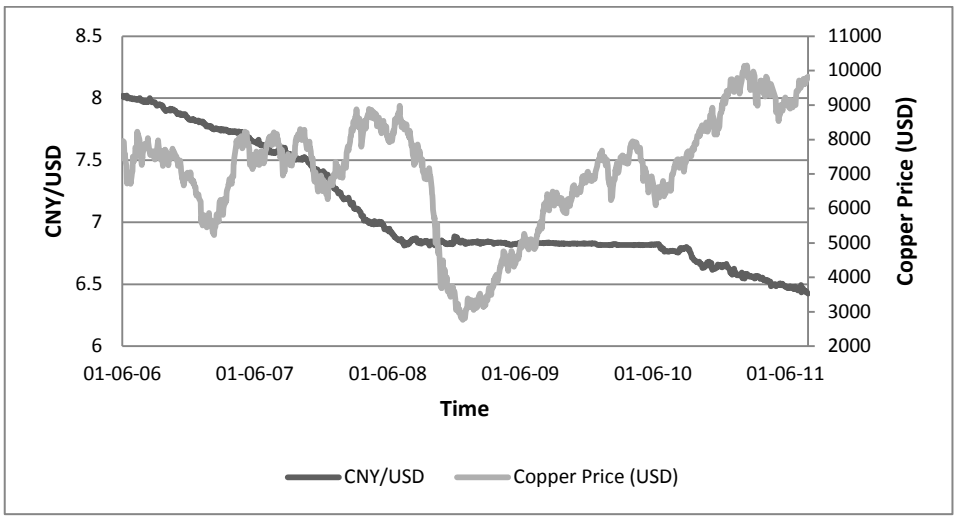

FIGURE 4: Movements of the copper price and the CNY/USD exchange rate

Source: *I-Net Bridge (2011)*

There is no clear difference between the movements of the copper price and movements in the CNY/USD exchange rate due to the crawling peg exchange rate regime used by China.

In FIGURE 5, the spot USD copper price per tonne and the ZAR/USD exchange rate is shown. The exchange rate fluctuated between ZAR/USD 6.4 and ZAR/USD 8.2 from June 2006 to August 2008. In August 2008, the exchange rate increased significantly. Thereafter, the exchange rate decreased significantly up until August 2011.

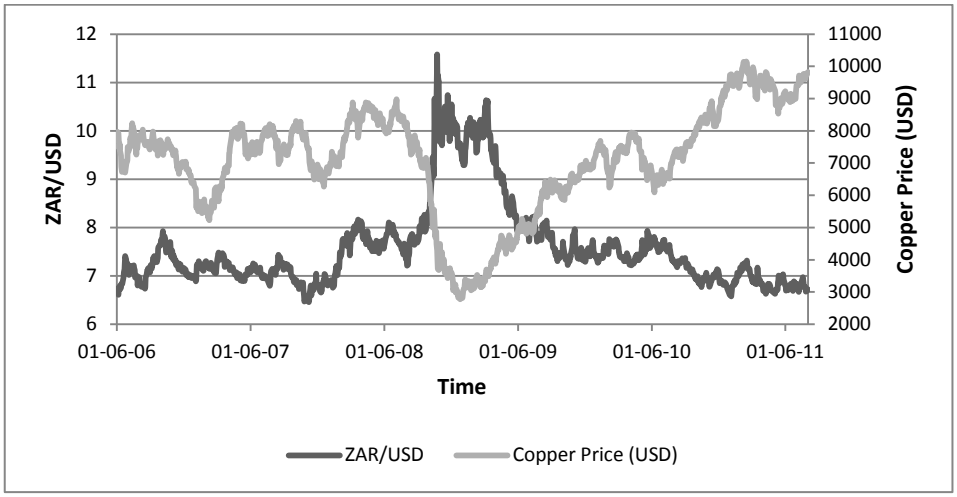

FIGURE 5: Movement of the copper price and the ZAR/USD exchange rate

Source: *I-Net Bridge (2011)*

In line with the observed relationship between movements in the copper price and movements in AUD/USD exchange rate, there is also a clear difference in August 2008 in the relationship

between movements in the copper price and the movements in the ZAR/USD exchange rate due to the financial crisis of 2007-2009.

2.5 Results of previous studies on co-movement relationships

Pindyck and Rotemberg (1990) investigated the co-movement relationship between the prices of commodities, using correlation and regression analyses (current values and lagged variables). The authors found that the price changes of commodities were correlated and these correlations were found to be larger when considering longer time periods.

Ai, Chatrath and Song (2006) investigated the co-movement relationship between commodity prices, based on the study by Pindyck and Rotemberg in 1990. Correlation and regression analyses were also used to determine co-movement. The co-movement between commodities is not as high as the co-movement between economies, as investigated by Chow, Huang and Niu in 2011.

Chen and Rogoff (2002) explored a forecasting relationship between commodity prices and exchange rates. The authors explored the relationship between the USD price of commodity exports and the floating real exchange rate of the country exporting the commodity. Chen and Rogoff (2002) identified a strong and stable relationship between the commodity prices and the floating real exchange rate, specifically that commodity prices influenced the floating real exchange rates.

Chen, Rogoff and Rossi explored the forecasting relationship further in 2010. They investigated the power of exchange rates of countries that export large amounts of commodities, known as commodity countries, in forecasting the prices of the commodities exported by that country. Chen et al. (2010) found that exchange rates of commodity currencies have a relatively strong forecasting power in predicting global movements in commodity prices.

Cashin et al. (2002) examined the influence of real commodity prices movements on the movements of real exchange rates. The relationship was explored for 58 commodity-dependent countries. They found strong evidence of the relationship in only 40% of the countries. This weaker relationship identified by Cashin et al. (2002) contradicts the results of the study done by Chen and Rogoff (2002).

2.6 Exchange rates and exchange rate regimes

Each country in the world uses a currency, and in order to determine the value of an item in a different currency, an exchange rate is used. An exchange rate between two currencies is the price of one currency expressed in a second currency (Copeland, 2008).

Exchange rate regimes used for a currency affect the movements of that currency, i.e. a floating exchange rate regime versus a fixed exchange rate regime. The choice of exchange rate regime by a country is important, as exchange rates affect the amount generated through goods and services as well as the movement of capital in and out of that country. The type of exchange regime rate chosen also affects the macroeconomic variables of a country, such as the balance of payments and inflation (Yagci, 2001).

Exchange rates are closely linked to economic principles, highlighted earlier – i.e. the law of one price and the law of supply and demand. The supply of one currency should be equal to the demand of a second currency. The relative values of two currencies, determined by supply and

demand, are not always the same, due to government intervention such as fiscal policies (Copeland, 2008).

There are three main exchange rate classifications: floating rates, fixed rates, and managed floating rates. Each classification has its own characteristics that affect the price of the exchange rate in terms of another currency (Copeland, 2008).

Floating exchange rates are completely flexible and free to move with the market forces of supply and demand. The price of the currency has no outside intervention determining its price (Copeland, 2008; Sozovska, 2004; and Tobin, 1993). A country's monetary policy operates independently of the floating exchange rate regime (Yagci, 2001).

Fixed exchange rates are unlike floating exchange rates in the sense that they are not free to move with the forces of supply and demand. Fixed exchange rates are pegged to a specific currency or a selected basket of currencies. The currency or currencies that are used as the peg determine the price of the currency being pegged (Copeland 2008; Sozovska 2004).

The final major exchange rate classification is the managed floating exchange rate regime. This is also known as a dirty floating exchange rate, as it is neither purely floating nor purely fixed, but a combination thereof, as decided by the authorities of the country (Copeland 2008; Sozovska 2004).

According to the International Monetary Fund (2011), Australia, Canada, Chile, South Africa and the United States are classified as having independent floating exchange rate regimes, while China changed from a crawling peg exchange rate regime to a managed floating exchange rate regime in 2010 (International Monetary Fund, 2010). Before 2010, the Chinese Yuan was pegged to a basket of currencies (Zeileis, Shah & Patnaik, 2010). Of the five countries selected for the current study, South Africa has the most volatile exchange rate, and its currency is also known as an emerging floater (Kohlscheen, 2010).

An independent floating exchange rate regime produces an exchange rate that is determined by the market, whereas a crawling peg exchange rate regime periodically adjusts the exchange rate. The adjustments to the currency in a crawling peg exchange rate regime are done by small amounts, which are fixed, preannounced rates (Eun & Resnick, 2009).

An important event during the period selected for the current study is the financial crisis of 2007 to 2009. A financial crisis is a "... disturbance to financial markets that disrupts the market's capacity to allocate capital – financial intermediation and hence investment come to a halt" (Portes, 1998:1). The financial crisis that started in 2007 affected the whole world and consisted of a credit crunch. It was one of the largest financial crises to affect the world to date. The financial crisis affected exchange rates and commodity prices, which resulted in adverse movements. The lack of regulation of the market was a major contributing factor to the recent financial debt crisis and credit crunch. The resultant loss of confidence in the market, in turn, crippled the lending markets globally (Gorton 2010; Melvin & Taylor 2009).

3. RESEARCH METHODOLOGY

The research objective of the study was to determine if there is a co-movement relationship between movements in the copper price and the exchange rates of five commodity currencies using secondary data. To achieve the objective, daily data was used as the variables for the correlation and regression analyses.

The study explored the relationship between the movements in the selected commodity currencies' exchange rates with respect to the USD and movements in the price of a commodity (copper) over a period of five years, namely from June 2006 to August 2011, using daily data (from secondary sources) for both the exchange rates and the commodity price. The relationships investigated were:

- movements in the AUD/USD exchange rate and changes in the copper price;
- movements in the CAD/USD exchange rate and changes in the copper price;
- movements in the CLP/USD exchange rate and changes in the copper price;
- movements in the CNY/USD exchange rate and changes in the copper price; and
- movements in the ZAR/USD exchange rate and changes in the copper price.

The secondary data used for the study to investigate if there is a relationship between the real price of a commodity and the real exchange rates of the commodity currencies (AUD/USD, CAD/USD, CLP/USD, CAD/USD and ZAR/USD) was the following: For the correlation analysis, the daily spot USD value of a tonne of copper as well as the daily value of the AUD/USD, CAD/USD, CLP/USD, CNY/USD, and the ZAR/USD exchange rates were used.

For the regression analysis, daily copper prices were used (expressed in USD per tonne). Daily AUD/USD, CAD/USD, CLP/USD, CNY/USD, and ZAR/USD exchange rates were used. Regression analysis included the use of lagged variables up to 10 periods. The time period included every trading day from June 2006 to August 2011, which yielded a total of 1 294 data points.

A research paradigm is a researcher's view of or general perspective on the research problem (Patton, 1990). The research paradigm used in this study was a positivist approach with deductive reasoning. Positivism is a philosophy whereby the researcher studies an observable reality through structured methods. Deductive reasoning entails first deducing a hypothesis, and then testing that hypothesis (Saunders, Lewis & Thornhill, 2009).

The data analysis methods selected for the current study are linked to research done by Pindyck and Rotemberg in 1990, Chow, Huang and Niu in 2011, as well as Ai, Chatrath and Song in 2006.

The co-movement analysis included correlation analysis of the variables as well as regression analysis of the variables. A coefficient of determination was also calculated to evaluate the strength of a relationship between one dependent variable and one independent variable (Saunders et al., 2009). The regression analysis was run using spot prices as well as lagged prices to identify delayed time impacts of either the copper prices or the exchange rates of the commodity currencies. All the analyses were done over the full five-year period.

The study included two variables, namely the copper prices and the exchange rates of five commodity currencies. In regression analysis, an independent and a dependent variable are required. A dependent variable (Y), also known as the response variable, is the variable being explained by the regression. An independent variable (X), also known as the explanatory variable, is the variable(s) used to explain the dependent variable. The variables are separated into dependent and independent variables to identify which variable explains what (Albright, Winston & Zappe, 2009; Doane & Seward, 2011).

In the current study, the variables were interchanged in order to find the best fit and to determine if there was a delayed impact of either copper prices or any of the five exchange rates of the commodity currencies.

There are three main limitations of the study:

- Firstly, only five commodity currencies were explored, namely the Australian Dollar, Canadian Dollar, Chilean Peso, Chinese Yuan, and South African Rand.
- Secondly, only one commodity was included in the study, namely copper.
- Thirdly, the data was assumed to be linear.

In addition to the three main limitations listed above, there are limitations to the data analysis techniques used, as well as the numerical data that was obtained from data sources, as each data source had slightly different values, based on their calculation techniques. Lack of access to information and resources during the research process could also constitute limitations of the study.

4. RESULTS AND FINDINGS

The analysis of the movements in the exchange rates of the five commodity currencies compared to movements in the copper price is illustrated and discussed below. The correlation analysis will be discussed in terms of the co-movement relationships between the copper price and the five commodity currencies' exchange rates.

The correlation values for all five commodity currencies and the copper price are displayed in TABLE 4. The correlation values of the co-movement between the copper price and the commodity currency exchange rates ranged from -0.056 for the CNY/USD to -0.873 for the CLP/USD. The values in between are -0.789 for the ZAR/USD (fourth-strongest correlation value), -0.839 for the CAD/USD (third-strongest correlation value), and -0.847 for the AUD/USD (the second-strongest correlation value).

TABLE 4: **Summary of correlations between movements in the copper price and the exchange rates of the commodity currencies**

	COPPER	*ZAR/USD*	*CAD/USD*	*AUD/USD*	*CLP/USD*	*CNY/USD*
COPPER	1.000	-0.789*	-0.839*	-0.847*	-0.873*	-0.056*
ZAR/USD	-0.789*	1.000	0.716	0.737	0.770	-0.234
CAD/USD	-0.839*	0.716	1.000	0.930	0.862	0.309
AUD/USD	-0.847*	0.737	0.930	1.000	0.895	0.398
CLP/USD	-0.873*	0.770	0.862	0.895	1.000	0.147
CNY/USD	-0.056*	-0.234	0.309	0.398	0.147	1.000

Source: *Authors' analysis*

* Statistically significant relationship

All five correlation relationships between movements of the five exchange rates of the commodity currencies and the copper price are statistically significant, as the *p*-values are less than .05.

In TABLE 5, the Multiple R and the ANOVA *p*-values of the relationships between the movements of all five exchange rates of the commodity currencies and the copper price are displayed for the regression analysis. The strongest relationship is evident between movements in the CLP/USD exchange rate and the copper price, with a Multiple R of 0.8726, and the weakest relationship is evident between movements in the CNY/USD exchange rate and the copper price, with a Multiple R of 0.0560.

The second-strongest relationship is evident between movements in the AUD/USD exchange rate and the copper price, with a Multiple R of 0.8465. The third-strongest relationship is evident between movements in the CAD/USD exchange rate and the copper price, with a Multiple R of 0.8393. The second-weakest relationship is evident between movements in the ZAR/USD exchange rate and the copper price, with a Multiple R of 0.7888.

All five relationships are statistically significant, with a *p*-value below 0.05; however, movements in the AUD/USD, CAD/USD, CLP/USD, and the ZAR/USD exchange rates have a higher statistically significant relationship with movements in the copper price than what the CNY/USD exchange rate shows.

TABLE 5: Summary of regression analyses

Relationship	*Multiple R*	*ANOVA p-value*
Copper and AUD/USD	0.8465	< 0.0001*
Copper and CAD/USD	0.8393	< 0.0001*
Copper and CLP/USD	0.8726	< 0.0001*
Copper and CNY/USD	0.0560	0.0440
Copper and ZAR/USD	0.7888	< 0.0001*

Source: *Authors' analysis*

* Statistically significant relationship

In TABLE 6, the Multiple R for the relationship between spot prices as well as the relationship between the copper price and the five exchange rates of the commodity currency countries are displayed up to the tenth lag period for the regression analysis using lagged variables. The strongest co-movement relationship is shown in the case of the CLP/USD exchange rate, with a Multiple R of 0.8726. The co-movement relationship between the spot copper price and the lagged CLP/USD exchange rate is stronger than the spot exchange rate co-movement relationship for the tenth lag period. The CLP/USD exchange rate is the only exchange rate to show an increase in the regression value for the relationship between the spot copper price and the commodity currency exchange rate. The weakest relationship is shown in the case of the CNY/USD exchange rate, with a Multiple R of 0.0560 for the relationship with the spot price to a Multiple R of 0.0500 for the relationship with the tenth lag period.

The second-strongest relationship is between movements in the AUD/USD and the copper price, with a Multiple R of 0.8465. The third-strongest relationship is between movements in the CAD/USD and the copper price, with a Multiple R of 0.8393. The second-weakest relationship is shown between movements in the ZAR/USD and the copper price, with a Multiple R of 0.7888.

All the relationships, except between movements in the lagged CNY/USD exchange rate and the copper price, are statistically significant.

TABLE 6: Summary of regression analyses with lagged variables

Relationship	*Multiple R*	
	Spot Copper	*Spot Exchange rate*
Copper and AUD/USD	0.8465*	0.8465*
Copper and AUD/USD 10 lag periods	0.8426*	0.8138*
Copper and CAD/USD	0.8393*	0.8393*
Copper and CAD/USD 10 lag periods	0.8146*	0.8249*
Copper and CLP/USD	0.8726*	0.8726*
Copper and CLP/USD 10 lag periods	0.8798*	0.8389*
Copper and CNY/USD	0.0560*	0.0560*
Copper and CNY/USD 10 lag periods	Error	0.0500
Copper and ZAR/USD	0.7888*	0.7888*
Copper and ZAR/USD 10 lag periods	0.7854*	0.7579*

Source: *Authors' analysis*

* Statistically significant at 95%

5. FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

In this study, the co-movement relationship between the copper price and the exchange rates of five commodity currencies was explored. In the previous section, the findings of the study were discussed with the aid of correlation and regression analysis. The overall aim of detailing the findings was to accept or not accept the null hypothesis provided.

The correlation analysis findings show a statistically significant co-movement relationship between four of the five exchanges rates of the commodity currencies and copper prices. The only exchange rate that does not have a co-movement relationship with the copper price is the CNY/USD, which is due to that exchange rate not being independently floating (see section 2.6).

Furthermore, in the regression analysis, a statistically significant co-movement relationship was found between the same four commodity currencies' exchange rates and the copper price. In the regression analysis of the lag periods, the CLP/USD exchange rate showed the most interesting co-movement relationship with the copper price, as the regression coefficient increased as the lag period increased when using the spot copper price and the lagged CLP/USD exchange rate as the variable.

Based on the findings of this study, possible further research includes the co-movement relationship between other spot exchange rates and the spot copper price, as well as the co-movement relationship between spot exchange rates and other spot commodity prices. The co-

movement relationship between spot and forward commodity prices can also be compared to spot and forward exchange rates.

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