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A STATISTICAL ANALYSIS OF INTERNATIONAL EXCHANGE RATE
FORMULAS

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ABSTRACT

This research thesis analyzes four important international financial exchange rate formulas. Interest Rate Parity, Covered Interest Arbitrage, Uncovered Interest Arbitrage, and Purchasing Power Parity will be tested by statistically analyzing their exchange rates from Bloomberg over the course of the last twenty years. In theory, Interest Rate Parity should hold at all times. If IRP does not hold, there is a potential for significant arbitrage. In this case, the theories of Covered Interest Arbitrage and Uncovered Interest Arbitrage will be examined. In addition to these, Purchasing Power Parity will also be tested to see if it can determine the appropriate change in exchange rates based on the price of a basket of goods.

Overall, the international financial formulas that were tested, for the most part, held true over the course of time. The greatest deviations were seen in the calculations of Uncovered Interest Arbitrage. This result was expected because Uncovered Interest Arbitrage has significant currency risk. Uncovered Interest Arbitrage does not lock in its potential profit with a forward rate, so its value is subject to the fluctuating spot exchange rates. These differences are magnified in the countries of Thailand and Mexico due to their developing economies. Other differences in the formulas are attributable to transaction costs, restrictive capital controls, and financial crises, such as the Mexican Peso Crisis of 1994, the Asian Financial Crisis of 1997, and the Subprime Mortgage Crisis of the late 2000s.

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CHAPTER 1: INTRODUCTION TO

INTERNATIONAL FINANCE

International finance is the culmination of a number of disciplines that, taken as a whole, have a major effect on economics today. In the current economy, almost every major company must have an international presence in order to remain competitive in its industry. With corporations becoming increasingly multinational, international finance will continue to serve as a vital tool in their pursuits. In addition to corporations, governments must also have global aspirations in their pursuits to avoid the negative consequences associated with their respective countries. These governmental bodies must possess an international strategy in order to trade their nation's goods and acquire funding from foreign bodies willing to loan to them. Therefore, it is absolutely necessary that these governments view international finance as one of their top priorities. Overall, international finance can be broken down into four separate, distinct categories:

- **Foreign Direct Investment (FDI):** FDI is the investment of foreign assets into another country for the purpose of building infrastructure. It typically involves investment through a variety of methods, such as building manufacturing plants in a foreign country or even adding value through expertise to another country. Governments as well as individual companies use Foreign Direct Investment¹. For example, a government can invest in one country's infrastructure and in

¹ "Understanding Foreign Direct Investment." *Going Global*. Web. 01 Apr. 2011.
<http://www.goingglobal.com/articles/understanding_foreign_direct_investment.htm>.

return receive compensation for their help. An example of this in today's economy is China and Angola. China is helping Angola build its infrastructure and in return Angola is supplying a portion of China's oil needs². Corporations can also take part in using FDI in their operations. An example of this is when a manufacturing company builds plants in a foreign country with the hopes of cheaper labor or easier transportation to their end user. A specific example of individual companies using FDI is Toyota's construction of plants in the United States. They built these plants and thus invested in the American labor market to facilitate easier delivery of inventory to United States consumers³.

- **International Trade:** International trade is the exchange of goods, services, and capital investment from one country to another. Many corporations in today's economy are struggling as a result of the global financial crisis. In order to succeed in these times, many companies have expanded their global presence. They feel that diversifying their trade over a number of markets will mitigate the risks associated with specific nation's economies. Some countries were not as affected by the recession as others. For example, companies in the United States can look to consumers in Asia and Western Europe⁴. Along with corporations, governments are also very involved with international trade. Organizations like GATT, or the General Agreement on Tariffs and Trade, and the more recent WTO, or World Trade Organization, have lowered barriers to trade and allowed

² Ganesan, Arvind. ""Transparency and Accountability in Angola" | Human Rights Watch." *Home / Human Rights Watch*. 13 Apr. 2010. Web. 01 Apr. 2011.

³ "Toyota Touts U.S. Investment." *Toyota Touts U.S. Investment - Los Angeles Times*. Los Angeles Times, 18 Apr. 2006. Web. 1 Apr. 2011. <<http://articles.latimes.com/2006/apr/18/business/fi-toyota18>>.

⁴ "About ITA." *International Trade Administration*. Web. 01 Apr. 2011. <<http://trade.gov/>>.

for a more transparent and cohesive trade platform. In addition to the formation of these organizations, governments have also benefited from the recent increase in international trade. For example, the United States is now more able to trade goods, such as crops and other food products to countries that have a shortage as well as defense instruments to allies in need of help. Overall, corporations and governments are very interested in the benefits of international trade because of the overall implications it has on their bottom lines⁵.

- **Futures Currency Contracts:** Futures currency contracts play a vital role in the exchange of goods. In order to lock in specific product revenues when dealing with foreign currencies, it is important to use futures, or forward, exchange rate contracts. These will provide a hedge against any future uncertainties in the exchange rate. A popular way of using futures contracts in trading currencies in the open market is a technique known as Covered Interest Arbitrage (CIA). This process will be discussed in detail later in the thesis. Other techniques using futures currency contracts are used as a very popular hedging tool. Multinational companies that trade all over the world, but convert their revenues to the domestic currency are the most likely candidates to use a futures currency contract strategy⁶.

⁵ "Understanding The WTO: Basics." *World Trade Organization - Home Page*. Web. 01 Apr. 2011. <<http://www.wto.org/>>.

⁶ Shapiro, Alan C. *Multinational Financial Management*. Hoboken, NJ: Wiley, 2006. Print.

- **Exchange Rates:** The overall exchange rate is perhaps the most important piece of international finance. This will be the primary focus of my thesis and is one of the roots of international finance. The reason behind its importance is the fact that exchange rates have an influence on all of the vital areas of international finance. Foreign Direct Investment is definitely affected by change in exchange rates. Labor can suddenly become more expensive in the host nation because of a dramatic rise in exchange rates. International trade is also dramatically influenced by exchange rates. A sudden decrease or increase in exchange rates relative to a major trading partner can drastically impact the trade balance of a nation. If goods become more expensive to produce and therefore sell, then exports will decrease. On the other hand, if the exchange rate becomes weaker in a certain country, imports will decrease and a trade balance will ensue. Finally, futures contracts exist because exchange rates are sometimes very volatile. As a result of this, it is important to hedge and lock in certain rates for future transactions. Overall, all three vital elements in international finance are greatly affected by fluctuating exchange rates, therefore demonstrating its great importance to economics as a whole. Consequently, exchange rates are the primary focus of my thesis⁷.

Exchange rates of currencies from all over the world are determined through a network of financial centers known as the Foreign Exchange Market, or Forex.

⁷ Eun, Cheol S., and Bruce G. Resnick. *International Financial Management*. Boston: McGraw-Hill Irwin, 2009. Print.

According to *The Economist's Guide to Financial Markets*, "Forex is a worldwide decentralized over-the-counter financial market for the trading of currencies, wherein financial centers around the globe serve as anchors of trading between a wide range of buyers and sellers 24 hours a day, five days a week"⁸. The Bank for International Settlements estimates that the Foreign Exchange Market has an average daily turnover of \$3.98 trillion, as of April 2010⁹. This \$3.98 trillion can be broken down into five major areas, or instruments. Foreign exchange swaps account for \$1.765 trillion, spot transactions are responsible for \$1.49 trillion, outright forwards have a daily turnover of \$475 billion, options & other products account for \$207 billion, and finally currency swaps have a daily turnover of \$43 billion¹⁰.

As identified by the Forex System Trading Advisor, there are eight major players in the Foreign Exchange Market. The major players are investment banks, major commercial banks, hedge funds, the Forex Interbank Market, Forex speculators, governments, Central Banks, and companies that have major sales or operations in foreign countries¹¹. In addition to these players, there are also a number of markets that are responsible for the most daily turnover in the Foreign Exchange Market. The biggest

⁸ "What Is Foreign Exchange (forex) Trading?" *The Forex Market*. Web. 14 Apr. 2011. <<http://theforexmarket.biz/what-is-foreign-exchange-forex-trading/>>.

⁹ "What Is Foreign Exchange (Forex)? - International Business Times." *IBTIMES.com: International Business News, Financial News, Market News, Politics, Forex, Commodities - International Business Times*. 11 Feb. 2011. Web. 14 Apr. 2011. <<http://au.ibtimes.com/articles/110821/20110210/what-is-foreign-exchange-currency-conversion-financial-markets-forex-foreign-exchange-markets.htm>>.

¹⁰ "Forex Market Overview." *Forex Trading / Forex Guide / GoForex*. Web. 14 Apr. 2011. <<http://www.goforex.net/forex-market-snapshot.htm>>.

¹¹ "Forex Interbank Market - Major Players." *Forex Trading System / Forex Trading / Trading System / Forex System*. Web. 14 Apr. 2011. <<http://www.forex-trading-system-advisor.com/forex-interbank.html>>.

market is the United Kingdom, followed by the United States, Japan, Switzerland, Singapore, Hong Kong, and Australia¹².

Overall, the basic principles of the Foreign Exchange Market are very simple. In theory, there is just a buyer and a seller meeting at a designated price. However, there are many subtleties to the Foreign Exchange Market that can be exploited to the traders' advantage. As outlined in my thesis, Interest Rate Parity is an equation that must hold true. When it does not, a speculator can use a variety of arbitrage formulas, such as Covered and Uncovered Interest Arbitrage, to obtain a profit. In addition to this, Purchasing Power Parity should also be able to give a trader an idea of the exchange rate based on a country's price of goods¹³.

¹² "Forex Market Overview." *Forex Trading / Forex Guide / GoForex*. Web. 14 Apr. 2011. <<http://www.goforex.net/forex-market-snapshot.htm>>.

¹³ "What Is Foreign Exchange (Forex)? - International Business Times." *IBTIMES.com: International Business News, Financial News, Market News, Politics, Forex, Commodities - International Business Times*. 11 Feb. 2011. Web. 14 Apr. 2011. <<http://au.ibtimes.com/articles/110821/20110210/what-is-foreign-exchange-currency-conversion-financial-markets-forex-foreign-exchange-markets.htm>>.

CHAPTER 2: THEORETICAL BACKGROUND

Interest Rate Parity (IRP)

IRP = (3 month forward rate / today's spot rate) – ((1 + Quarterly United States Treasury Rate) / (1 + Quarterly Foreign Treasury Rate))¹⁴

“The theory of Interest Rate Parity provides the link between the foreign exchange markets and the international money markets. The theory states: The difference in the national rates for securities of similar risk and maturity should be equal to, but opposite in sign to, the forward rate discount or premium for the foreign currency, except for transaction costs.”¹⁵

The theory must hold true in order for international financial markets to operate efficiently and equilibrium. Therefore, if the domestic interest rate of a particular nation is greater than the interest rate of a foreign nation, the parity states that the forward exchange rate must be selling at a premium in the forward market. Conversely, if the domestic interest rate of a particular nation is less than the interest rate of a foreign nation, the parity states that the forward exchange rate must be selling at a discount in the forward market¹⁶.

¹⁴ Madura, Jeff. *International Financial Management*. Australia: Cengage Learning, 2010. Print.

¹⁵ Moffett, Michael H., Arthur I. Stonehill, and David K. Eiteman. *Fundamentals of Multinational Finance*. Boston: Addison-Wesley, 2006. Print.

¹⁶ Field, Laura. "International Parity Relationships." Finance 407: International Financial Management. Smeal College of Business, State College, PA. Lecture.

An example of using Interest Rate Parity in the markets is:

1. Exchange 1 US Dollar in the spot market for British Pounds.
2. Invest this money in British Governmental Treasury Rates.
3. Finally, one must enter into a forward contract today in order to sell your pounds forward in full year.¹⁷

I was able to collect Interest Rate Parity data for just Australia and Great Britain due to a lack of available forward exchange rates for the other countries in the study.

Covered Interest Arbitrage (CIA)

CIA = LN (3 month forward rate / today's spot rate) – (Quarterly United States Treasury Rate - Quarterly Foreign Treasury Rate)¹⁸

Covered interest arbitrage is an investment strategy that attempts to locate inconsistencies between interest rates and corresponding forward exchange rates. Covered Interest Arbitrage is employed when Interest Rate Parity does not hold. When IRP does not hold, there are significant available arbitrage profits. As mentioned previously, the arbitrage opportunity is successful when the spot and forward exchange rates of a certain currency do not match the interest rates (usually government bonds) of the domestic and foreign country. When using this investment strategy, there is no currency risk because the forward exchange rate locks in the profit¹⁹.

¹⁷ Field, Laura. "International Parity Relationships." Finance 407: International Financial Management. Smeal College of Business, State College, PA. Lecture.

¹⁸ Shapiro, Alan C. *Multinational Financial Management*. Hoboken, NJ: Wiley, 2006. Print.

¹⁹ Madura, Jeff. *International Financial Management*. Australia: Cengage Learning, 2010. Print.

An example of using Covered Interest Arbitrage in the markets is:

1. Borrow US Dollars.
2. Exchange these Dollars for British Pounds in the open market.
3. Invest the Pounds at the United Kingdom Treasury Rate.
4. Sign a Forward contract to convert the Pounds back to Dollars at a designated time in the future.²⁰

I was able to collect Covered Interest Arbitrage data for just Australia and Great Britain due to a lack of available forward exchange rates for the other countries in the study.

Uncovered Interest Arbitrage (UIA)

UIA = LN (Spot rate 3 months in the future / today's spot rate) – (Quarterly United States Treasury Rate - Quarterly Foreign Treasury Rate)²¹

Uncovered interest arbitrage is a very similar investment strategy to covered interest arbitrage because it takes advantage of inconsistencies in interest rates with foreign nations. The difference between these two arbitrage opportunities, however, is that uncovered interest arbitrage does not take advantage of forward exchange rates to

²⁰ Eun, Cheol S., and Bruce G. Resnick. *International Financial Management*. Boston: McGraw-Hill Irwin, 2009. Print.

²¹ Field, Laura. "International Parity Relationships." Finance 407: International Financial Management. Smeal College of Business, State College, PA. Lecture.

lock in the potential profit. As a result, uncovered interest arbitrage is subject to currency risk²².

An example of using Uncovered Interest Arbitrage in the markets is:

1. Borrow Japanese Yen.
2. Exchange the Yen for United States Dollars in the open market.
3. Invest the Dollars in US money markets for one year.
4. Use the spot rate one year from now to exchange the Dollars back into Yen.²³

I was able to collect Uncovered Interest Arbitrage data for all of the countries in the study because the relevant data was available.

Purchasing Power Parity (PPP)

Purchasing Power Parity (PPP) = $\text{LN (3 month spot rate / today's spot rate)} - ((\% \text{ change in CPI over 3 months}) - (\text{United State change in CPI over 3 months}))$ ²⁴

There are two types of Purchasing Power Parity studied today. First, there is Absolute Purchasing Power Parity, which states that an identical product or service, regardless of location, should be the same price. Therefore, in this scenario, Purchasing Power Parity can determine the local exchange rate in a foreign country by simply

²² Shapiro, Alan C. *Multinational Financial Management*. Hoboken, NJ: Wiley, 2006. Print.

²³ Eun, Cheol S., and Bruce G. Resnick. *International Financial Management*. Boston: McGraw-Hill Irwin, 2009. Print.

²⁴ Eun, Cheol S., and Bruce G. Resnick. *International Financial Management*. Boston: McGraw-Hill Irwin, 2009. Print.

knowing the price of a good. A specific example of this is the comparison of Big Mac prices at various McDonald's locations around the world. This is known as the Big Mac Index, and it has proven to hold true on almost every continent. Michael Pakko and Patricia Pollard were the first to introduce this concept in 1996. Their conclusions from the study were that the Big Mac index held in the long-run, but there were several vast deviations because of a few reasons. These reasons include barriers to trade, transaction costs, like Value Added Taxes in the Scandinavian region, varying profit margins, and prices of "non-traded" goods²⁵. In the end, however, the Big Mac index can provide vital statistics into whether or not a currency is overvalued with respect to currencies all over the world²⁶.

Second, Relative Purchasing Power Parity states that the spot exchange rate for any given country is established by the relative price of a basket of goods in that country. A measure of the relative price of a basket goods for any given country is the Consumer Price Index (CPI). By using the Consumer Price Index, one can determine the "real" or PPP exchange rate at any given time. This theory assumes that markets are efficient and the Consumer Price Index is readily available for any given country²⁷.

I was able to collect Purchasing Power Parity data for all of the countries in the study because the relevant data was available.

²⁵ Pakko, Michael, and Patricia Pollard. "Burgernomics: A Big Mac™ Guide to Purchasing Power Parity." *Federal Reserve Bank of St. Louis*. Print.

²⁶ Field, Laura. "International Parity Relationships." Finance 407: International Financial Management. Smeal College of Business, State College, PA. Lecture.

²⁷ Moffett, Michael H., Arthur I. Stonehill, and David K. Eiteman. *Fundamentals of Multinational Finance*. Boston: Addison-Wesley, 2006. Print.

CHAPTER 3: PREVIOUS STUDIES

Jacob A. Frenkel (University of Chicago) and Richard M. Levich (New York University) performed a study entitled *Covered Interest Arbitrage: Unexploited Profits?*. This study tested the covered interest arbitrage formula in a variety of economic environments from a specified time frame. Their study wanted to test potential arbitrage opportunities in world markets. The authors felt that there was an opportunity for unexploited profits as a result of differences in exchange rates and their corresponding interest rates. In their study, they designed a new way to account for transaction costs in the foreign exchange and foreign securities market. They argued that the difference in the transaction cost accounts is the primary reason for profit opportunities in covered interest arbitrage. Their study also found that along with differences in the transaction costs, demand and supply elasticities and lags in taking advantage of the arbitrage opportunities. Finally, Frenkel and Levich (1975) conclude that covered interest arbitrage does not in fact have unexploited profit opportunities²⁸.

Kevin Clinton (Bank of Canada) performed a study entitled *Transactions Costs and Covered Interest Arbitrage: Theory and Evidence*. In this study, Clinton (1988) studied the deviations as a result of covered interest parity. Clinton found that these differences were initially catalogued to transaction costs across international markets. However, Clinton found that the swap market in foreign exchange could not explain deviations in covered interest parity. The study demonstrates that the differences in foreign exchange markets are

²⁸ Frenkel, Jacob, and Richard Levich. *Covered Interest Arbitrage: Unexploited Profits?* University of Chicago, New York University. Web. 31 Mar. 2011. <<http://www.jstor.org/pss/1830925>>.

no greater than the lowest of transaction costs. The data presented in the study does not show spreads of more than just a few basis points, so observed deviations of IRP can be attributed to differences in transaction costs in either the swap market or one of the two securities markets studied²⁹.

In their study, entitled *Capital Controls, Political Risk, and Deviations from Interest-Rate Parity*, Michael Dooley and Peter Isard (Board of Governors, Federal Reserve System) show the reasons behind interest rate differentials are due to political risk. This study defines the potential political risk as possible future restrictions on capital controls. Dooley and Isard's study (1980) also uses the theory that interest differential is due to the "gross stocks of debt outstanding against different governments and the distribution of world wealth among residents of different political jurisdictions". The data used in the study focuses on Euro mark interest rates and German interest rates with controls on capital flows between the years of 1970 and 1974. The reasoning behind the differential of IRP in their study is directly attributable to two separate controls. First, there is a deviation as a result of the effective tax rates enacted by the current controls. In addition to the effective tax rate, there is also significant political risk due to future restrictive capital controls³⁰.

Jonathan Batten (Hong Kong University of Science and Technology) and Peter Szilagyi (University of Cambridge) produced a study named, *Arbitrage, Covered Interest Parity and Long-Term Dependence Between the US Dollar and the Yen*. Their project utilized daily exchange rates from 1983 to 2005 in both the spot and forward markets. In

²⁹ Clinton, Kevin. "Transactions Costs and Covered Interest Arbitrage: Theory and Evidence." *Journal of Political Economy* 96.2 (1988): 358. Print.

³⁰ Dooley, Michael P., and Peter Isard. "Capital Controls, Political Risk, and Deviations from Interest-Rate Parity." *Journal of Political Economy* 88.2 (1980): 370. Print.

addition to the spot and forward rates, they also used equivalent short term interest rates over the sample period. In this study, Batten and Szilagyi (2006) determine whether the two currencies held according to the Covered Interest Parity Theorem. The theorem states that borrowing one currency while simultaneously exchanging that currency with another and investing it in that nation 's governmental bonds and buying a 3 month futures contract on the currency will equal investing the same amount of money in governmental rates of the domestic nation. The study discovered four important findings in their analysis of the Covered Interest Parity Theorem in the US Dollar and Yen. First, they determined that there were significant advantages to borrowing the US Dollar and lending Yen in the late 1980s and 1990s. Second, they found that the advantages in borrowing the US Dollar deteriorated by the year 2000. They attribute this finding to the progression of electronic trading and pricing systems. Next, Batten and Szilagyi (2006) found, by using regression analysis, that interday negative changes in spot rates as well as positive differences in US interest rates and negative changes in Japan interest rate contribute more to the deviation in Covered Interest Parity than differences in interday volatility. Finally, by using a statistic from fractal geometry known as the Hurst exponent, the authors find that there are multiple times where there is a long period of negative or positive disequilibrium. The negative dependence can be linked to arbitrageurs sustaining the long term equilibrium of Covered Interest Arbitrage. There is also evidence to support that both positive and negative dependence can be attributed to US Dollar declines and appreciations as well as Yen declines and appreciations³¹.

³¹ Batten, Jonathan, and Peter Szilagyi. "Covered Interest Parity Arbitrage and Temporal Long-term Dependence between the US Dollar and the Yen." *Physica A: Statistical Mechanics and Its Applications* 376 (2006): 409-21. Print.

Capital Controls and Covered Interest Parity by Takatoshi Ito (University of Tokyo) examines Covered Interest Parity between Yen-denominated and dollar-denominated interest rates. These assets include Euro-Yen and Euro-Dollar three month deposit rates and the corresponding three month governmental interest rates in Japan and the United States. The purpose of this study is to determine what portion of the deviations seen in Covered Interest Parity is attributable to the capital controls enforced by the Japanese government. The study found that transaction costs, especially a transactions tax on repurchase agreements has led to periods of disequilibrium in Covered Interest Parity. A secondary market in Japan that focuses on repurchase agreements is known as Gensaki. According to Ito (1987), equilibrium has been holding in the Euro market since 1977. Prior to this, there were violations of the Covered Interest Parity theorem in 1975 and 1976. The Euro-Dollar and Gensaki Covered Interest Parity theorem did not hold in the mid to late 1970s because of capital controls by the Japanese government. However, the theorem reached equilibrium again in 1980, when a new law was enacted that lifted most capital controls between the Gensaki market and the Euro-Dollar deposit market³².

In the article entitled, *Arbitrage in the Foreign Exchange Market: Turning on the Microscope*, Qaisar Akram (Norges Bank), Dagfinn Rime (Central Bank of Norway), and Lucio Sarno (Cass Business School) identify arbitrage opportunities in the foreign exchange market. Their analysis uses data from three major capital and foreign exchange markets over a time frame of at least seven months at tick frequency. This information was obtained from a special order from Reuters. The purpose of their project was to find

³² Ito, Takatoshi. "Capital Controls and Covered Interest Parity." *The National Bureau of Economic Research*. Web. 01 Apr. 2011. <<http://www.nber.org/papers/w1187>>.

evidence on “round-trip” or “one-way” arbitrage opportunities in real time. Their data yielded numerous results in favor of arbitrage opportunities in the real time market. They found that there were many instances of “short-lived” arbitrage opportunities that could be taken advantage of by arbitrageurs. The durations of these, on average, were long enough to obtain unexploited profits, but also low enough to corroborate evidence that many of the previous opportunities went by unnoticed³³.

In the article, *PPP and the Real Exchange Rate – Real Interest Rate Differential Puzzle Revisited: Evidence from Non-Stationary Panel Data*, Georgios Chortareas (University of Athens) and Rebecca Driver (Association of British Insurers) examine two issues associated with the basic principles of international macroeconomics. First, they examine whether or not Purchasing Power Parity demonstrates a long-term equilibrium of real exchange rates. Secondly, they test the relationship between real interest rate and real interest rate differentials. Their analysis of Purchasing Power Parity demonstrated that there is little evidence supporting the principles of it. This conclusion contrasts with what many of the former studies have found about Purchasing Power Parity. On the other hand, their second study yielded more positive results. They found a long-term relationship between real exchange rates and real interest rates. Overall, their study concluded that they cannot find a long-term relationship with Purchasing Power Parity, but they can find a link between real interest rates and real exchange rates³⁴.

³³ Akram, Qaisar, Dagfinn Rime, and Lucio Sarno. "Arbitrage in the Foreign Exchange Market: Turning on the Microscope." *Journal of International Economics* 76.2 (2006): 237-53. Print. <<http://ideas.repec.org/p/imf/imfwpa/91-2.html>>.

³⁴ Chortareas, Georgios, and Rebecca Driver. "PPP and the Real Exchange Rate - Real Interest Rate Differential Puzzle Revisited: Evidence from Non-Stationary Panel Data." *Bank of England Working Paper* 13 (2001). Print.

In 1999, Franc Klaassen (University of Amsterdam) came out with a new study entitled, *Purchasing Power Parity: Evidence from a New Test*. In this project, Purchasing Power Parity is examined through a new test. The paper states that most economists take Purchasing Power Parity to be true, even though empirical evidence for PPP is not very strong. In the project, Klaassen finds evidence in support of Purchasing Power Parity using a new test, which is “embedded in a Markov regime-switching model for the exchange rate”. Purchasing Power Parity is determined to hold true when the “regime-switching deviations” are reliant upon the PPP differences. The second result of the study is that Purchasing Power Parity differences are shorter lived in countries that have a more open trade policy³⁵.

³⁵ Klaassen, Franc. "Purchasing Power Parity: Evidence from a New Test." *Tilburg University, Center Working Paper* 1999.9 (1999). Print.

CHAPTER 4: INTERNATIONAL EXCHANGE RATES

My thesis will aim to look at a number of international currencies and their exchange rate formulas in reference to the U.S. Dollar. The currencies are:

Country:	Currency:
Australia	Australia Dollars (AUD)
Canada	Canada Dollars (CAD)
Denmark	Denmark Kroner (DKK)
Great Britain	Great Britain Pounds (GBP)
Hong Kong	Hong Kong Dollars (HKD)
India	India Rupees (INR)
Japan	Japan Yen (JPY)
Mexico	Mexico Pesos (MXN)
Sweden	Sweden Kronor (SEK)
Thailand	Thailand Baht (THB)

Australian Dollar

The Australian Dollar (AUD) is the official currency of the Commonwealth of Australia and other surrounding lands, such as the Pacific Island states of Kiribati, Nauru, and Tuvalu. Currently, it is the fifth-most traded currency in the world, most notably because of its high interest rates, stable economy, minimal governmental intervention in their foreign exchange market, and its diversification as a result of its exposure to Asian economies. The Australian Dollar reached parity for the first time in its history in October of 2010. The valuation of the Australian Dollar has increased dramatically in the

last decade with respect to the U.S. Dollar. In 2001, the Australian Dollar was worth a mere 47 U.S. cents and in 2011; it was valued at a high 1.03 U.S. dollars³⁶.

Canadian Dollar

The Canadian Dollar (CAD) is the official currency of Canada currently the seventh-most traded currency in the world. The Canadian Dollar has a very long history that started back in 1858. At this time, there were multiple currencies that were accepted in Canada, such as the Canadian Pound, the New Brunswick Dollar, and Newfoundland Dollar. In 1871, the Uniform Currency Act was passed that established one uniform currency, the Canadian Dollar. This Canadian Dollar has gone through turbulent times over the course of its history due to World Wars I and II and years of changing its exchange policy. The currency was pegged at 1.1 Canadian Dollars to one U.S. Dollar at the end of the war. In the years following, the exchange rate fluctuated in order to maintain parity between the two countries. A new peg was instituted in 1962 that reflected an exchange rate of 1.21 Canadian Dollars to 1 U.S. Dollar. This fixed exchange rate lasted until 1970, when the exchange rate was set to float. The Canadian Dollar, with respect to the U.S. Dollar, was at a 20 year low in 2002 when it was valued at 0.62 U.S. cents. The high occurred several years later in 2007 when the Canadian dollar overtook the U.S. dollar and reached a high of 1.0865 U.S. dollars³⁷.

³⁶ "Australian Dollar and Australia Currency Information including Currency Exchange Rates." *Currency Converter Calculator and Foreign Money Exchange Rates*. Web. 01 Apr. 2011. <<http://www.gocurrency.com/countries/australia.htm>>.

³⁷ "Canadian Dollar and Canada Currency Information including Currency Exchange Rates." *Currency Converter Calculator and Foreign Money Exchange Rates*. Web. 01 Apr. 2011. <<http://www.gocurrency.com/countries/canada.htm>>.

Danish Krone

The Danish Krone (DKK) is the official currency of the Kingdom of Denmark and is officially pegged to the Euro. The krone was first introduced in the wake of the Scandinavian Monetary Union. At this point, the common currency was adopted by Denmark, Norway, and Sweden. In 1914, the union was disbanded and in 1940 the Danish Krone was pegged to the German Reich mark³⁸. Due to the end of this German occupation, the Krone was pegged at 24 kroner to one British Pound. The past decade has been quite volatile due to changes in the Euro. In 2000, the Danish Krone was trading at 0.1111 Danish Krone to each dollar, and then a dramatic increase in the mid 2000s led the Danish Krone to a high of 0.2143 in 2008³⁹.

British Pound

The British Pound (GBP) is the official currency of the United Kingdom and other British territories abroad. The pound is the fourth most traded currency in the world. Along with the U.S. dollar, Euro, and Japanese Yen, the pound makes up the group of currencies that determine the value of the IMF Special Drawing Rights. With roots as one of the oldest currencies in the world, the pound has had a long and storied history. More recently, however, the pound has been closely tied to the U.S. dollar. In 1940, the pound was pegged to the U.S. dollar at a rate of one pound to \$4.03. It was then maintained as a result of the Bretton Woods system, which oversaw exchange rates after World War II. Then in August 1971, the Bretton Woods system broke down and the

³⁸ "Danish Krone, DKK, Currency of Denmark." *Currency Converter Calculator and Foreign Money Exchange Rates*. Web. 01 Apr. 2011. <<http://www.gocurrency.com/countries/denmark.htm>>.

³⁹ "Danish Krone." *CRN India*. Web. 28 Mar. 2011. <<http://www.crnindia.com/currency/krone.html>>.

pound was able to float. In the past 10 years, the pound reached a high of 2.1074 in 2007 and a low of 1.3727 in 2001⁴⁰.

Hong Kong Dollar

The Hong Kong Dollar (HKD) is the official currency of the jurisdiction of Hong Kong and currently the ninth most traded currency in the world. When the Hong Kong trading port was initially formed, there was no local currency, so alternate currencies like the Indian Rupee, the Spanish and Mexican Reales, and Chinese Renminbi was accepted. The Hong Kong dollar was then established; however there were many disturbances in its history. In 1868, the Hong Kong mint was closed down and in 1941, Japanese occupation made the Japanese military Yen the only accepted currency in Hong Kong. Finally, in 2005, the currency was pegged with upper and lower limits in relation to the U.S. dollar. The upper limit is 7.75 Hong Kong Dollars to the U.S. dollar and the lower limit is 7.85 Hong Kong Dollars to the U.S. Dollar. In the last 20 years, the Hong Kong dollar reached a high of US\$0.12992 in 1992 and a low of US\$0.12772 in 2007. The reason for the small fluctuation in the currency is the upper and lower limits established by the currency board system⁴¹.

⁴⁰ "British Pound, GBP, United Kingdom, Information on the Currency of the UK." *Currency Converter Calculator and Foreign Money Exchange Rates*. Web. 01 Apr. 2011.
<http://www.gocurrency.com/countries/united_kingdom.htm>.

⁴¹ "Hong Kong Dollar and Hong Kong Currency Information including Currency Exchange Rates." *Currency Converter Calculator and Foreign Money Exchange Rates*. Web. 01 Apr. 2011.
<http://www.gocurrency.com/countries/hong_kong.htm>.

Indian Rupee

The Indian Rupee (INR) is the official currency of the Republic of India. India was one of the first producers and distributors of coins, around the sixth century B.C.. The first rupee was established by Sher Shah Suri in the 16th century. In 1959, in order to reduce the strain on India's foreign reserve, the Indian government introduced a new currency to be used exclusively for exchanges outside of India known as the Gulf Rupee. Then, after India devalued its currency, Qatar and the United Arab Emirates created their own currencies. This reduced the strain on the currency and allowed the Indian Rupee to flourish. In the last twenty years, the Indian Rupee reached a high of US\$0.05525 in 1991 and a low of US\$0.01924 in 2009⁴².

Japanese Yen

The Japanese Yen (JPY) is the official currency of Japan and is currently the third most traded currency in the foreign exchange market. The Yen lost most of its value as a result of World War II. As a part of the Bretton Woods System., the Yen was then fixed to the US dollar. This was used to stabilize the Japanese economy and to curb inflation in Japanese consumer goods. In 1973, the Japanese Yen was allowed to free float as a result of the United States decision to dissolve its gold standard. In the past twenty years, the Japanese Yen reached a high of US\$0.012403 in 1995 and a low of US\$0.006792 three years later in 1998⁴³.

⁴² "India Rupee and Indian Currency Information including Currency Exchange Rates." *Currency Converter Calculator and Foreign Money Exchange Rates*. Web. 01 Apr. 2011.
<<http://www.gocurrency.com/countries/india.htm>>.

⁴³ "Japanese Yen and Japan Currency Information including Currency Exchange Rates." *Currency Converter Calculator and Foreign Money Exchange Rates*. Web. 01 Apr. 2011.
<<http://www.gocurrency.com/countries/japan.htm>>.

Mexican Peso

The Mexican Peso (MXN) is the official currency of Mexico and is currently the twelfth most traded currency in the foreign exchange market. While under control of the Spanish empire, Mexico used Spanish dollars as its currency. In 1821, Mexico gained its independence from Spain; however, they still used Spain's monetary system until 1863. At this time, Mexico used coins known as centavos, which were the equivalent of one-hundredth of a peso. In 1866, the coin known as the peso was introduced, and it remained in effect, after some turbulence, until 1994. In December 1994, the Mexican Peso was suddenly devalued, most notably due to policy initiatives by Mexico's president, Salinas de Gortari. These policies put great strain on the economy of Mexico⁴⁴. Currently, the Mexican peso is considered one of the more stable currencies and is traded in high volumes on the open market today⁴⁵. In the last twenty years, the Mexican Peso reached a high of 0.34176 in the early 1990s and a low of 0.06424 in 2009⁴⁶.

Swedish Kronor

The Swedish Kronor (SEK) is the official currency of Sweden. The introduction of the Krona was a result of the Scandinavian Monetary Union. At this time, Norway, Denmark, and Sweden adopted the same currency, which was in effect until World War I. After the union disbanded, each country decided to use different currencies, but they

⁴⁴ Whitt, Joseph. "The Mexican Peso Crisis." *Federal Reserve Bank of Atlanta*. Print.

⁴⁵ "Peso Becoming Top Carry-Trade Currency as Exports Soar: Argentina Credit." *Bloomberg*. Web. 11 Apr. 2011. <<http://www.bloomberg.com/news/2010-11-04/peso-becoming-top-carry-trade-currency-as-exports-soar-argentina-credit.html>>.

⁴⁶ "Mexican Peso and Mexican Currency Information including Currency Exchange Rates." *Currency Converter Calculator and Foreign Money Exchange Rates*. Web. 01 Apr. 2011. <<http://www.gocurrency.com/countries/mexico.htm>>.

kept the same name. The Swedish Kronor reached a high of US\$0.196495 in 1992 and a low of US\$0.09081 in 2001⁴⁷.

Thai Baht

The Thai Baht (THB) is the official currency of Thailand. From 1956 to 1973, the Thai Baht was fixed the U.S. dollar at an exchange rate of 20.8 Baht to one Dollar. In 1984, the Baht was devalued to 25 per dollar because of a strengthening United States economy and as a result of the Asian Financial Crisis. Finally, in 1998, the Baht was free floated and was allowed to fluctuate due to changing market conditions. In the past twenty years, the Thai Baht reached a high of US\$0.04319 in 1997 and a low of US\$0.01801 in 1998⁴⁸.

⁴⁷ "Swedish Krona." *CRN India*. Web. 28 Mar. 2011. <http://www.crnindia.com/currency/swed_krona.html>.

⁴⁸ "Thailand Baht and Thailand Currency Information including Currency Exchange Rates." *Currency Converter Calculator and Foreign Money Exchange Rates*. Web. 01 Apr. 2011. <<http://www.gocurrency.com/countries/thailand.htm>>.

CHAPTER 5: TESTS

Tables

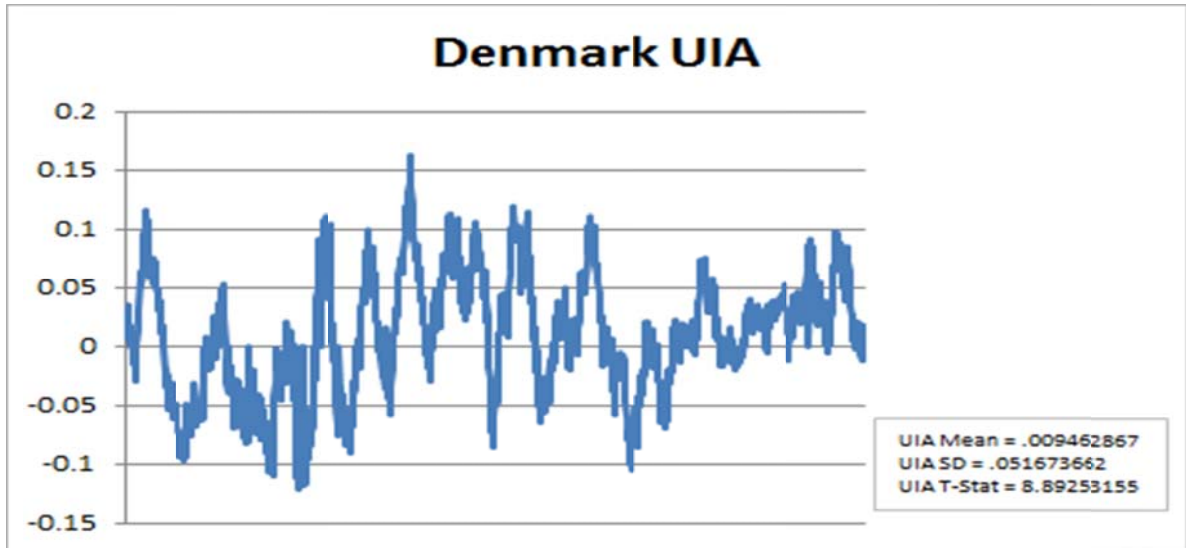
	Australia UIA	Canada UIA	Denmark UIA	Great Britain UIA
Mean	0.0380175812	0.0073693722	0.0094628674	0.0147174094
Std Dev	0.0642006280	0.0481543253	0.0516736620	0.0678895247
T-Stat	9.9969526633	7.9402232870	8.8925315583	41.3746549160
	Hong Kong UIA	India UIA	Japan UIA	Mexico UIA
Mean	(0.00093255845)	0.00661090021	(0.00108059199)	0.00669010016
Std Dev	0.00308917484	0.03784798155	0.06479319244	0.05366337254
T-Stat	(15.19626567561)	7.14653631415	(1.07489392859)	6.45871190001
	Sweden UIA		Thailand UIA	
Mean	0.002385331		0.012518402	
Std Dev	0.059068626		0.037395417	
T-Stat	2.648972943		12.908804095	

	Australia PPP	Canada PPP	Denmark PPP	Great Britain PPP
Mean	(0.0012682409)	0.0010536876	0.0015851578	0.0009232029
Std Dev	0.0605677343	0.0226520861	0.0315298328	0.0260100138
T-Stat	(0.1837408724)	0.7130789313	0.6032982731	0.4695432743
	Hong Kong PPP	India PPP	Japan PPP	Mexico PPP
Mean	(0.0000618779)	(0.0076995626)	0.0024854503	(0.0126868782)
Std Dev	0.0071403777	0.0248418716	0.0325408980	0.0406523689
T-Stat	(0.1328460228)	(4.7513352558)	0.9811096011	(4.7841285916)
	Sweden PPP		Thailand PPP	
Mean	0.0011313230		0.0015567816	
Std Dev	0.0330223654		0.0217398752	
T-Stat	0.4684888414		0.8069980717	

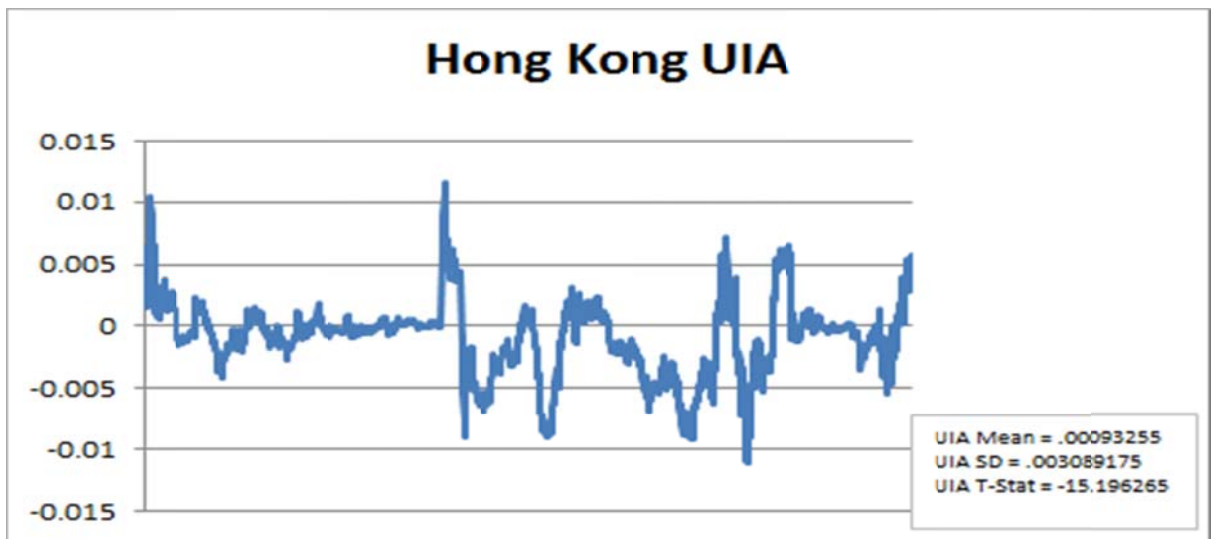
Graphs

The graphs below demonstrate Uncovered Interest Arbitrage in Denmark and Hong Kong:

Denmark

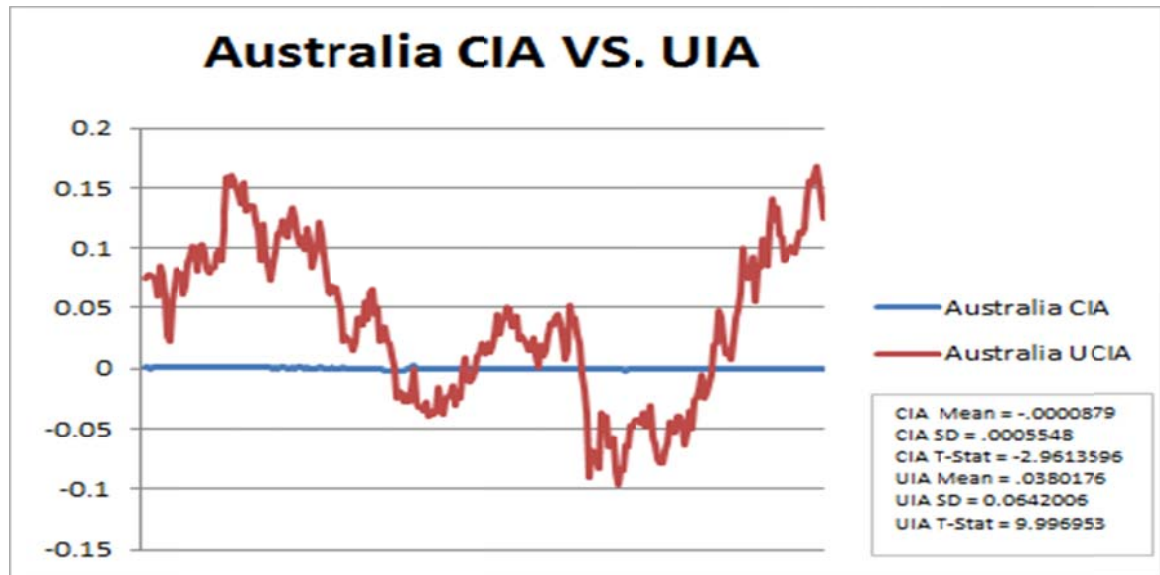


Hong Kong

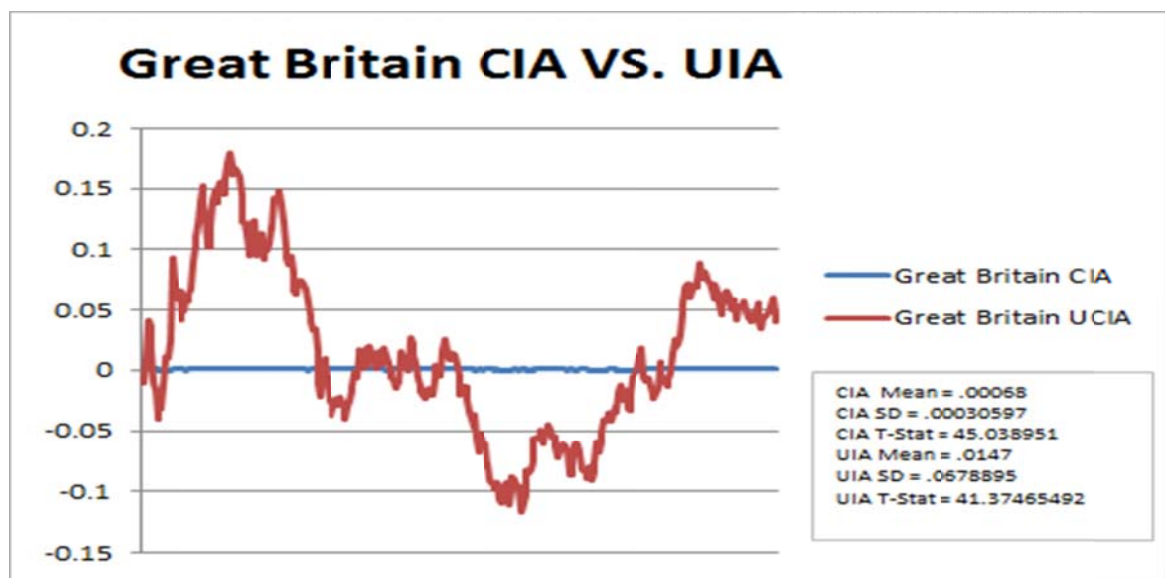


The graphs below demonstrate the difference between Covered Interest Arbitrage and Uncovered Interest Arbitrage. The first graph shows the difference in Australia and the second shows Great Britain.

Australia

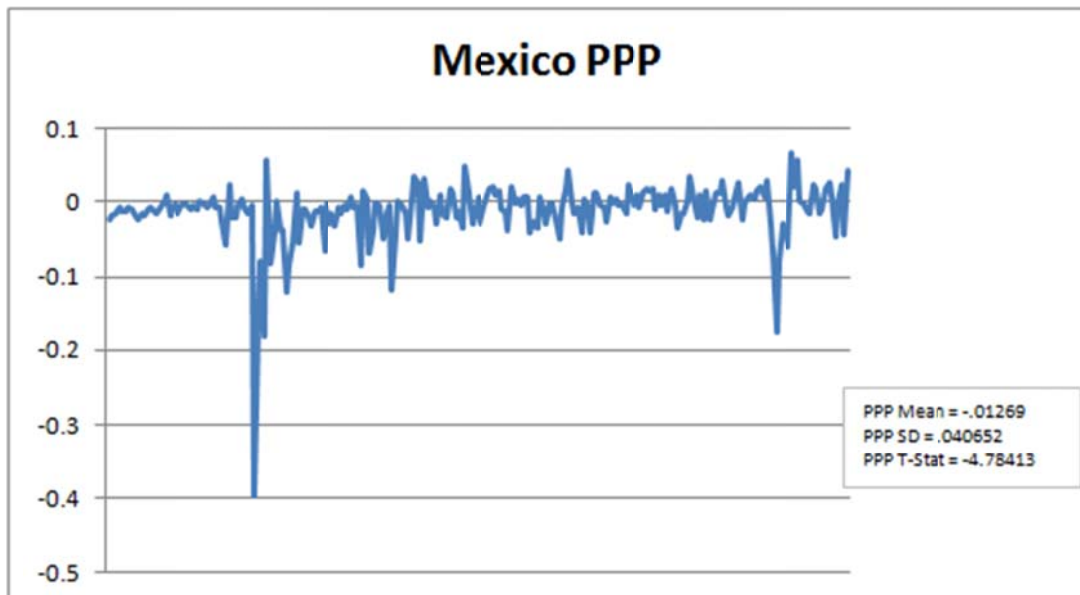


Great Britain

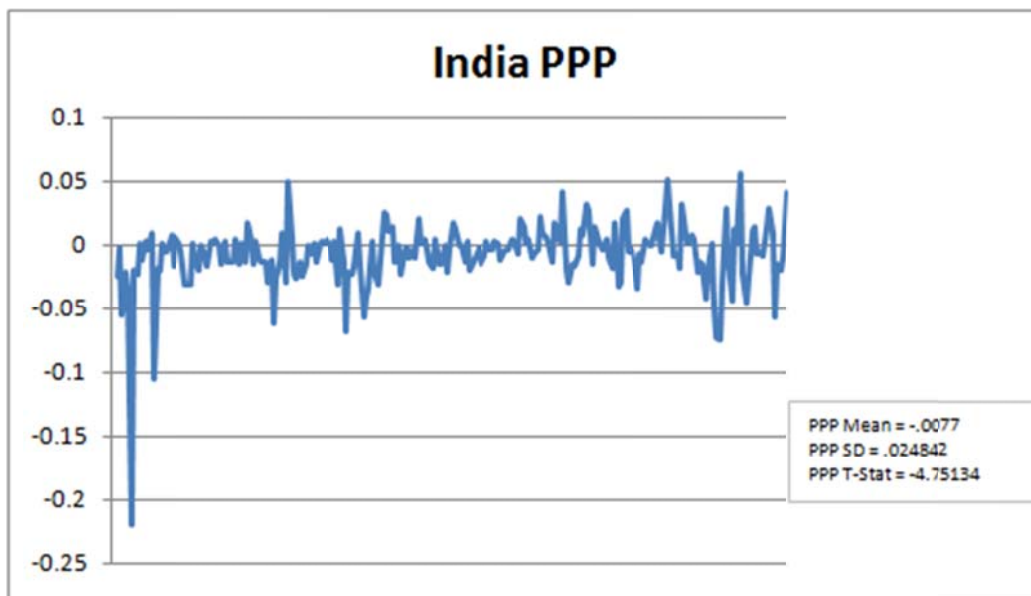


The following graphs show Purchasing Power Parity in both Mexico and India.

Mexico



India



CHAPTER 6: CONCLUSIONS

Australia

	Australia IRP	Australia CIA	Australia UIA	Australia PPP
Mean	(0.018546728)	(0.000087951)	0.038017581	(0.001268241)
Std Dev	0.002917194	0.000554831	0.064200628	0.060567734
T-Stat	(118.772191285)	(2.961359651)	9.996952663	(0.183740872)

I was able to calculate all four formulas for Australia because of its availability of 3 month forward rates. In each condition, except Purchasing Power Parity, the mean was shown to be zero and have an absolute value t-stat of over two. A t-stat of above the absolute value two demonstrates that the numbers are statistically significant and thus a valid number to use. Purchasing Power Parity did not have a T-stat above 2, so a relationship could not be confirmed. The uncovered interest arbitrage showed the most fluctuation because the mean was at 0.038. This mean is higher than normal, so as a result, potential arbitrage opportunities may exist when using this condition. In addition to Uncovered, Covered Interest Arbitrage has a low T-stat that could be indicative of potential arbitrage.

Canada

	Canada UIA	Canada PPP
Mean	0.0073694	0.0010537
Std Dev	0.0481543	0.0226521
T-Stat	7.9402233	0.7130789

Canada does not have available 3 month forward rates available, so I could not calculate Covered Interest Arbitrage or Interest Rate Parity. Uncovered Interest Arbitrage had an average of zero and a T-stat above the threshold of 2. Purchasing Power Parity did not have a representative T-stat above the absolute value of 2, so a relationship was not confirmed.

Denmark

	Denmark UIA	Denmark PPP
Mean	0.0094629	0.0015852
Std Dev	0.0516737	0.0315298
T-Stat	8.8925316	0.6032983

Denmark does not have available 3 month forward rates available, so I could not calculate Covered Interest Arbitrage or Interest Rate Parity. Uncovered Interest Arbitrage had an average of zero and a T-stat above the threshold of 2. Purchasing Power Parity did not have a representative T-stat above the absolute value of 2, so a relationship was not confirmed.

Great Britain

	Great Britain IRP	Great Britain CIA	Great Britain UIA	Great Britain PPP
Mean	(0.001434748)	0.000680568	0.014717409	0.000923203
Std Dev	0.000645854	0.000305968	0.067889525	0.026010014
T-Stat	(44.981431416)	45.038950659	41.374654916	0.469543274

I was able to calculate all four formulas for Australia because of its availability of 3 month forward rates. In each condition, except Purchasing Power Parity, the mean was shown to be zero and have an absolute value t-stat of over two. A t-stat of above the absolute value two demonstrates that the numbers are statistically significant and thus a valid number to use. Purchasing Power Parity did not have a T-stat above 2, so a relationship could not be confirmed. The uncovered interest arbitrage showed the most fluctuation because the mean was at 0.0147. This mean is higher than normal, so as a result, potential arbitrage opportunities may exist when using this condition.

Hong Kong

	Hong Kong UIA	Hong Kong PPP
Mean	(0.000933)	(0.000062)
Std Dev	0.003089	0.007140
T-Stat	(15.196266)	(0.132846)

Hong Kong does not have available 3 month forward rates available, so I could not calculate Covered Interest Arbitrage or Interest Rate Parity. Uncovered Interest Arbitrage had an average of zero and a T-stat above the threshold of 2. Purchasing Power Parity did not have a representative T-stat above the threshold, so a relationship was not confirmed.

India

	India UIA	India PPP
Mean	0.006611	(0.007700)
Std Dev	0.037848	0.024842
T-Stat	7.146536	(4.751335)

India does not have available 3 month forward rates available, so I could not calculate Covered Interest Arbitrage or Interest Rate Parity. Uncovered Interest Arbitrage and Purchasing Power Parity had averages of zero and T-stats above the threshold of 2.

Japan

	Japan UIA	Japan PPP
Mean	(0.001081)	0.002485
Std Dev	0.064793	0.032541
T-Stat	(1.074894)	0.981110

Japan does not have available 3 month forward rates available, so I could not calculate Covered Interest Arbitrage or Interest Rate Parity. Both Purchasing Power Parity and Uncovered Interest Arbitrage did not have a representative T-stat above the absolute value of 2, so a relationship was not confirmed.

Mexico

	Mexico UIA	Mexico PPP
Mean	0.006690	(0.012687)
Std Dev	0.053663	0.040652
T-Stat	6.458712	(4.784129)

Mexico does not have available 3 month forward rates available, so I could not calculate Covered Interest Arbitrage or Interest Rate Parity. Uncovered Interest Arbitrage had an average of zero and a T-stat above the threshold of 2. Purchasing Power Parity had a representative T-stat above 2, so a relationship could be confirmed in Mexico, but their mean Purchasing Power Parity number was higher than the average.

Sweden

	Sweden UIA	Sweden PPP
Mean	0.0023853	0.0011313
Std Dev	0.0590686	0.0330224
T-Stat	2.6489729	0.4684888

Sweden does not have available 3 month forward rates available, so I could not calculate Covered Interest Arbitrage or Interest Rate Parity. Uncovered Interest Arbitrage had an average of zero, but their representative T-stat was near the 2 threshold. As a result, further investigation into their relationship is needed. Purchasing Power Parity did not have a representative T-stat above the absolute value of 2, so a relationship was not confirmed.

Thailand

	Thailand UIA	Thailand PPP
Mean	0.012518	0.001557
Std Dev	0.037395	0.021740
T-Stat	12.908804	0.806998

Thailand does not have available 3 month forward rates available, so I could not calculate Covered Interest Arbitrage or Interest Rate Parity. Uncovered Interest Arbitrage had a T-stat within the 2 threshold; however their mean was much higher than the average seen with Uncovered Interest Arbitrage. Purchasing Power Parity did not have a representative T-stat above the absolute value of 2, so a relationship was not confirmed.

Results of My Data

- Exchange rates proved to be very volatile throughout the twenty years that I analyzed. This result was expected due to the fact that there were a number of financial crises during the period studied. The Mexican Peso Crisis of 1994, the Asian Financial Crisis of 1997, and the Subprime Mortgage Crisis of the late 2000's.
- Some of the weaker countries (from a financial standpoint), such as Thailand, showed a greater volatility in their exchange rates relative to their governmental treasury rates. This was also expected because there is a lack of transparency in developing nations' economies. This could lead to inefficiencies in their exchange rates because investors can be somewhat reluctant to invest their money in a developing country.
- The more stable nations, like Great Britain and Canada, showed little fluctuation in their rates relative to their interest rates. This result was expected because Great Britain and Canada are well established developed countries. These nations have had much time to analyze their economic policies and see which ones have worked the best. This leads to a more stable currency in calm times and in times of crisis.
- India was perhaps the most stable currency analyzed over the course of the last twenty years. This result was quite interesting because India is still considered a developing nation. Their stable currency can be attributable to a number of reasons. First, India has much Foreign Direct Investment from countries around

the world. In addition to this, they have close diplomatic and political ties with Western countries.

- Interest Rate Parity is a theorem that needs to hold in order for financial markets to be in equilibrium. When this parity formula does not hold, there is potential arbitrage. Over the course of the last twenty years, Interest Rate Parity held for the vast majority of the time. As a result of this, most foreign financial markets are in equilibrium.
- When analyzing Uncovered Interest Arbitrage and Covered Interest Arbitrage, there was greater volatility in Uncovered Interest Arbitrage. This was expected because Uncovered Interest Arbitrage is not being hedged with a 3 month forward rate. Since Uncovered Interest Arbitrage does not use a forward rate to lock in potential profits, it is subjecting itself to significant currency risk.
- When analyzing Covered Interest Arbitrage, there was lower volatility because the currency is hedged with a 3 month forward rate. Currency risk is therefore mitigated in this situation.
- Most of the deviations seen in Covered Interest Arbitrage are due to two reasons. First, transaction costs vary over financial centers across the world. In addition to transaction costs, capital controls are also a major factor in the deviations seen in Covered Interest Arbitrage.
- Two types of Purchasing Power Parity are studied in finance today. Absolute and Relative Purchasing Power Parity are similar concepts but have a very distinct difference. Absolute attempts to determine the exact spot rate based on the fluctuations of one good in a particular country. Relative PPP determines the

approximate change in exchange rates based on a basket of goods. My thesis utilized CPI, or Consumer Price Index, to define a basket of goods. My thesis found that PPP, in the countries studied, had means and standard deviations close to zero, but a relative T-stat could not be established in my analysis. This means that my findings cannot be considered statistically significant.

Overall, the calculations performed in this study showed a relationship that confirms the international financial formulas of Covered Interest Arbitrage, Uncovered Interest Arbitrage, and Interest Rate Parity. There were a couple exceptions to this rule. First, Australia showed an unusually high mean in Uncovered Interest Arbitrage. Its mean was well above the average for the ten nations. Australia also had a low T-stat with respect to Covered Interest Arbitrage. Next, Japan did not yield a T-stat above the threshold of two when analyzing Uncovered Interest Arbitrage. In addition, Sweden's T-stat was above two but not in a comfortable range above the bare minimum. Also, Thailand's mean Uncovered Interest Arbitrage was unusually high compared to the other nations analyzed. Finally, Great Britain had a higher mean when analyzing Uncovered Interest Arbitrage. In these scenarios, currency risk is perhaps the most likely problem because nearly every formula did not use hedging, and as a result were uncovered.

Purchasing Power Parity demonstrated means close to zero with very low standard deviations, thus proving that it can determine the spot exchange rates for today. However, in many of the countries, Purchasing Power Parity did not show a representative T-stat for its relationship between a country's spot exchange rates and its corresponding Consumer Price Indices. The study used Relative PPP to determine what the spot exchange rate would be today. According to the *Fundamentals of Multinational Finance*, however, "relative PPP holds that PPP is not helpful in determining what the spot rate is today, but that the relative change in prices between two countries over a period of time determines the change in the exchange rate over that period"⁴⁹. Therefore, using relative PPP to find

⁴⁹ Moffett, Michael H., Arthur I. Stonehill, and David K. Eiteman. *Fundamentals of Multinational Finance*. Boston: Addison-Wesley, 2006. Print.

the change in exchange rates over a given period of time will lead to better, more consistent results.

Variations in these international financial formulas are attributable to two areas: transaction costs and capital controls. When analyzing all of the formulas, it is assumed that transaction costs do not exist. However, in reality, they do exist and play a big role in arbitrageurs' success. Most of the time, the rate at which the arbitrageur borrows is much higher than the rate at which he invests. This is due, for the most part, to the bid-ask spread. The investor will encounter the high end of the spread when borrowing and the low end of the spread when investing. In addition to transaction costs, capital controls play a major role in the outcome of arbitrageurs in the market today. Governments can enforce capital restrictions so that goods and services cannot move in or out of the country. They can implement these restrictions through a variety of methods, like imposing taxes and outright banning certain countries from trading with them⁵⁰.

In today's environment, capital controls have been a topic of controversy. In recent years, emerging markets have become the beneficiary of cash inflows from developed countries. In fact, the inflow of cash, after the financial crisis, is equal to 6% of the emerging world's GDP. IMF policymakers fear that this sudden inflow will lead to a whole host of problems, such as overvalued currencies. As a result, many countries have turned to capital controls, like a tax on portfolio investment in Brazil and Peru charging more for its central bank paper to non-citizens. Opponents of capital controls argue that these restrictions will artificially undervalue the currency of the nation. This will lead to

⁵⁰ Field, Laura. "International Parity Relationships." Finance 407: International Financial Management. Smeal College of Business, State College, PA. Lecture.

disequilibrium in the Foreign Exchange Markets and opportunities for arbitrage in markets around the world⁵¹. Overall, transaction costs and capital controls can have a significant influence on the outcome of investing and borrowing in foreign nations.

In conclusion, the international financial formulas analyzed in this study, for the most part, held true. When Interest Rate Parity did not hold, potential arbitrage was available to speculators in the countries examined. Covered and Uncovered Interest Arbitrage were used to calculate these arbitrage opportunities. The study proved that there was significantly less risk in using Covered Interest Arbitrage to take advantage of the disequilibrium of the Foreign Exchange Markets. The risk was mitigated due to the three month forward rate hedge used to lock in the profits. In addition, Purchasing Power Parity did not specifically identify the spot exchange rate for today but was successful in determining the overall change in exchange rates over a given period of time. Overall, most variances seen in the international financial formulas can be explained by transaction costs and capital controls. Transaction costs can vary over countries and lead to disequilibrium in certain situations. Capital controls can also lead to disequilibrium and in turn significant fluctuations in arbitrage and parity formulas⁵².

⁵¹ "A Disjointed Attempt by the IMF to Refine Its Thinking on Capital Controls." *The Economist* 9 Apr. 2011: 86. Print.

⁵² Eun, Cheol S., and Bruce G. Resnick. *International Financial Management*. Boston: McGraw-Hill Irwin, 2009. Print.

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APPENDIX

Key Formulas Used

Interest Rate Parity Formula (IRP) = (3 month forward rate / today's spot rate) – ((1 + Quarterly United States Treasury Rate) / (1 + Quarterly Foreign Treasury Rate))

Covered Interest Arbitrage Formula (CIA) = LN (3 month forward rate / today's spot rate) – (Quarterly United States Treasury Rate - Quarterly Foreign Treasury Rate)

Uncovered Interest Arbitrage (UIA) = LN (Spot rate 3 months in the future / today's spot rate) – (Quarterly United States Treasury Rate - Quarterly Foreign Treasury Rate)

Purchasing Power Parity (PPP) = LN (3 month spot rate / today's spot rate) – ((% change in CPI over 3 months) – (United State change in CPI over 3 months))

T-Stat = Mean of deviations / (Standard deviation of deviations / square root of the number of deviations)

Data Tables

	Australia IRP	Australia CIA	Australia UIA	Australia PPP
Mean	(0.018546728)	(0.000087951)	0.038017581	(0.001268241)
Std Dev	0.002917194	0.000554831	0.064200628	0.060567734
T-Stat	(118.772191285)	(2.961359651)	9.996952663	(0.183740872)

	Great Britain IRP	Great Britain CIA	Great Britain UIA	Great Britain PPP
Mean	(0.001434748)	0.000680568	0.014717409	0.000923203
Std Dev	0.000645854	0.000305968	0.067889525	0.026010014
T-Stat	(44.981431416)	45.038950659	41.374654916	0.469543274

	Canada UIA	Canada PPP		Denmark UIA	Denmark PPP
Mean	0.0073694	0.0010537	Mean	0.0094629	0.0015852
Std Dev	0.0481543	0.0226521	Std Dev	0.0516737	0.0315298
T-Stat	7.9402233	0.7130789	T-Stat	8.8925316	0.6032983
	Hong Kong UIA	Hong Kong PPP		India UIA	India PPP
Mean	(0.000933)	(0.000062)	Mean	0.006611	(0.007700)
Std Dev	0.003089	0.007140	Std Dev	0.037848	0.024842
T-Stat	(15.196266)	(0.132846)	T-Stat	7.146536	(4.751335)
	Japan UIA	Japan PPP		Mexico UIA	Mexico PPP
Mean	(0.001081)	0.002485	Mean	0.006690	(0.012687)
Std Dev	0.064793	0.032541	Std Dev	0.053663	0.040652
T-Stat	(1.074894)	0.981110	T-Stat	6.458712	(4.784129)
	Sweden UIA	Sweden PPP		Thailand UIA	Thailand PPP
Mean	0.0023853	0.0011313	Mean	0.012518	0.001557
Std Dev	0.0590686	0.0330224	Std Dev	0.037395	0.021740
T-Stat	2.6489729	0.4684888	T-Stat	12.908804	0.806998

ACADEMIC VITA

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EDUCATION

The Pennsylvania State University
The Schreyer Honors College
Smeal College of Business

University Park, PA
Graduation Date: May 2011

Bachelor of Science Degree in Finance, Concentration in Accounting
Minor in International Business
Honors in Finance and International Business

Albert-Ludwigs Universität Freiburg
International Education Services (IES) ▪ European Union Center

Freiburg, Germany
January 2009 - May 2009

RELATED EXPERIENCE

KPMG LLP

New York, NY

Intern (Transactions and Restructuring – Modeling)

June 2010 - August 2010

- Analyzed and reviewed areas of concern in financial models assembled by private equity clients
- Specialized in a variety of M&A transactions in the renewable energy and natural gas market
- Identified potential deal breakers in debt funding and other critical areas in several multi-billion dollar deals

Sanofi Pasteur

Swiftwater, PA

Intern (Finance)

June 2009 - August 2009

- Utilized several different SAP applications in order to improve the overall business flow of the organization
- Handled \$50-70 million of bank reconciliations and \$5-10 million of accounts payable auditing weekly
- Revamped expense reporting system for employee processing by reorganizing over 30,000 accounts

Prudential Financial

Scranton, PA

Intern (Operations/Metrics)

June 2008 - August 2008

- Solved significant business problems after analyzing statistical data on the referenceability of Prudential
- Improved efficiency of the Retirement Workbook application for Prudential's 40,000 participants
- Shadowed at Newark office to gain a better understanding of the investment and finance side of Prudential

LEADERSHIP/ OTHER EXPERIENCE

Smeal Goes Global

Vice President of Finance

University Park, PA

January 2010 - December 2010

- Assist students in choosing the appropriate study abroad program through presentations and e-mails
- Manage the funds and day-to-day operations of the organization in order to promote studying abroad

Nittany Consulting Group

Director of Corporate/ Client Relations

University Park, PA

August 2009 - June 2010

Member

August 2008 - June 2010

- Organize and plan semester-long real world consulting projects for local businesses and corporations
- Developed and designed a sustainable living community for Native Americans in the western United States
- Placed first in the annual Johnson and Johnson case competition at Penn State University

Smeal Study Abroad Program

Student IES European Union Program

Freiburg, Germany

January 2008 - May 2008

- Traveled to eleven European Union nations while learning about their economic and financial policies
- Participated in meetings at the EU Parliament and Commission and WTO and U.N. headquarters

HONORS

President's Freshman Award ▪ Dean's List (All Semesters) ▪ Member of Beta Gamma Sigma Honors Society
First Place KPMG Campus Case Competition ▪ First Place Regional Johnson & Johnson Case Competition

ADDITIONAL STUDENT ORGANIZATIONS

Penn State International Programs Outreach Ambassador ▪ Springfield THON ▪ Schreyer Honors College Student Council ▪ Participant in the Next CEO Competition ▪ Announcer for the Penn State Men's Soccer Team ▪ Valley Community Library Board (President Two Years) ▪ Penn State Investment Association

COMPUTER SKILLS/ INTERESTS

Advanced in Microsoft Office ▪ Bloomberg ▪ Coursework in German and Spanish ▪ Traveling ▪ Golf