



Inspiring Excellence

Internship Report on Statistical arbitrage and risk management at AFC Capital Limited (AFCCL)

Submitted to:

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LETTER OF TRANSMITTAL

April 30, 2017

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Subject: Submission of Internship Report.

Dear Sir,

This letter is regarding the submission of my internship report, entitled “Statistical Arbitrage and risk management at AFC Capital Limited”. The purpose of this report is to learn about strategies and risk management of various financial instruments. I have successfully completed my internship program at AFC Capital Limited. I worked there for three months. Working on this report was a great learning experience for me as I have learnt the differences between practical and theoretical work. I tried my level best to present the report to be objective, systematic and reliable.

I would like to thank you for all the support and structured guidelines that you have provided for my learning throughout this journey. I would be more than happy to present on the subject matter of this report to you.

Yours Sincerely,

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Acknowledgement

The Successful accomplishment of this report was possible due to the contribution of many traders, investment managers and scholars who took their valuable time to share their ideas and methods with the world. It would not have been possible without the knowledge and expertise they share with people.

I would like to thank my honorable internship supervisor Mr. Md. Hasan Maksud Chowdhury, Assistant Professor of BRAC Business School for his continuous guidance and assistance in preparation of this report. His invaluable advice has helped me a lot in writing this report. I am immensely thankful to our Professor for the support he has provided during my Internship period.

I would like to express my sincere gratitude to my organizational supervisor, Mr. Tanvir Islam, Head of Derivatives and Global markets at AFC Capital Limited for showing me the practical methods required in active trading management. During my internship, he consistently helped to get better at what I was supposed to do.

Finally, I want to extend my gratitude to my Family, friends and classmates for inspiring me to do something fruitful.

Executive Summary

The global financial industry has evolved greatly in last three decades. Complex Financial engineering has led to innovation of a wide variety of financial instruments. Many of these evolved due to the necessity of hedging against unanticipated price fluctuations but speculation is a greater motive today. Being a financial institution AFC Capital Limited seeks to asses profitable investment strategies. Traders deploy quantitative methods to scan for active trading strategies. One of the widely used strategies include statistical arbitrage with proprietary modifications to suit for different markets worldwide. A significant part of every trade involves risk management. This paper seeks to develop active trading strategies based on arbitrage opportunities and managing risk with quantitative methods. A statistical arbitrage involves analyzing mispricing between instruments and exploit the discrepancy. We look at these opportunities from classic research examples to shed some light on the strategy. In the risk management part we look at GARCH and Artificial Neural Network methods to quantify possible risk. These models feature volatility forecast and enables a trader to spot the inherent risk present in those instruments.

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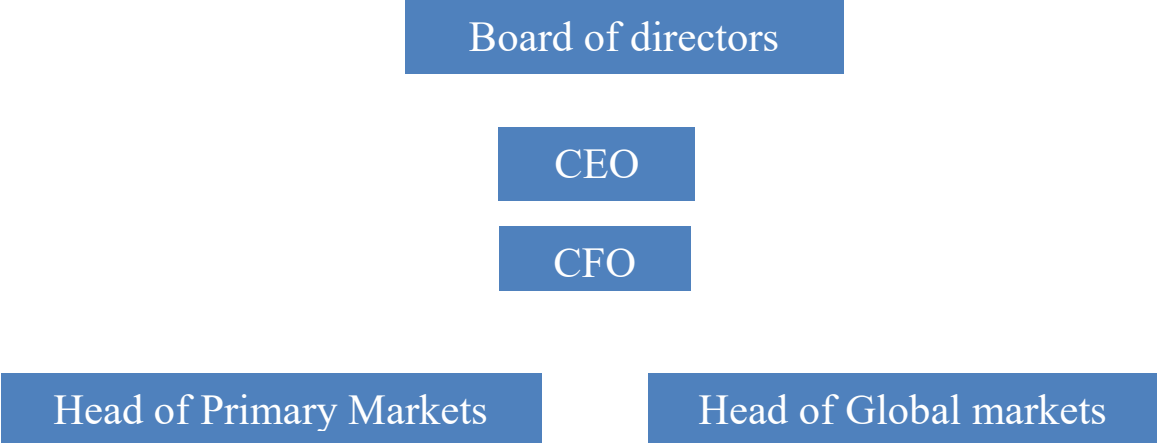
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1.1 Introduction

AFC Capital is a Bangladeshi Non-banking financial institution that specializes in issue management and post issue solutions for IPOs, Corporate advisory services and global markets. The global markets division strives to find global opportunities for trading & investment. The company is a subsidiary of Active Fine Chemicals Limited, a renowned Bangladeshi Active pharmaceutical ingredients (API) manufacturer established in 2004. The parent company holds a multiple number of companies under its umbrella, namely, AFC Biotech, AFC Health Fortis, AFC Agro, IDDL (Intelligent Development and Designs limited) and AFC Capital. This vertical integration has allowed AFC limited to become one of the most active local conglomerates in the country. The company actively seeks new markets and wants to diversify its set of offerings. In 2009, the company went public by listing in Dhaka stock exchange and raised capital from the public to strengthen its position. Since then the company grew to become what it is today.

AFC Capital serves companies in Bangladesh by helping them raise capital, corporate advisory and also helps its clients grow investments. The company diversifies its investment portfolio by investing in a wide array of financial instruments to reduce risk and increase the likelihood of positive returns. Bangladeshi capital market is undergoing a new reform from 2009 and recovering since then. After the market crash in 2009 a vast number of investors lost their money and many took their investments out of the capital market. It was a difficult time for local economic climate. Since then Bangladesh is going under a phase where the capital market is under a positive reform. However, Bangladeshi capital market is smaller compared to most of the developed countries. The global markets features a vast range of options for considering investments. From stocks and bonds to derivative products such as futures, forwards, options and swaps- every instrument is unique in nature and traded in global markets. The evolution of such a wide array of instruments emerged from the emerging need of new instruments to hedge risk, but short term gains are also sometimes the motive.

1.2. Management structure



The management structure of AFC Capital Limited is functionally simple. The CEO is the top position in the structure followed by the CFO. As there are two divisions in the company, two divisional heads run the operational segment of the divisions. The primary market division serves as a merchant bank by providing Issue and Post issue management services along with corporate advisory and restructuring services. The global markets division seeks to find active trading strategies worldwide. The firm believes in strong teamwork and emphasizes on leadership skills.

The CEO is one of the renowned professionals in the industry and has more than a decade of experience in the merchant banking industry. The CFO is a qualified chartered accountant and chartered secretary along with long track record in the financial industry. The head of Global markets has years of experience in the area of Trading and investment banking in the APAC region and successfully manages high net worth clients.

1.3 Mission, Vision, Strategic Objectives

Mission: To help Investors achieve their financial goals by managing investments with sound expertise and utmost care.

Vision: Play a leading role in ever growing investment management industry

Strategic Goals: The strategic goals of AFC Capital includes the following:

1. Strengthening its resource base to better capture the dynamics of markets worldwide
2. Expanding its investment styles to cover more instruments under portfolio
3. Diversify its presence on a wider array of markets
4. Maintaining competitive position in the industry

The mission of AFC capital is simple and logical. The integrity to the clients is emphasized driven by skill and care. The mission lays down an important point, investors are everything in investment management. It's a duty to serve the client with what the firm can do best. The vision sheds light on the blueprint of the firm, it's a broad vision. The vision upholds the desire to contribute in the overall investment industry. The strategic goals are set to achieve some critical factors, such as strengthening of resource base, expanding investment style to cover more instruments under portfolio, diversify its presence on a wide array of markets and maintaining competitive position in the industry. Resource base refers to the technical tools, skilled managers, and creativity while expanding investment styles stands for the different strategies investment management firms use such as long/short equity, merger arbitrage, convertible bond arbitrage, fixed income arbitrage, managed futures and so on. Each of these strategies has unique situations and instruments, and requires specific expertise in relevant areas. Diversifying its presence on a wider array of markets refer to both geographical diversification and the markets over there. The last strategic goal is generic which is maintaining a competitive position in the industry, which means that the firm strives to maintain a position that is strong and not easily comprisable.

1.4 Core values

AFC Capital Limited maintains an environment of openness and honesty to foster critical thinking and innovation. Each employee is encouraged to use his/her highest potential and due diligence in the related work. Every corporate house relies on the collective effort of its talented employees, at AFC teamwork is highly emphasized. Everyone is encouraged to be both assertive and open-minded in order to build their understanding and discover their best path. The types of disagreements and mistakes that are typically discouraged elsewhere are expected at Bridgewater because they are the fuel for the learning that helps us maximize the utilization of our potential. It is through this unique culture that we have produced the meaningful work and meaningful relationships that those who work here and our clients have come to expect. The following are cornerstone of core values that belong to AFC Capital Limited.

People

People are the firm's most important assets. It's the people who make it possible to attain the organizational goals. Developing and retaining great people is critical.

Diversity

Collective diversity is AFCCL's strength and the firm is committed to create an inclusive organization which will facilitate dynamic opportunities to those who with merit. AFCCL is a place of diverse people with unique experience and extensive backgrounds. AFCCL considers diversity as a fundamental part of business values.

Responsibilities

AFC Capital Limited is committed to doing business in a way that benefits its clients, employees and shareholders, and has a positive impact on the communities in which we operate around the world. The firm sees these goals as complementary, not mutually exclusive. Its business approach is grounded in the belief that the firm will do the most good by doing what they are good at — developing market-based solutions that enable its clients to meet strategic goals. Responsibility is at the center of environmental and employee engagement efforts, which are focused on:

Ethics

Ethical conduct is an important aspect in today's business arena. AFC believes in sound ethical practices and always emphasize on ethical conduct. This is a value that is irreplaceable because without ethical values a company cannot gain goodwill.

Environment

AFC Capital Limited sees sustainability as a necessary component of longevity, and believe the financial services industry can play an important role in helping governments, corporations and individuals especially in Bangladesh transition to a low carbon economy. With operations and capabilities ranging from origination to risk management, AFCCL is uniquely positioned to develop comprehensive solutions to our clients' most complex environmental challenges.

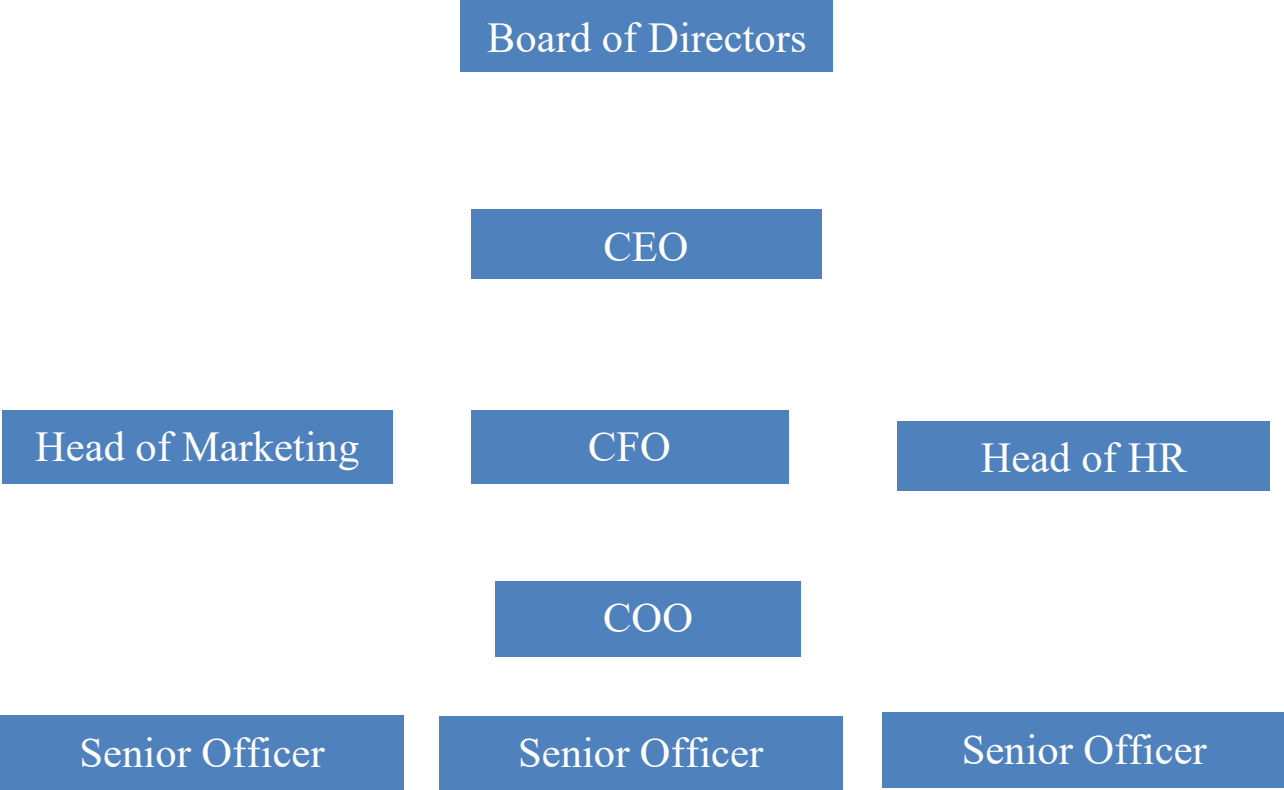
1.5 The parent Organization

Active Fine Chemicals Limited is a renowned Bangladeshi Active Pharmaceutical Ingredients (API) manufacturer listed in Dhaka stock market. Today we have 41 APIs produced in the country and AFC limited produces almost all of them. APIs are basically types of raw materials that's significant in composition of the generic drugs. Bangladesh is self-dependent in generic drugs sector, however, more than 95% of the raw materials are imported. The global API market is huge and the main players are country like China, India, and Korea. Bangladesh has a huge opportunity to penetrate the global API market, like all other competitors it requires Government support to expand research and production facility. AFC capital has three more sister concerns that includes AFC Capital Limited, AFC Agro Biotech and AFC Health Limited. The diversified conglomerate strives to diversify its business offerings as new opportunities arrive and extract the maximum potential that's available in the market.

1.6 Products offered by the Parent company

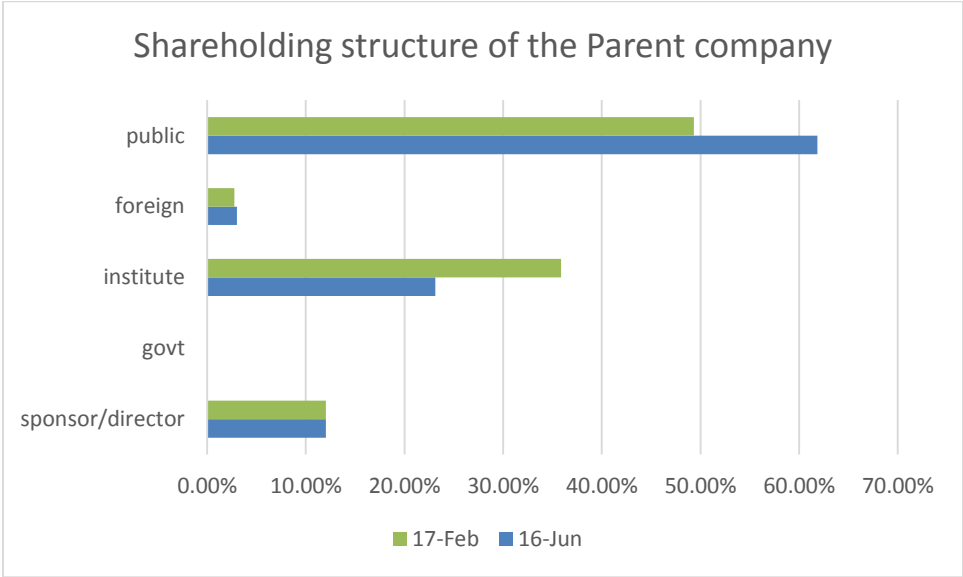
The parent company offers wide range of Active Pharmaceutical Ingredients (API) to the local generic pharmaceutical manufacturers. Some renowned products include Azithromycin, Erythromycin, and Ketorolac. These products are indispensable for generic pharmaceutical preparation. Health care sector has taken up a rise in recent years due to greater health consciousness. Our pharmaceutical exports has kept growing double digit since 2010, and accordingly, the demand of API has gone up vastly. API formulation is a sophisticated process which requires expert skill in the fields of Chemistry, Biology and Engineering. The health sector now employs more than 2 lakhs of white collar labor. The Government also offers cash incentive on pharmaceutical exports, and considering to offer incentive on API exports also. The global demand for these products are rising ever high and many enterprise has shown interest into the industry, but, being a high capital intensive industry, the industry involves high capital risk at stake. Successes in drug trials worldwide can be as low as one out of seven depending on the drug type, making it a huge risk for the initial capital required for research & development.

1.7 Structure of The Parent Company



1.8 Holding structure of the parent company

Public shareholding has decreased over the last two years while Sponsor/director shareholding remained the same. Foreign shareholding decreased slightly in last two years while institutional shareholding increased considerably. Government had no shareholding in the company so far.



1.9 Divisions

There are two divisions at AFC Capital, A primary Markets division and another, Global markets division.

1.9.1 Primary Markets Division

Bangladesh has more than 300 companies listed in Dhaka and Chittagong stock market. More companies are willing to go public every year because of the growing need to raise capital for building a business in a very competitive environment. Public companies are subject to greater scrutiny as the rules and regulations for public companies are more stringent in nature to save the general investors and protect the integrity of the market. A capital market of any country is very important because it facilitates efficient movement of money between lenders and borrowers and helps entrepreneurs raise the capital required to convert their idea into business. AFC Capital helps companies raise money from the public by assisting in the whole Initial Public Offering process. Business climates are dynamic worldwide and companies undergo frequent changes in strategic and operational level. This stages often incorporate corporate restructuring and thus require expert firms to assist in the process by offering advisory services. The primary markets also helps companies by advisory relationships which helps them to reevaluate the company dynamics and effectively restructure the business to meet the ever changing needs of the business environment. Managing client portfolios is often a rigorous work in the field of investment management, so the people has to be expert in the markets that they operate which is an important aspect the company believes in.

In order to manage ethical practices the firm inspires its employees to follow code of conduct and ethical standards as trust is the underlying foundation in investment profession. The firm manages different types of portfolio based on the client's risk and return objectives and investment horizon. Some portfolios plan to provide steady returns with risk minimized, some portfolios may feature higher return possibilities but embedded with higher risk. More and more companies now considering going public because businesses need capital to fund their research, operations, acquisitions and many other purposes. According to most of the investment research firms, global equity sector and private equity has given higher returns than most of the other sectors. A capital

market also represents a nation's economy in a nutshell. A developed country's capital market poses greater opportunity for the enterprises to fund their business needs, allows investors to earn a higher rate of return and enables efficient flow of capital among the people involved.

1.9.2 Some recent IPOs by AFC Capital

INTRACO REFUELING STATION LIMITED

Public Issue of 20,000,000 Ordinary Shares of Tk. 10.00 each at par, total size of fund to be raised amounting to Tk. 200,000,000.00.

PACIFIC DENIMS LIMITED

Public Issue of 75,000,000 Ordinary Shares of Tk. 10.00 each at par, total size of fund to be raised amounting to Tk. 750,000,000.00.

SIMTEX INDUSTRIES LIMITED

Public Issue of 30,000,000 Ordinary Shares of Tk. 10.00 each at an issue price of Tk. 20 each including a premium of Tk. 10 per share amounting to Tk. 600,000,000.00

SHASHA DENIMS LIMITED

Public Issue of 50,000,000 Ordinary Shares of Tk. 10.00 each at an issue price of Tk. 35 each including a premium of Tk. 25 per share amounting to Tk. 1,750,000,000.00

KHAN BROTHERS PP WOVEN BAG INDUSTRIES LIMITED

Public issue of 20,000,000 ordinary shares of BDT 10.00 each at an issue price of BDT 10.00 each at par amounting to BDT 200,000,000

UNITED AIRWAYS (BD) LIMITED

Rights Offer of 210,000,000 Ordinary Share of Tk. 10 per Share at an issue price of Tk. 15 each including a premium of 5.00 per share amounting to Tk. 3,150,000,000 to offered on the basis of 1R:1 (One right shares for 1 existing share)

C & A TEXTILES LIMITED

Public Issue of 45,000,000 Ordinary Shares of Tk. 10.00 each at par amounting to Tk.
450,000,000.00

1.9.3 Global Markets Division

The global market division is a quantitative division that delves into the global markets for active investment strategies. Over the years, volatility has caused rising need to diversify investments across many assets classes and hedge against unanticipated market moves. This concept is embedded in the very classical theory of Markowitz's efficient asset allocation and optimization. In order to develop active trading strategies, analysts analyze global economy from both a macro and micro perspective and convert the data into information that are meaningful. These often involve diving into big data and effectively convert the data into information that are insightful and actionable. The global markets include instruments that range from stocks and bonds to derivative products such as futures, forwards, options and swaps. These instruments are not unique in their nature and tends to feature different characteristics on the ways they are traded. Some are traded on the counter and others are traded over the counter markets. In many cases parties tend to customize special contracts that has attributes like the instruments mentioned above.

The global market is very liquid compared to individual developing company's markets. Large number of institutional investors, retail investors, and traders take part in the market. The markets are driven by these market participants with various intentions, some are engaged in long term wealth management, some wants to hedge the risk involved in their operations, and some others want short term gains. However, all the instrument has its unique risk feature and exposes the investor to risk depending on the feature of the instrument. Investors depending on their risk and return objectives invests on a wide variety of instruments, while broker dealer provides market capital, traders move the market and long term investors tends to go with block orders. The global market division tries to assess the global investment markets by quantitative methods. These methods include analyzing the markets, quantifying risk or exposure, forecasting and risk management techniques.

1.9.4 Widely traded instruments

Stocks, bonds and derivative products are most commonly traded financial instruments. A derivative product derives its value from its underlying asset. A corn futures contract, for example,

is a derivative product that derives its value from its underlying asset which in this case is corn. Originally the necessity of futures emerged to hedge the risk of assets that are highly volatile in nature. A farmer who expects that the price of her corn will fall below and a retailer who expects the price would go up can both be better off if they had a futures contract where the seller (farmer) could save herself from potential down prices and the retailer can hedge against unanticipated rising prices to secure her profits. While the need to hedge still remains today, speculation is the greater motive today. A forward is similar to futures, but they are not standardized, means they are traded via over the counter (OTC) markets unlike futures (these trade on formal exchanges) and subject to less stringent regulation. An option is another type of derivative product but unlike future and forwards, options don't carry the obligation to buy or sell rather it depends on the buyer whether she should exercise the contract. In order to compensate the seller of the option because of the uncertainty in whether the option will be exercised, an option premium is attached to the instrument. New York stock exchange is the largest stock exchange while Chicago mercantile exchange is the world's largest futures and options exchange. The group has its corporate headquarters at Chicago and has presence on derivative and future exchanges in Chicago, New York, London. All the markets can be accessed worldwide through electronic platforms. The Company was established by a merger between Chicago Mercantile Exchange and Chicago Board of trade in 2007. Group consists of four designated contract markets: CME, CBOT, NYMEX, and COMEX. Today its product offerings mostly include futures, options and swaps across a wide area such as crude, gold, natural gas, petrochemical, agriculture, currencies, weather, real estate, interest rates and many others. This wide array of products helped CME evolve as the largest marketplace for derivatives. There are different membership costs and can vary, prices for memberships are determined in an auction. CME has its own premier electronic system providing connectivity worldwide to keep traders updated real time about all the instruments. This system provides 24 hours of access to global markets and allow making trades. But, there are many platforms out there and can vary depending on trader preferences.

In 2017's January average daily volume reached 16 million contracts per day, a decrease of 12% from January of 2016. Options volume decreased by 19% compared to January of 2016, averaging to 3.4 million contracts a day. Electronic options decreased by 5%. Metals average volume was 525,000 contracts per day in January featuring an increase of 30% from January of 2016. Gold futures average daily volume increased 38%, silver futures average daily volume grew by 40%.

Metals volume overall increased by 23% on a year-over-year basis for base metals for the month. Agricultural average volume increased by 3% from January 2016, soybean grew by 9% while soybean meal futures increased by 15%.

Average daily volume (in thousands)			
Product line	Jan-17	Jan-16	% change
Interest rates	8,931	8,935	-0.04%
Equity indexes	2,495	4,139	-39.72%
FX	920	970	-5.15%
Energy	2,539	2,597	-2.23%
Agricultural commodities	1,166	1,133	2.91%
metals	525	405	29.63%
Total	16,576	18,179	-8.82%

2.0 The project

2.1 Background

As the markets gets larger and more integrated, the interconnection among global business climates is clearer today than it was two or three decades ago. Today we have highly liquid global markets with real-time electronic platforms to manage trading. But the complexity in delving into big data that's available today and making sense of it for taking profitable trade positions is still a very humanely work. Trading involves different time horizons depending on the strategy deployed and the sentiment of the market. Trading involves a combination of technical analysis and fundamental analysis. While technical analysis helps forming real-time decisions for short time frames, fundamental analysis provides a ground with a broad foundation of the market dynamics. A simple example of combining both methods would be researching a commodity (i.e. crude oil) to find its global supply/demand, pricing structure and use technical analysis to find the most opportunistic price point for entry-exit for the relevant commodity derivative (i.e. Crude Futures).

The last three decades has featured an evolution of a vast ecosystem in the global financial products market. Today the financial instruments range from stocks and bonds to futures, options, swaps and many more. The necessity of such a wide array of products emerged with the growing necessity to raise capital, facilitate economic exchange and need to hedge against price fluctuations of the assets that are highly volatile in nature. But speculation maybe the main motive today. Today we have futures, forwards, options, swaps and many exotic instruments which are derivative products in nature but varies depending upon the underlying asset, expiry and market where it is traded. As day trading depends heavily on short term market movements, leverage acts as a double edged sword for the traders. With low margin requirements in derivative markets, the trader can effectively make larger returns on small price fluctuations and could also lose a lot on small price moves.

2.2 Objectives of the project

The objective of this project is to analyze for trading strategies built on statistical arbitrage methods and managing risk with volatility forecast tools such as GARCH. These methods are renowned in the field of trading because of its practicality and simplicity to use. The objectives are core to the profession of trading and emphasizes on useful and impactful strategies that have been in use for long periods of time, but of course, with individual modifications.

2.3 Methodology

The augmented Dickey Fuller test is used to test for stationarity. The augmented Dickey Fuller test is built upon the concept of a unit root. If the autoregressive process of a time series (Z) coefficient α equals 1 in the following equation, a unit root is present and thus can be concluded as non-stationary. We use Eviews 7.2 to perform Augmented Dickey Fuller test. The P values then can be compared against the 0.05 significance level and a decision can be reached.

Critical values for Dickey–Fuller t-distribution.				
	Without trend		With trend	
Sample size	1%	5%	1%	5%
T = 25	-3.75	-3.00	-4.38	-3.60
T = 50	-3.58	-2.93	-4.15	-3.50
T = 100	-3.51	-2.89	-4.04	-3.45
T = 250	-3.46	-2.88	-3.99	-3.43
T = 500	-3.44	-2.87	-3.98	-3.42
T = ∞	-3.43	-2.86	-3.96	-3.41

Typically we use 0.05 significance level. The result from the test is reached after comparing the test statistic with the Dickey-Fuller critical values for a level of significance. The null hypothesis is that the series does have a unit root. If we can reject the null hypothesis, we can statistically say that the series does not have a unit root.

The Johansen cointegration test is a method to assess long term relationship between variables. There are two types of Johansen test, the Trace method and the Eigenvalue.

The trace test examines the number of linear combinations (i.e. E) to be equal to a given value (E_0), and the alternative hypothesis for E to be greater than E_0 .

Null hypothesis, $H_0: E > E_0$ (There is no cointegration)

Alternative hypothesis, $H_a: E > E_0$ (There is cointegration)

To test for the existence of Cointegration using the trace test, we set $E_0 = 0$ (no cointegration).

In the maximum eigenvalue test, we want to find out the same relationship (cointegration) exists or not.

Null hypothesis, $H_0: E = E_0$ (There is no cointegration)

Alternative hypothesis, $H_a: E_0 + 1$ (There is cointegration)

General Autoregressive conditional heteroskedasticity (GARCH) model was first developed by Engle and Bollerslev (1986). This method incorporates a long run unconditional variance, conditional variance of a lagged series and squared returns.

$$\sigma^2 = \Phi + \alpha\mu^2_{t-1} + \beta\sigma^2_{t-1}$$

Exchange rate (USD/CAD)	Residual	Squared Residual	Lagged squared change (K)	Conditional variance (V)	Log likelihood function	conditional standard deviation (time weighted)	Unconditional standard deviation (no time weighted)
	$(R_t - R_{t-1})$	$(R_t - R_{t-1})^2$	lag 1 of $(R_t - R_{t-1})^2$	$\omega + (\alpha * k) + (\beta * V)$	\ln $(1/\sqrt{2 * 3.1415 * v}) * (\exp * (-0.5 * \text{lag sq.res/v}))$	$(\text{cond var})^{0.5}$	long run standard deviation

First we compute the residual, then take square of it. We use lagged squared change and lagged squared change because of its further use in log likelihood estimation. We compute the long term

unconditional variance as some long term volatility and optimize the alpha, beta and omega values using solver function.

2.4 Statistical Arbitrage

Statistical Arbitrage seeks to find pricing anomalies between instruments and exploit the opportunity. The following chart shows daily returns of Lockheed Martin and Delta Air lines. Firstly, we want to see whether these returns are stationary, we want to have a statistical edge. We perform Augmented Dickey Fuller test to check for unit root. The null hypothesis of the test is that the returns have a unit root, if we can statistically reject the null hypothesis, we say that the series is stationary and does not have to go under differencing method (Thomas B. Fomby, n.d.).

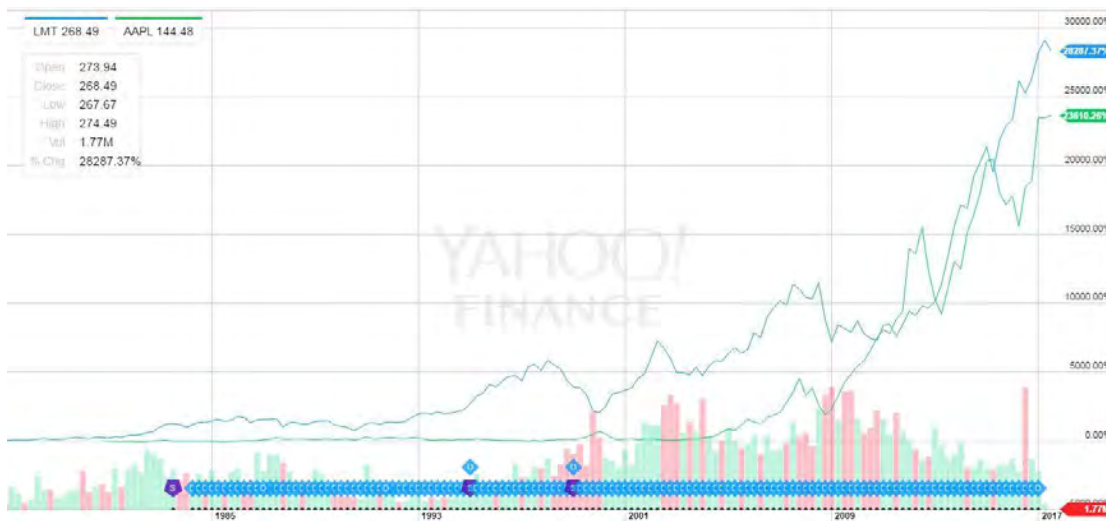


Fig: Lockheed Martin Corporation and Apple stock price

We run Augmented Dickey fuller test in Eviews 7.2 at 5% significance test for Lockheed Martin Corporation and Apple Incorporated. The results are presented below.

Null Hypothesis: **LMT** has a unit root
 Exogenous: Constant
 Lag Length: 0 (Automatic - based on SIC, maxlag=24)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-43.14811	0.0000
Test critical values:		
1% level	-3.433863	
5% level	-2.862978	
10% level	-2.567583	

Null Hypothesis: **AAPL** has a unit root
 Exogenous: Constant
 Lag Length: 0 (Automatic - based on SIC, maxlag=24)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.172869	0.0218
Test critical values:		
1% level	-3.433863	
5% level	-2.862978	
10% level	-2.567583	

The results in both the cases show P values less than 0.05 significance level (tested assuming no trend), we reject the null hypothesis concerning the unit roots of the stocks and thus the series does not have unit root. The t-Statistic also leads to the same results but P value is more widely used. This means that the data is stationary and does not need to be differenced. Now, we will check for cointegration. We will perform a Johansen cointegration Test in Eviews 7.2 to check for cointegration. By looking at the results of the cointegration we can quantify the level of long term relationship between these instruments and therefore try exploit anomalies when deviation of their stock price ratios differ greatly. The null hypothesis in Johansen test is that there is no cointegration between the series.

Date: 04/25/17 Time: 23:25
 Sample (adjusted): 5/04/2010 1/24/2017
 Included observations: 1756 after adjustments
 Trend assumption: Linear deterministic trend
 Series: LMT AAPL
 Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.184986	361.6633	15.49471	0.0001
At most 1	0.001408	2.474252	3.841466	0.1157

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
 * denotes rejection of the hypothesis at the 0.05 level

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.184986	359.1891	14.26460	0.0001
At most 1	0.001408	2.474252	3.841466	0.1157

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

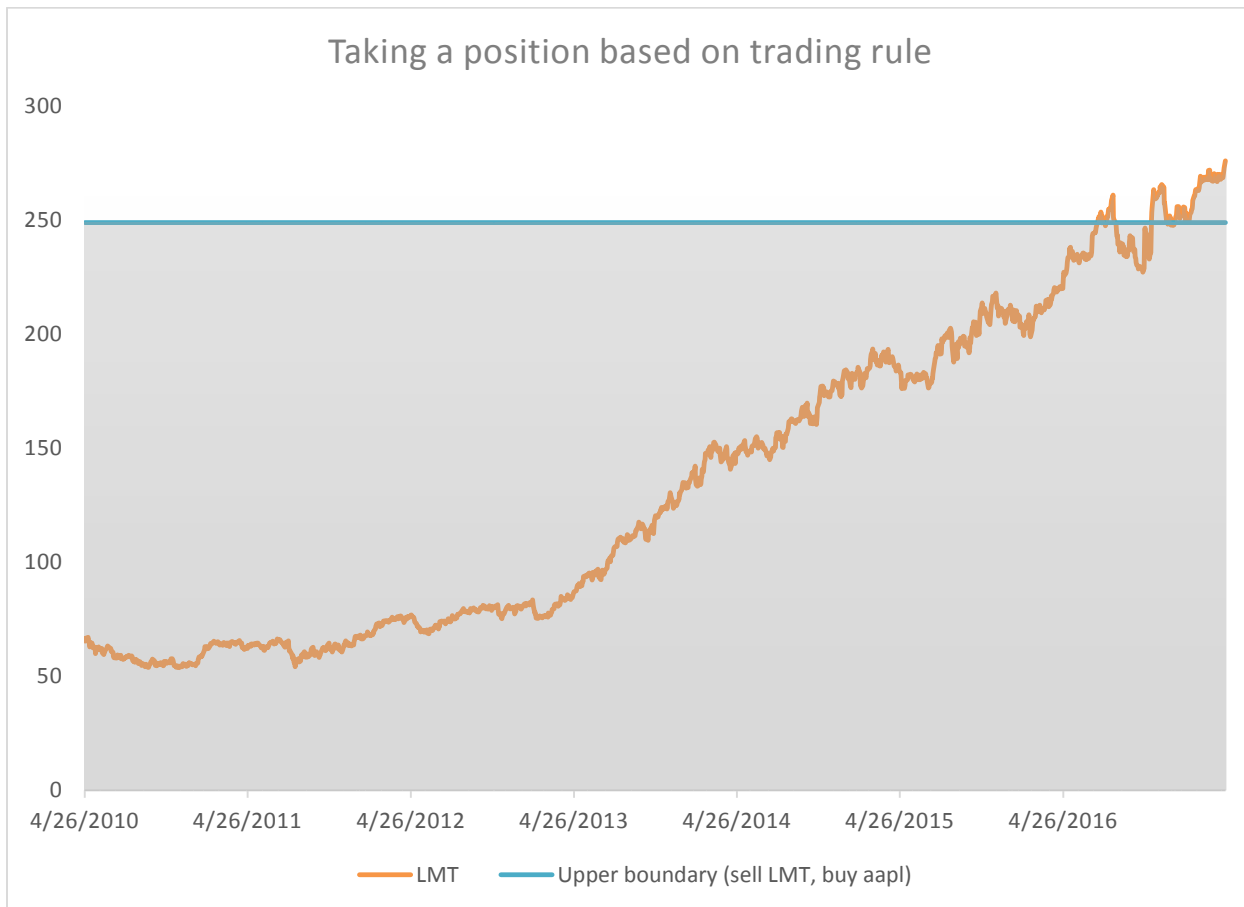
The first test shows the test based on Trace method where the P value is less than 0.05 which means that we can reject the null hypothesis that there is no cointegration. We can statistically say that the returns are cointegrated. The unrestricted cointegration test also stands with the Trace test which leads towards statistically concluding that there is significant cointegration between Lockheed Martin and Apple. Now as we find cointegration between these stocks we can statistically say that the variables have long term relationship and then we can form a theoretical value from which if the prices deviate we can take positions to exploit the arbitrage opportunity (Zhang, 2012). We will setup two trading rules based on upper and lower theoretical values. When the prices deviate from this we will take positions in the instruments. Our theoretical value for the upper bound are derived from 1 year moving average factor, historical price ratio and standard deviation of the price ratios' moving average.

The upper entry: sell LMT, buy AAPL (if market price > entry price)

The lower entry: buy LMT, sell AAPL (if market price < entry price)

In the next part I will setup my formula for calculating the theoretical prices.

Entry price: 1 year moving average of LMT – price ratio of AAPL/LMT + (3 * Standard deviation of LMT/AAPL ratio moving average) = \$249 [Short LMT and Long AAPL when price ratio hits \$249]



When LMT hits the entry position, we take short positions in LMT and long positions In Apple.

Another simpler method would be to take positions when the price ratio deviates equal to or more than 2 standard deviations. Above are the historical price ratio of Lockheed Martin and Apple incorporated. The graph below plots the historical ratio over the two stocks in the same time period featuring the deviation of their price ratios. A trading indication arrives when the instruments' volatility is relatively different from the mean. In situations where this ratio deviates from the mean by more than a standard deviation, there is opportunity to exploit this mispricing anomalies. In the following chart the points are orange circled to indicate trading positions.



Often there are mispricing between a company's stock and its foreign shares. In this case we consider American Depository Receipt (ADR) as foreign shares. The figure below features an arbitrage opportunity on the company Petrobras Argentina SA. The picture graphically shows that the ADR and the stock of the company features opportunity for taking trade positions when they diverge. But it is a difficult question on which position to take, long or short because its not known which price will converge.



Figure: Petrobras Argentina SA stock and ADR (NYSE)

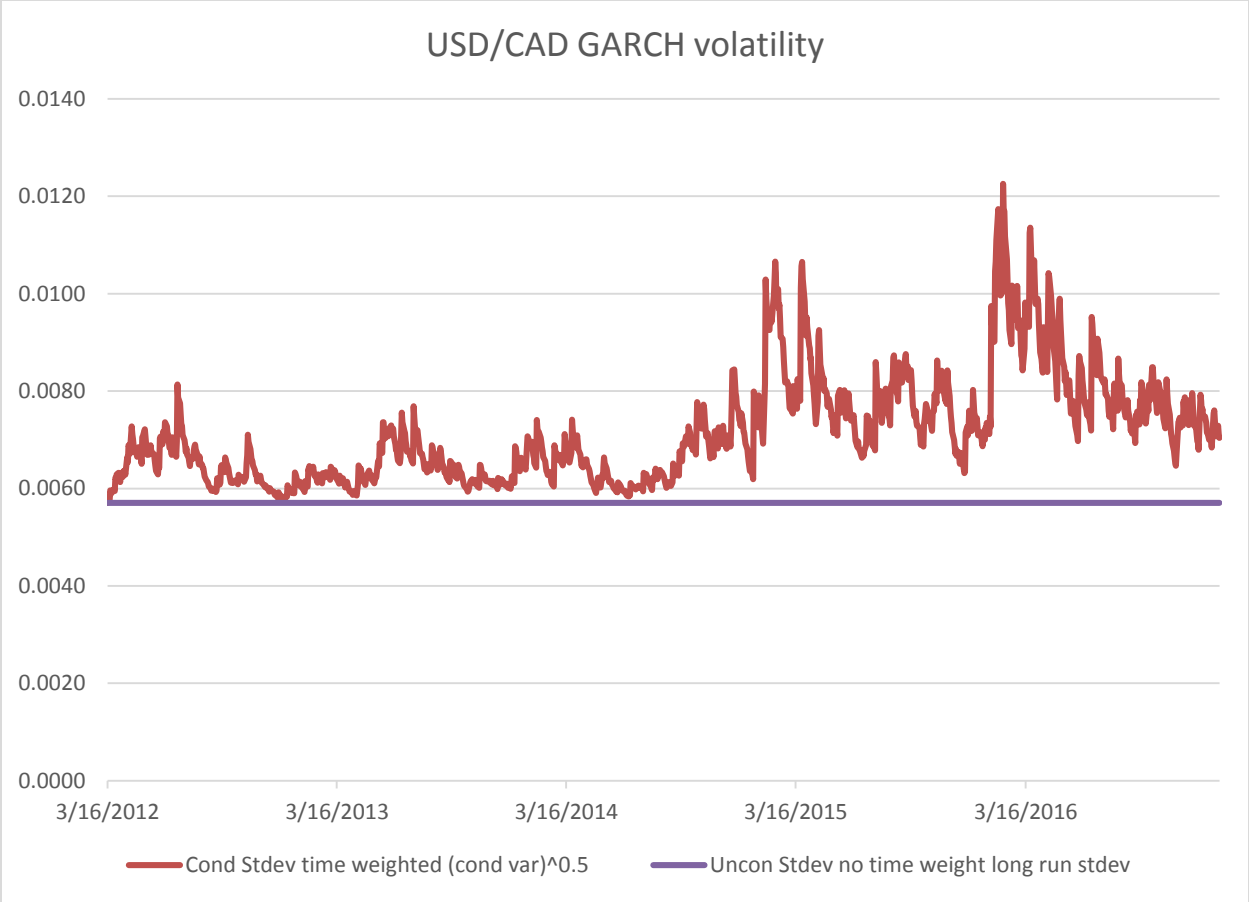
These opportunities don't stay for long time horizons as traders spot the relationship and try to exploit it, making less and less room for the traders with the same strategy. Creativity plays a great role in trading because that's an important cornerstone in building strategies.

Mortgage Backed Securities (MBS) are hybrid securities that provide opportunities for arbitrage. An MBS is a type of fixed income security that has a prepayment option which allows the homeowners to prepay or pay in installments throughout the entire mortgage. These features turn the mortgage's future cash flow and value uncertain. Regular markets are not apt for performing valuation of the prepayment option attached to the MBS. There are proprietary models to approximate the value and risk at its horizon. The Option adjusted Spread (OAS) represents the average spread of an MBS above the Treasury bond's yield curve and makes the market price of MBS equate to the projections of future cash flows (of the MBS). MBS are identified as option adjusted spreads, the MBS which offers the highest OAS values are bought and hedge by shorting Treasury bonds of equal duration to create a position with zero duration. (Stefanini, 2006) The spreads between the long and short positions between these two are usually small and traders often have to use large leverage which exposes the trader to a greater risk.

MBS securities are highly impacted by the treasury yield curve. To illustrate an arbitrage opportunity, a trader can purchase a 30 year Fannimae 6% MBS, shorting interest swaps with 2,5,10 and 30 years horizon and purchase options to hedge against prepayment risk. According to Filippo Stefanini's research, the mortgage-backed securities arbitrage strategy historically displays a very high percentage of positive months (89 %) and the average performance of positive months is +1_2%. The performance has been very strong, with an annualized return of 10.1% between 1994 and 2004, and a low volatility (4.7 %). The largest drawdown was important (-13_5 %), lasted for seven months and was recovered over a very long period (28 months). The result of MBS arbitrage was better than other two comparables.

2.5 Modelling short term volatility: GARCH (1, 1)

The necessity for the advent of volatility models emerged from the growing need to be able to manage risk more effectively by forecasting it. The General Auto Regressive Conditional Heteroscedasticity is a widely used approach in forecasting short term volatility (Francq & Zakoian, 2010). Autoregressive conditionally Heteroscedasticity (ARCH) models were introduced by Engle (1982) and their GARCH (generalized ARCH) extension is due to Bollerslev (1986). In these models, the key concept is the *conditional variance*, that is, the variance conditional on the past. In the classical GARCH models, the conditional variance is expressed as a linear function of the squared past values of the series. (Engle & Bollerslev, 1986). The following chart is created from a GARCH 1,1 model based on USD/CAD exchange rate.



The method incorporates a long term volatility, a lagged return and a variance factor to forecast dispersion. The chart stretches towards 2017 and forecasts volatility of 0.006 for USD/CAD.

3 Conclusion

Due to the complexity of the nature inherent on today's world of financial instruments, institutional traders often use proprietary models to assess the risk and reward potential of various trading strategies. Often backtesting is generated for the strategy used against historical data and results are compared to expected results to assess the upside potential of the strategy deployed. There are many data providers who provide clean and reliable data for premium charge so that traders can develop their models to better quantify the risk that is present to their strategies. The global financial market is getting more integrated everyday as technology is bringing us closer. Today markets react more to the global news and events and traders also try to exploit these opportunities to earn a positive return. However, as markets are dynamic, no strategy can ensure profitability. So traders continuously modify their method and add more factors in the models to better capture the relationships persistent in the markets. Investors, traders, analysts- all these groups are consistently analyzing for active trading strategies which minimizes risk and maximizes profit. But it is safe to say that there are always tradeoffs between risk and return, and the concept of theoretical arbitrage is not applicable for the markets because there's never riskless opportunities in the markets. The models that are used deploying statistical arbitrage borrows from knowledge from scholars, ideas from traders and forms somewhat hybrid versions of theoretical models. Over the last few years the global markets have evolved into highly liquid and efficient ecosystem where traders thrive to make a profit. Risk management is a core issue in all sorts of trade management, more and more traders are using risk forecasting tools to capture the risk inherent in the markets. Although its not always possible for these tools to capture the exact risk, these methods provide a solid foundation in trying to do so. Risk management principles also vary from trader to trader as people have individual perceptions of the market and unique attitude towards risk. The markets don't provide a one stop solution for risk management but using a variety of tools gives a trader some sort of edge over managing risk. As different macroeconomic events and expectations move the markets, the markets are never static. Often volatile markets offer the best opportunities to traders but with a tradeoff for high risk. Risk and return objectives play a crucial role in trading securities as different investors have different risk tolerance and return objectives.

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