

Master in Quantitative Economics and Finance

**Factor models for optimized**

**option trading strategies**

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**Abbreviations**

CFTC - U.S. Commodities Futures Trading Commission

TFF - Traders in Financial Futures

CoT - Commitment of Traders

ARIMA - Autoregressive Integrated Moving Average

ARMA - Autoregressive Moving Average

AR - Autoregressive Model

GARCH - Generalized Autoregressive Conditional Heteroscedasticity

ADF - Augmented Dickey-Fuller

ACF - Autocorrelation Function

PACF - Partial Autocorrelation Function

WPL - Weekly Profit Loss Function

NP - Net Positioning

NP% - Net Positioning Returns (week-over-week)

**Disclaimer**

# Introduction

## Motivation

In today’s computer-driven world, investment professionals have access to a vast array of sources from which they derive informed investment decisions. The later come in two basic forms: discretionary trades and systematic trades. The first are based on intuition, experience and research, while the later on mechanical setups that generate trading signals. Although distinctly different, both methods aim to implement one, or more, forms of analysis to determine market direction. Price prediction has been an area of ongoing research for a long time, and, since the late 1990’s, the construction and use of sentiment indicators for empirical analysis has also become mainstream.

The price of an asset is determined by the buying / selling activity undertaken by the market participants at any point in time. It is therefore of interest to determine if insights in future price movements can be obtained from this activity. A detailed analysis of such data could, among others, reveal how specific participants view market fundamentals and their perception of future conditions. Indeed, while technical indicators, news and research represent the cornerstone of the investment pyramid, professionals have always been interested on the positioning of their likes in the markets. As a simplification, knowing that an established and reputable investor is on the same side of a trade can provide, even to a small degree, confidence. It is therefore no wonder that an emerging method of tracking price behaviour is to collect and analyse the market participants’ activity.

One of the principal challenges researchers face in this area is the limited amount of data available. Since investor performances at the trade level are scarcely available to the public, research has been exhausted[[1]](#footnote-1) on asset classes where this problem does not apply (e.g. mutual funds[[2]](#footnote-2)). Interestingly, a set of high quality figures that, although carefully monitored by market professionals, appear to have remained largely untapped by the research community are the U.S. futures position databases. These U.S.-wide data are regularly updated by the *U.S. Commodities Futures Trading Commission* (CFTC) in the *Commitments of Traders* (COT) and *Traders in Financial Futures* (TFF) reports, and provide insights on the aggregate positioning of investor sub-categories. Combining this information with market data can provide a novel understanding of market dynamics that are pertinent to academic research as well. In the next section, relevant literature across the fields of sentiment analysis and market positioning to forecast future prices is presented.

## Literature Review

Studies supporting the semi-strong *Efficient Market Hypothesis* (EMH) have been around since the 1990’s. (Siegel, 1992) found correlations between the shift in investors’ sentiment indicators and stock price movements before the market crash in October 1987[[3]](#footnote-3), while (Brunnermeier & Nagel, 2004) determined that in another stock market collapse, the technology bubble burst in March 2000, hedge funds had in a short period of time reversed their exposure to the technology sector from long to short, benefiting from the subsequent crash.

Much of the more recent literature focuses on measuring investor sentiment and how this is priced into risk by augmenting the default finance model that assumes EMH (Friedman, 1953) (Fama, 1965). For instance, (Brown & Cliff, 2004) analysed the impact of investor sentiment on asset returns with the use of VAR models, while (Berger & Turtle, 2012) employed a multi-factor model to investigate the cross-sectional returns of stocks against investor sentiment.

As previously mentioned, the lack of data has constrained research on an important proxy of investor sentiment, the actual positioning of the investors. (Stewart, 1949) undertook the first extensive analysis of trader positions by analysing the trades of 9’000 investors; his findings indicate that 75% of small investors lost money[[4]](#footnote-4). Since in the futures markets profits and losses must balance, he deducted there had to exist one or more other groups of investors who were on the other side of these trades, and made substantial profits.

Research undertaken using the actual CFTC data appears to be limited to a handful of academics. Among the first was (Houthakker, 1957) who examined the aggregate positioning of large hedgers, large speculators and small traders in the cotton, corn and wheat futures markets. His research concluded that large traders (i.e. large hedgers and speculators) possessed superior forecasting abilities, as opposed to small traders[[5]](#footnote-5). The lack of any statistical significance test however made (Chang, 1985) challenge these results; using the HM non-parametric test[[6]](#footnote-6) to check the timing abilities of the different investors, he determined that large hedgers were consistent losers, and attributed speculators’ profits in certain markets to risk premia[[7]](#footnote-7), and not to forecasting skills. Two years later, the research of (Hartzmark M. , 1987) contradicted Chang’s results; his analysis suggested that speculative traders earn negative or zero profits, while large hedgers are the most profitable[[8]](#footnote-8). In a follow-up study (Hartzmark M. , 1991) found that traders with consistent forecasting abilities are no more than one would expect due to chance, in other words that “luck determines trader performance”[[9]](#footnote-9). The extend of results contradicting each other clearly evidences the widely-recognized issues of analysing aggregate information (Holderness, 2016) (Hsiao, 2005).

More recently, (Buchananan, Hodges, & Theis, 2001) made use of the CoT reports to prove that prior to large price moves large speculators successfully took their largest positions. In what can however be considered to be the most comprehensive use of these datasets to date, (Wang, 2001) produced preliminary evidence that future commodity prices can be forecasted using the previous reported positioning. Interestingly, he determined that increased speculator and hedgers positions correlated well with trend continuation and reversal patterns in the price of the underlying commodity prices[[10]](#footnote-10).

What appears to be particularly interesting throughout the limited research undertaken using the CFTC data, is the lack of any literature on forecasting asset classes other than commodities[[11]](#footnote-11). To the extent of this review, only (Wang C. , 2003) appears to have looked into non-commodity assets. Using the same approach applied to his earlier study (Wang, 2001), but on the S&P500 futures contracts this time, he obtained exactly the same results: speculators’ positioning constitutes a trend continuation indicator, while hedgers’ positioning a price reversal indicator.

## Research Objective

While research has been conducted in a similar field, known as Sentiment Analysis and Models (Notter, 2013), and literature exists on forecasting commodity prices using the CoT datasets (Wang C. , 2003), the current paper aims to present a novel approach to utilizing these market positioning data (CoT and TFF) to produce a consistent cross-asset option trading model. In more detail the extent to which the results of (Wang C. , 2003) hold across other asset classes will be investigated, and an investment portfolio will be presented. The research objective is therefore to determine whether a successful investment portfolio can be constructed on the positioning data disclosed in the CFTC reports.

In order to accommodate the particularities of the CFTC data, a custom investment process has been devised in this paper (Section 3.3). In short, the developed models produce signals on a weekly basis, and performance is reproduced by selling 1-week, 20-25 delta strike options.

# Data Acquisition - Description

## Positioning Data

The CFTC overseas all trading activity in the U.S. futures market, and requires from all of its futures exchange clearing members and commission merchants, as well as foreign brokers, to report daily positions that meet specific reporting levels. Although the exact requirements vary depending on the market, the latest levels cover approximately 70%-90% of total open interest in each product (CFTC, 2006) (see Appendix 5.1). The CFTC has been compiling since 1962 the CoT report[[12]](#footnote-12), an aggregation of this data per market in long and short positions, and delivers them in two classifications: “futures only” and “futures and options" (Figure 2‑1), and two main broad participant categories:

1. *Commercials* - a trading entity that is commercially "...engaged in business activities hedged by the use of the futures or option markets".
2. *Non-Commercials* - remaining participants.

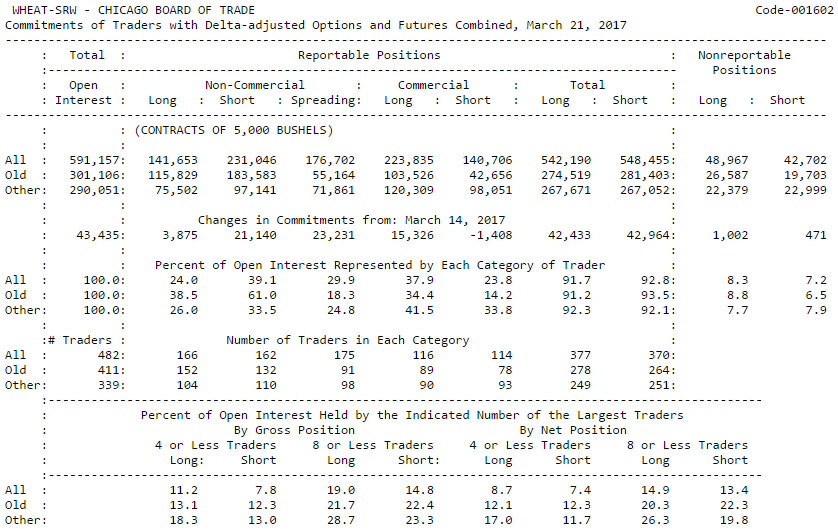


Figure 2‑1 – CoT Report Format

Since these data however separate reportable traders in very broad categories, in 2010 the CFTC announced the delivery of an additional weekly report. The later, termed the Traders in Financial Futures (TFF) report[[13]](#footnote-13), separates large trades in the financial markets in "sell-side" (Dealer / Intermediary) and "buy-side" (Asset Manager / Institutional, Leverage Funds, Other Reportable) participants:

1. *Dealer / Intermediary* - market participants that earn commissions from selling financial products, capturing the bid/ask spread and accommodating their clients. These include large institutions such as banks and securities' dealers that tend to run matched books, or offset their risk across clients and markets.
2. *Asset Manager / Institutional* - this segment covers institutional investors, such as mutual and pension funds, insurance companies, endowments etc.
3. *Leverage Funds* - these are various types of asset managers and hedge funds whose strategies may involve, among others, opening outright positions or arbitrage within or between markets.
4. *Other Reportables* - market participants not covered in the three categories above; traders in this category use markets mostly to hedge business risk. Examples include central banks, corporate treasuries, credit unions, mortgage originators, etc.

The CFTC backfilled the TFF report from June 13, 2006, which is since delivered in a consistent format (Figure 2‑2) along with the CoT report.

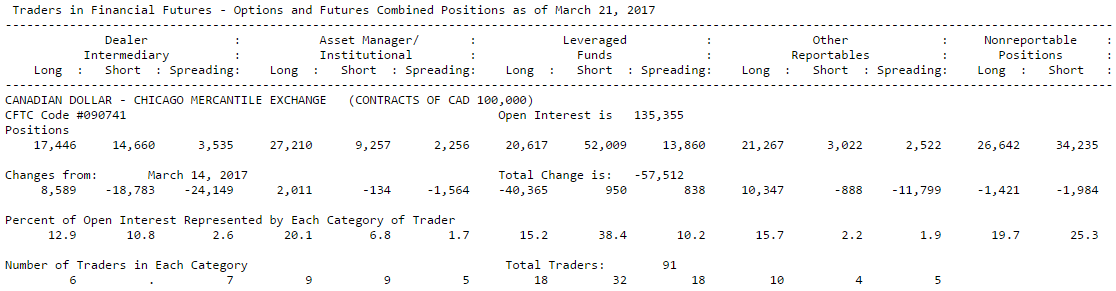


Figure 2‑2 – TFF Report Format

Since the present report will make use almost exclusively of the TFF / CoT data, certain limitations of the later are worth mentioning. The classification of the participants in any of the presented categories is conducted using a strict guideline, but as the CFTC states, judgement on the part of the Commission staff is sometimes required (e.g. particular classification due to the predominant business activity of the participant). Additionally, the Commission classifies the participants, and not their trading activities. For instance, hedge funds are known to fall under the "Leverage Funds" category, but not all of their activity can always be described as speculative (e.g. using the foreign exchange futures market to hedge exposure to an OTC core position). Finally, a multifunctional organization with more than one trading entities may have each entity classified separately in each market. It can therefore be the case that an asset manager with two trading entities has part of its positions in a market described as commercial (under the first entity), and the rest as non-commercial positions (under the second entity) (CFTC, 2006).

For the purpose of this report, the historical weekly CoT and TFF raw data have been collected and compiled in uniform databases for the period 01.06.2006-27.12.2016. While the data includes more than 600 instruments, and spans across numerous main and secondary markets[[14]](#footnote-14), the number of instruments with complete weekly positioning information is more limited. Particularly complete are currency, treasury and index data; this, in combination with the lack of any literature analysing these data, further strengthens the case of this thesis.

## Option Data

The CFTC reports are released to the public every Friday at the close of US markets. Making use of the latest positioning information, the investment process, described in detail in Section 3.3, stipulates trades must be placed every Monday at GMT 14:00[[15]](#footnote-15). In more detail, if one, or more, signals are generated, 1-week, 20 delta strike options on the underlying asset are sold. To that end, historical call/put premiums have been collected from Bloomberg for every Monday since 2006, in line with the first available TFF data[[16]](#footnote-16).

The use of Bloomberg option data provides numerous advantages. The platform calculates historical option premia by using a number of market variables at the requested time and date (e.g. spot price, instrument volatility etc.). Furthermore, the data produced feature, except for the premium, also the settlement status of the priced option at expiry, along with its resulting profit/loss. This is particularly convenient since no additional calculations need to be performed to account for profit/losses in different currencies (e.g. trading non-USD denominated instruments), spot prices at expiry and public holidays. These features allowed the creation of a uniform cross-asset dollar-denominated database of call/put option premia based on a 1 million USD notional.

# Methodology

## Data Preparation

As outlined in Section 2.1, complete historical positioning databases were compiled from the aggregated CoT and TFF reports. Since these databases however contain the long/short positioning of each group of participants in absolute terms (i.e. number of contracts held), the data were transformed so as to indicate net participant positioning as a factor of total number of contracts held. To that end, the following transformation was applied:

,where is the net percentage positioning of a participant in a market. As an example, if Asset Managers positioning features 150’000 contracts long and 65’000 contracts short, the net positioning of the group is 85’000 contracts long on a total of 215’000 contracts, or 39.5%. The main advantage of this approach is that it creates a uniform positioning metric across market participants (Figure 3‑1). This transformation was applied on both the CoT and TFF datasets, yielding net positioning information for all market participants.

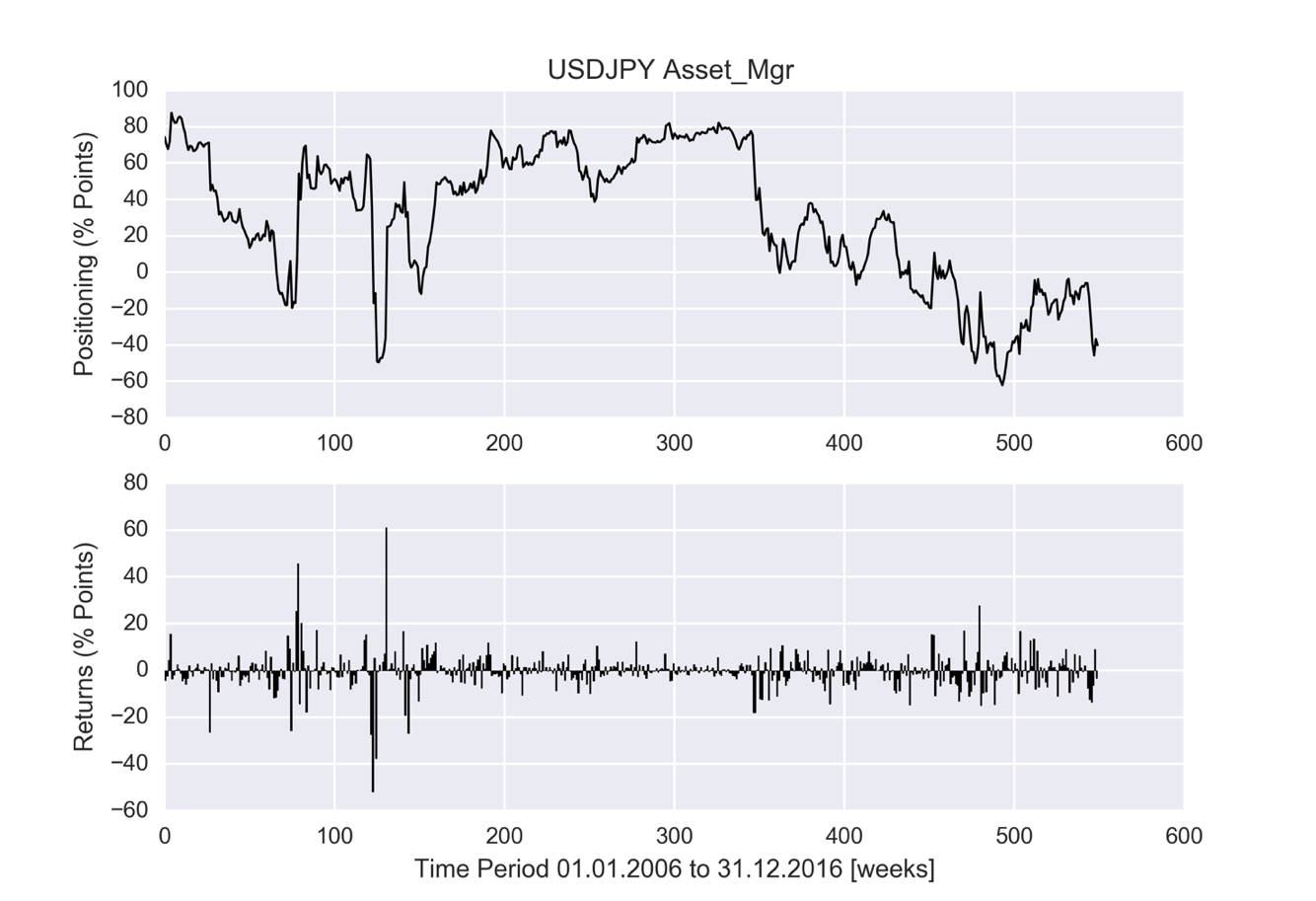
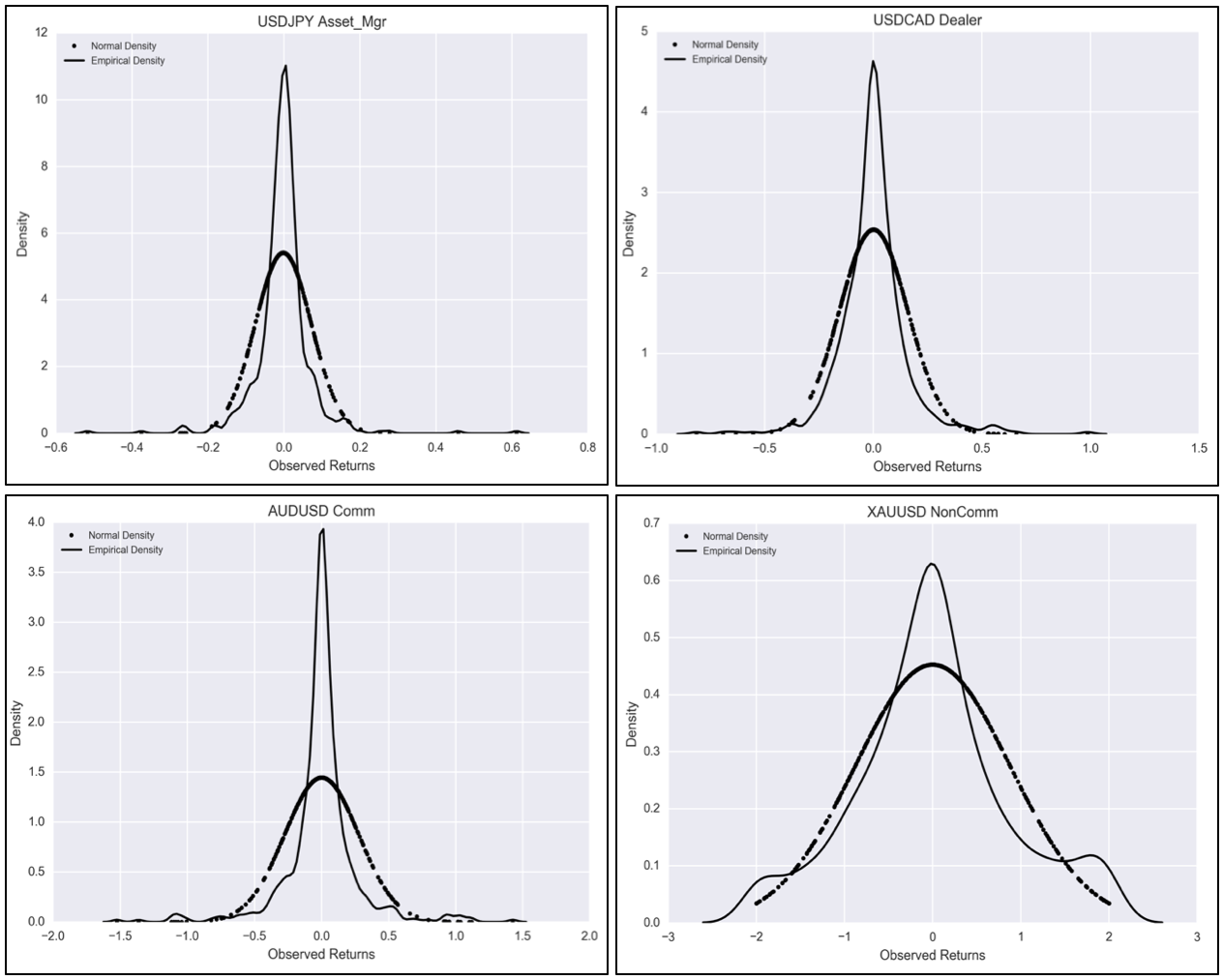


Figure 3‑1 – Positioning and Returns for Asset Managers in USDJPY

## Data Features

Since investment decisions will be based on participants’ positioning and week-over-week changes, the statistical properties of these data are of interest.

In line with Figure 3‑2, most assets’ empirical density appears to have higher peaks around their means and often fatter tails, than that of their corresponding normal distributions. In other words, the empirical density function is taller and skinnier, but with a wider support, than the normal density, making the normality assumption questionable.

Figure 3‑2 – Probability Density Function for USDJPY (AM), USDCAD (De), AUDUSD (Com), XAUUSD (NonComm)

Stationarity is another feature of the time series that needs to be investigated. This is of particular importance, since it lays at the core of any potential predictive power deriving from the CFTC data. One of the most commonly used unit root tests that provide information on the potential stationarity, or not, of a time series, is the Augmented Dickey-Fuller (ADF) test[[17]](#footnote-17). The test was carried out on all available time series data; the majority[[18]](#footnote-18) of time series feature results similar to the ones presented in Table 3‑1. The test statistic is in most cases smaller than the 1% critical value, implying the null hypothesis (H0) can be rejected with a significance level of less than 1%[[19]](#footnote-19). Therefore, the vast majority of the processes are deemed to not have a unit root, yielding stationary, or time-independent, time series.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ADF Test | AUDUSD | XAUUSD | USDJPY | GBPUSD | USDCAD |
| Commercials | Non-Commercials | Asset Managers | Dealers | Leverage Money |
| Test Statistic | -1.12E+01 | -1.08E+01 | -9.85E+00 | -8.75E+00 | -1.36E+01 |
| p-value | 1.98E-20 | 1.71E-19 | 4.39E-17 | 2.93E-14 | 1.80E-25 |
| # Lags Used | 1.10E+01 | 1.60E+01 | 7.00E+00 | 1.00E+01 | 3.00E+00 |
| # Observations | 5.60E+02 | 5.55E+02 | 5.41E+02 | 5.38E+02 | 5.45E+02 |
| Critical Value (5%) | -2.87E+00 | -2.87E+00 | -2.87E+00 | -2.87E+00 | -2.87E+00 |
| Critical Value (1%) | -3.44E+00 | -3.44E+00 | -3.44E+00 | -3.44E+00 | -3.44E+00 |
| Critical Value (10%) | -2.57E+00 | -2.57E+00 | -2.57E+00 | -2.57E+00 | -2.57E+00 |

Table 3‑1 – Augmented Dickey-Fuller test for a random selection of assets

With questionable normality and likely stationarity of the time series, the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF)[[20]](#footnote-20) of the processes is investigated next to determine the randomness of the data.

**ACF/PACF with 95% Confidence Intervals**

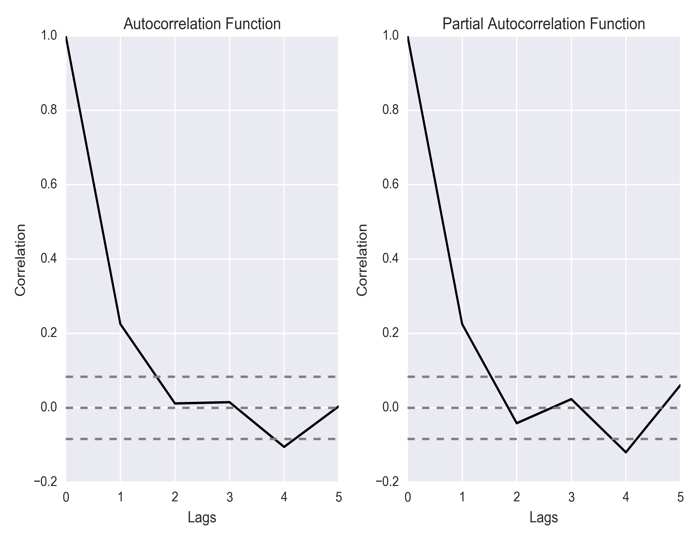
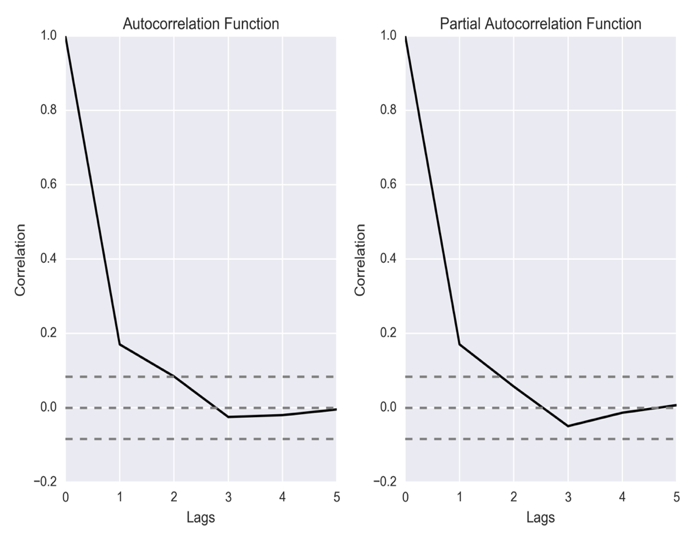


Figure 3‑3 – ACF / PACF on Positioning Returns of Asset Managers / Dealers in USDJPY / EURUSD

Calculating the ACF/PACF as seen in Figure 3‑3 for all the available time series, it was determined the majority of assets of the TFF exhibit strong positive autocorrelation with regards to their previous values (i.e. lag of 1); interestingly the result is diametrically the opposite for the data of the CoT (Figure 3‑4). While for the TFF datasets the autocorrelation with a one-period-lag is substantially positive, for the CoT time series the autocorrelation with a one-period-lag is instead considerably negative. In both cases the autocorrelations are high in absolute terms, and well above the 95% confidence intervals (dashed lines in Figure 3‑3 and Figure 3‑4).

**ACF/PACF with 95% Confidence Intervals**

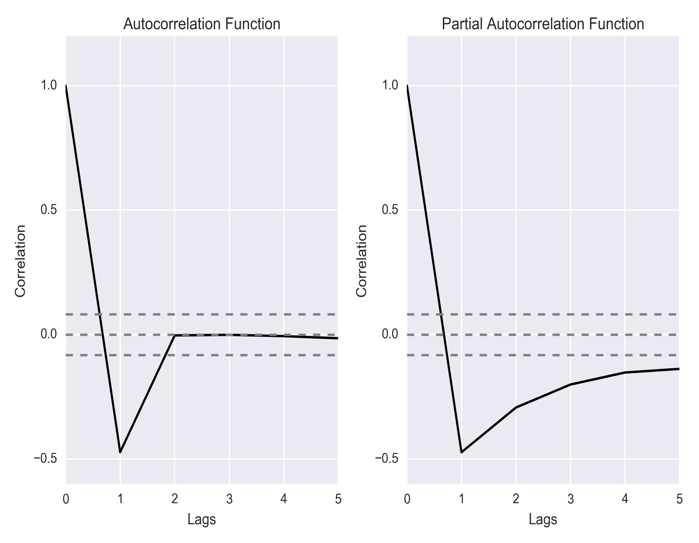
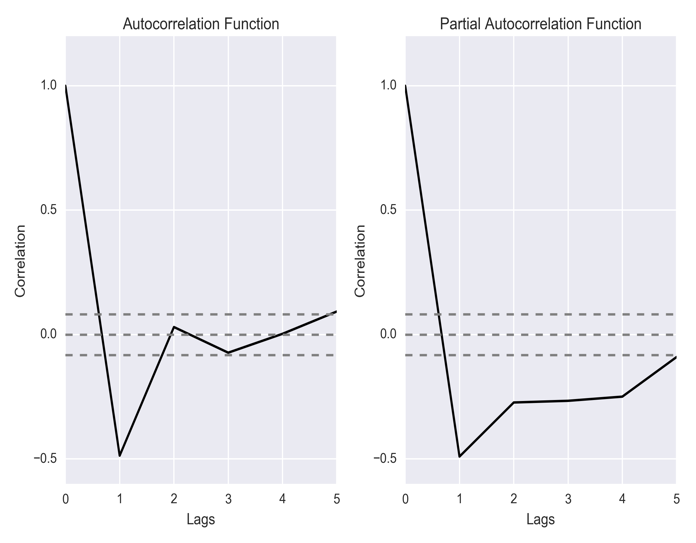


Figure 3‑4 ACF / PACF on Positioning Returns of Commercials / Non-Commercials in GBPUSD / USDCHF

The tests conducted determined questionable normality, likely stationarity and non-randomness of the time series. Based on these conclusions, a statistical model can be built to exploit these features within the scope of a sound investment process.

## Investment Framework

The investment processes implemented within the context of the literature examined are fairly simple. They mainly consist of monitoring the positioning data released and take cash positions in the market by using the 1-period properties of the time series presented in Section 3.2. For instance, (Upperman, 2006) looks out for extremes in the positioning of wheat contracts, and, knowing the negative 1-period autocorrelation of the time series, attempts to catch price reversals using cash instruments, such as the futures’ market. Furthermore, it appears researched strategies concentrate on interpreting the CFTC datasets with a subsequent long investment time-horizon; proposed trades are therefore kept open for a number of weeks or months.

In this report, a new framework within which the proposed strategies will operate is presented. Instead of establishing cash positions, the potential of using options is examined; this alternative provides the investor with a range of advantages, such as potential for increased leverage, numerous parameterization options, reduced margin requirements and simple exit possibilities. As discussed in Section 2.1, positioning data are released from the CFTC on a weekly basis. The plan brought forward is therefore to analyse the data and create processes that yield one-week-long trading signals, economically quantified by selling out-of-the-market options. The potential profit hence lies within the premium collected on stipulating the option, and a subsequent non-exercise at expiry. As an example, if the analysis yields a SELL signal on a specific week for a market, an out-of-the-money, 1-week-long call option is sold; the premium is collected and after one week the option either expires worthless or in the money. Since the option data collected (Section 2.2) provide final settlement profit/loss of the options, the net Weekly Profit Loss function can be defined as follows:

The primary factors that influence option pricing are common across most option pricing formulae: the underlying’s price at the time of taking out the option, the strike price, the time until expiration, volatility, interest rates and dividends. Since this paper focuses on currencies and commodities, dividends do not apply, while interest rates are pre-set by the interest differentials between the underlyings of the asset (e.g. Euro and US Dollar for EURUSD). The volatility used to price options, known as implied volatility, is also pre-set since it represents the volatility the market, or counterparty, expects for the underlying asset over the life of the option. Therefore, the main parameters an investor is allowed to customize according to his needs are the strike, the notional and the expiration date/time of the option (Figure 3‑6).

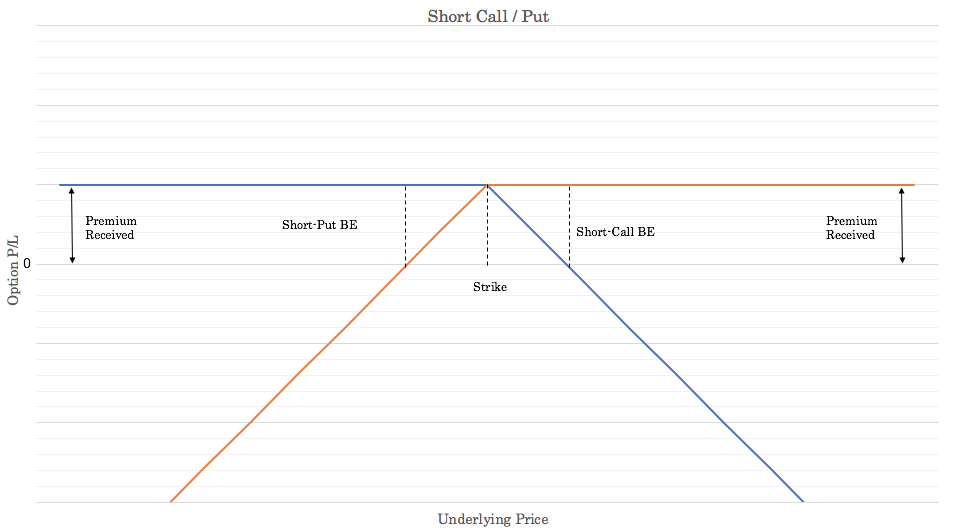


Figure 3‑5 – Option Pricing Plots / Parameters

As previously mentioned, the proposed strategy consists of selling call or put options depending on the signal generated. The options to be traded are all out of the money, with a strike of 20-Delta[[21]](#footnote-21), and a duration of one week. For the purposes of this paper options were priced on Mondays, at GMT 14:00, and hence expire the following Monday at GMT 14:00, when possibly the next option is traded (Figure 3‑7).



Figure 3‑6 – Duration of Options under Proposed Investment Process

For all tasks relating to data analysis, model development as well as portfolio construction and optimization, the computational packages MATLAB and Python are utilized. Both packages feature a plethora of statistical and economics tools allowing for the cross-validation of the results produced[[22]](#footnote-22).

## BASE Model

To determine the preliminary predictive capabilities of the CFTC data, a BASE Model was developed (Figure 2‑1).

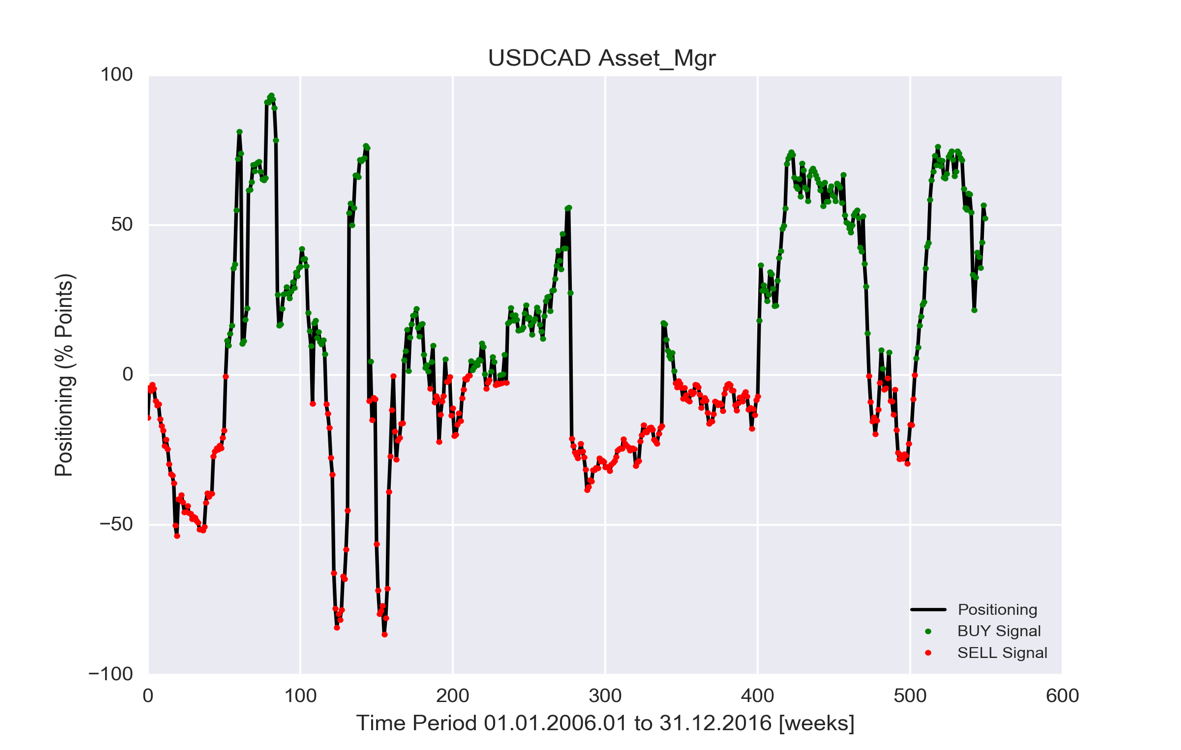


Figure 3‑7 – BASE Model Signals on USDCAD using Asset Managers’ Positioning

The process has a simplistic framework which monitors the positioning of market participants in an asset and attempts to be on the same side of the trade as them[[23]](#footnote-23). Therefore, if for instance Commercials’ positioning is net positive (i.e. long) at any point in time, the system will produce a LONG signal for the next period as well, selling, as a result, the put option. The model can hence be summarised as follows:

,and the Weekly Profit Loss function is hence:

The process looks only at the absolute positioning of a participant, completely disregarding its’ actual scale or relation to the overall market dynamics. Furthermore, one of the shortcomings of the system is its constant presence in the markets. Nonetheless, the BASE model constitutes a good benchmark for the AR and GARCH models presented in Sections 3.5 and 3.6.

## AR Model

There exist many models used for time series forecasting and monitoring, however three very broad classes are most often used. These are the autoregressive (AR) models, the integrated (I) models and the moving average (MA) models. These processes are often combined together to produce new models, such as the ARMA model and the ARIMA model. The most commonly employed model for time series analysis is the autoregressive process (AR), a difference equation determined by random variables, whose distribution is the key component to model time series.

Based on the time series properties determined in Section 3.2[[24]](#footnote-24) the first order autoregressive equation is examined. The *pth* order autoregressive time series (also known as ) is defined as follows:

,where and are assumed to be uncorrelated random variables (i.e. ). Therefore, the process is simply a first order linear difference equation described by:

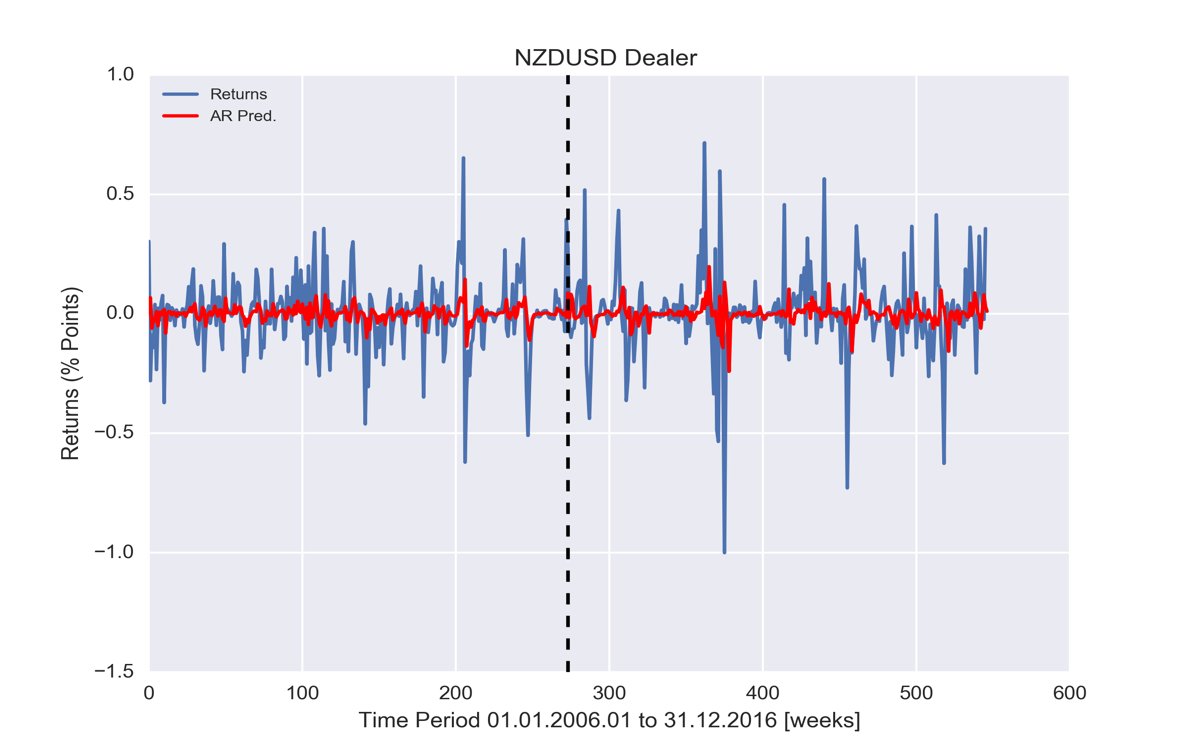
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Figure 3‑8 - Positioning Returns and AR(1) Fit for Dealers in NZDUSD

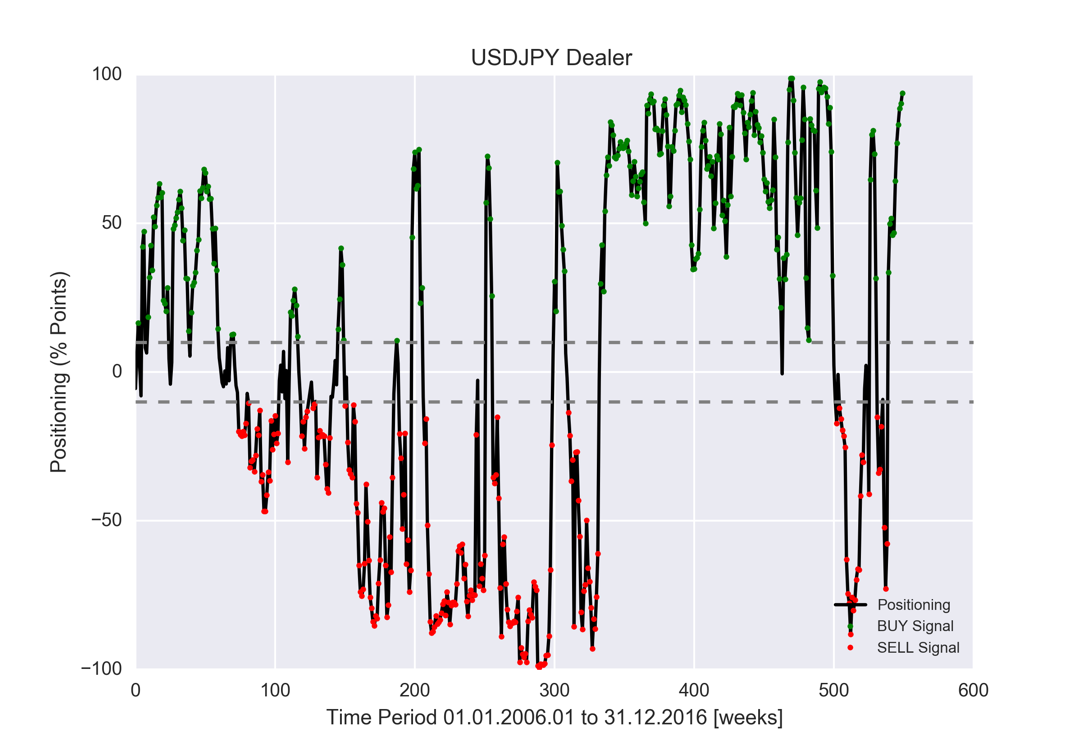


Figure 3‑9 - Positioning Filter on USDJPY for Dealers’ Positioning

Although the core investment approach remains the same as in the BASE model, for the model the predicted positioning returns are employed to produce a trade signal:

In order to yield significant model parameters, the AR model is optimized and fitted on half of each time series and then re-fitted at every data point going forward to create the next period forecast. Additionally, a minimum positioning threshold is put in place to filter out net positions and an optimization is further developed to yield an optimal weight between the forecast and the latest positioning data point. In more detail:

1. *Filter* – Analysis of the time series evidences that if the net positioning of a market participant is in the range of , the likelihood of a successful signal reduces substantially[[25]](#footnote-26). Therefore, any signals generated based on a net positioning in this range are disregarded (e.g. Figure 3‑9).
2. *Weight Optimization* – The premise here is to produce a consistent positioning prediction using a combination of the last period data and the forecast. The aim of the optimization process is therefore to yield an optimal weight between the two that maximizes the strategy’s equity at the end of the in-sample data[[26]](#footnote-27):

,where:

* – the positioning of the market in the previous period
* – the positioning predicted for the next period
* *N* – sample size

and subject, as per point *1.*, to the resulting combined absolute prediction being bigger than 10% (i.e.).

To summarize, the designed method optimizes the weight (*w*) between the latest positioning data point and the forecast to maximize the equity at the end of the in-sample data. In the process, the optimized absolute positioning forecasts that are smaller than 10% are disregarded, yielding a neutral signal, during which the model takes no positions in the market.

## GARCH Model

Having developed a positioning forecast model (Section 3.5), the alternative of a volatility based strategy is investigated. The idea behind this is to use the forecasted volatility produced by a GARCH process to filter out trades from the BASE model described in Section 3.4. The premise is therefore that large positioning reversals (i.e. high volatility events), that result in losing trades, can be forecasted through such a model and excluded from the BASE trading strategy.

The motivation behind studying conditional heteroscedasticity in financial time series is that of volatility of returns; this is of particular importance in finance since it is a notion highly synonymous to risk (Bollerslev, 1986). Let us first investigate the concept of *heteroscedasticity* and then discuss the *conditional* part.

Given a set of random variables, the collection is said to be heteroscedastic if there are certain subsets of variables within the larger set that have a different variance from the remaining variables. This could, for instance, be the case in a non-stationary time series that exhibits trending or seasonality effects; in such scenarios, it is possible for the variance to increase with this trend or these seasonality effects.

The correlation between an increase in variance and future further increase in variance occurs for many reasons and is a highly-researched topic. For instance, in the case of downside portfolio protection insurance used by long–only funds, a substantial one-period drop in the equities in the portfolios can trigger automated risk management sell orders, which in turn further supresses the price of equities. Such occurrences, as well as many other forms of volatility, lead to heteroscedasticity that is serially correlated, and thus conditional on periods of higher variance; such series are known as conditional heteroscedastic.

While volatility clustering, this phenomenon of periods of relatively high and/or low volatility, is a seemingly common attribute of market data, no universally accepted explanation of it exists (Alexander, 2008). One set of models that attempt to model these clusterings are the GARCH processes. Given a time series , described at each instance by , where is discrete white noise with zero mean and unit variance, GARCH methods attempt to model these volatility clusters by defining as:

,where and are parameters of the model. Therefore, a GARCH(1,1) model is defined as :

,where , . Furthermore, in order for the next period forecast of variance to be a blend of the last period forecast and squared return we require:

For the purposes of this paper, the positioning returns are fed in the GARCH(1,1) model to make a forecast for the next period volatility . Once again, the model is fitted on the in-sample data (i.e. first half of the time series length) and re-fitted at every data point before predicting the next period volatility on the out-of-sample data (i.e. second half of the time series) (Figure 3‑10). To remove trades for which a high volatility has been forecasted, volatility filter is employed. In more detail the realized variance of the last four period returns is calculated, converted to volatility , and compared to the forecasted next period volatility; if the forecasted volatility is higher than the realized volatility, the trade is skipped. Therefore, the model can be summarized as follows:

,where:

* – the previous period positioning
* – the next period variance forecasted by the GARCH(1,1) model
* – the realized variance of the last four data points

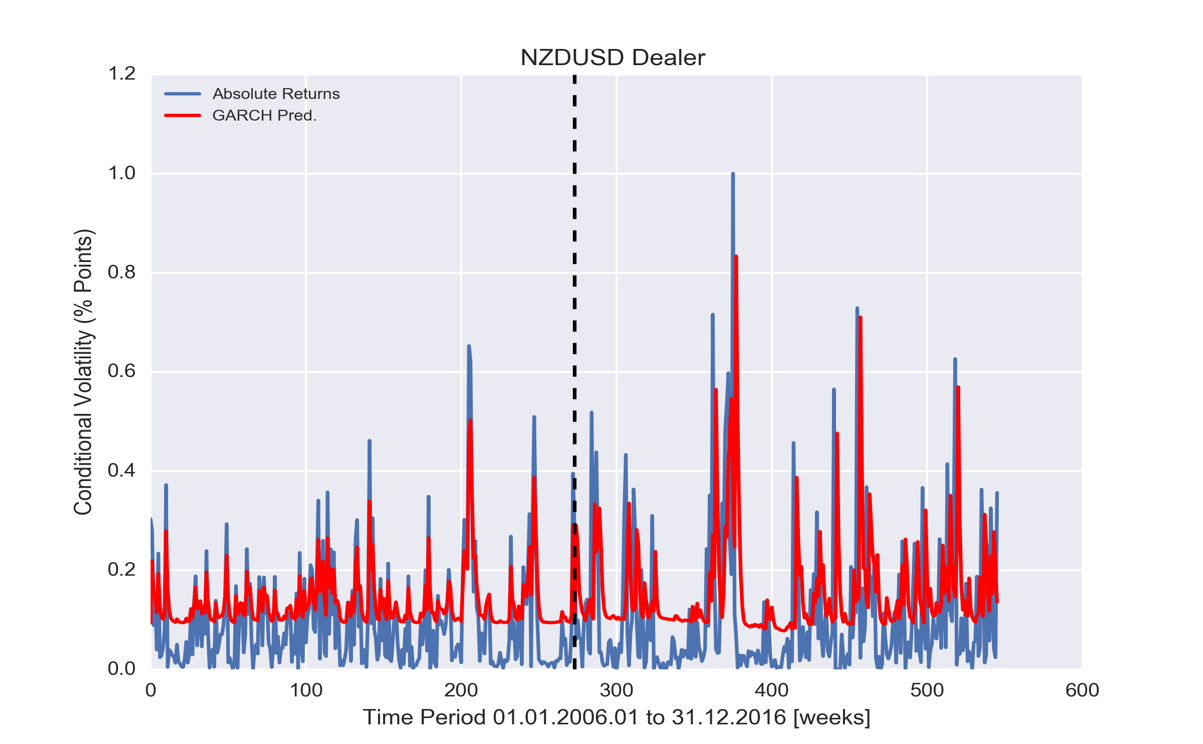


Figure 3‑10 – Absolute Positioning Return and GARCH Fit for Dealers in NZDUSD

## Asset Selection

Given the number of assets available in the CFTC reports and the diversity of market participants, constructing an optimal portfolio for the presented strategies is no trivial task. While several selection models exist in the literature that apply limitations to the number of assets and the portfolio weights in a portfolio, the Limited Asset Markowitz Model is investigated here.

The classical Mean-Variance portfolio optimization process (Markowitz, 1952) aims to determine the fractions of a given capital to be invested in each asset belonging to a pool of assets. The objective function of this model is to minimize the risk of the return of the entire portfolio (i.e. variance), while restricting the expected return of the portfolio to reach a specified value. In more detail, assuming available assets, each asset with an expected return , and the covariance of the returns of assets and , the classical MV model is:

,where is the required level of portfolio return. Next, two constraints are added, one limiting the number of assets that can be held in the portfolio to , and one that the quantity allocated to each asset must be constrained within a defined interval . Applying these two constraints yields the Limited Asset Markowitz (LAM) model:

subject to:

,where .

For the purposes of this paper, the Limited Asset Markowitz Model was implemented using the Python programming language with the following constraint parameters:

* Number of Assets – 10
* Allocation Interval –

# Results

This model was run for all complete time series and market participants, yielding 670 equity lines and respective performance metrics.

Limitations-> many players, someone is best?

Optimize Portfolio Selection process (optimize number of assets and allocation interval?)

# Conclusions

IMPROVEMENTS (optimize 20delta for strike of options, expand to indices, treasuries etc)

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# Appendix

## CFTC Current Reporting Levels



1. See (Carhart, 1997) and (Brown & Goetzmann, 1995). [↑](#footnote-ref-1)
2. Mutual funds are often compelled to publish their trades and performances aiming to attract new investors. [↑](#footnote-ref-2)
3. Monday, October 19, 1987, also referred as a „Black Monday” in finance, was one of the largest one-day percentage declines for stock exchanges around the world (Barro, 1989). [↑](#footnote-ref-3)
4. Updated research points to 75%-90% negative performances in the futures market (Babcock & Williams, 1989). [↑](#footnote-ref-4)
5. This conclusion is in line with the more recent research of (Leuthold, Garcia, & Lu, 1994) who reported significant profits for all large traders analysed. [↑](#footnote-ref-5)
6. (Henriksson & Merton, 1981) [↑](#footnote-ref-6)
7. In his paper (Chang, 1985) distinguished between rewards for forecasting abilities and for taking risk (risk premia). (Hartzmark M. , 1991) [↑](#footnote-ref-7)
8. Of interest, (Hartzmark M. , 1987) results indicated that 0.1% of the large hedgers earned 58% of the total profits in the period analysed. [↑](#footnote-ref-8)
9. In (Hartzmark M. , 1991) study, consistent forecasting abilities were defined as consistent profits. It must be noted that most of the results were not statistically significant. [↑](#footnote-ref-9)
10. The results of (Wang, 2001) were based on six agricultural futures markets. [↑](#footnote-ref-10)
11. As discussed in the Section 2.1, the CoT reports include information spanning across asset classes (commodities, currencies, indices, fixed income instruments etc.). [↑](#footnote-ref-11)
12. The data are produced every Tuesday, and released to the public every Friday. [↑](#footnote-ref-12)
13. The TFF report is also delivered in the same formats as the CoT; "futures only" and "futures and options". [↑](#footnote-ref-13)
14. Markets covered include commodities, indices, currencies, treasuries, bonds etc., across national and local exchanges (e.g. NYSE, NYMEX, CBOE, KCBT etc.). [↑](#footnote-ref-14)
15. The investment process is built on trading options priced on Mondays at GMT 14:00 and expiring the following Monday at GMT 14:00. [↑](#footnote-ref-15)
16. Public holidays are replaced by the next available trading day (usually Tuesday). [↑](#footnote-ref-16)
17. The ADF test employs an autoregressive model and optimizes an information criterion across multiple different lag values. The null hypothesis (H0) states the time series can be represented by a unit root that is not stationary (i.e. time series has a time-dependent structure), while the alternate hypothesis (H1), is that it is stationary (i.e. time series has no time-dependent structure) (Cromwell, Hannan, Labys, & Terraza, 1994). [↑](#footnote-ref-17)
18. ADF test was applied on 134 complete asset’s time series; the null hypothesis (H0) was rejected at the 1% significance level for 82.3% of them. [↑](#footnote-ref-18)
19. Rejecting the null hypothesis at the 1% significance level implies that the probability the ADF test results are a statistical fluke are low. [↑](#footnote-ref-19)
20. The (P)ACF gives the (partial) correlation of a time series with its own lagged values. [↑](#footnote-ref-20)
21. The Delta of an option is a value that estimates the rate of change in the price of an option given a 1 point move in the underlying asset. Using a higher delta when pricing an option increases the distance of the strike from the spot, thus making potential execution of the option less likely; subsequently the likely premium received is also reduced. [↑](#footnote-ref-21)
22. MATLAB utilized for model development and optimization, while Python employed for cross-validation of results, portfolio construction and plotting. [↑](#footnote-ref-22)
23. As an example, if in Dealers have a net long (short) position in an asset at any point in time, the model will opt to sell the put (call) options. [↑](#footnote-ref-23)
24. Times series exhibit strong 1-period autocorrelations. [↑](#footnote-ref-24)
25. In the 670 equity lines analysed, the 10 largest losing trades are generated with a probability of 73.4% from positioning data in the area. [↑](#footnote-ref-26)
26. The data (*N* data points) are split in half and the optimization is run on the in-sample part of the data (*0* to *N/2*). Subsequently the resulting allocation is employed in the out-of-sample data (*N/2* to *N*). [↑](#footnote-ref-27)