The Economic and Financial Underpinnings of Technical Analysis

FORECASTING FINANCAL TIME SERIES DATA USING MACHINE LEARNING, AND ANALYSING THE EFFECT OF SUPPORT AND RESISTANCE

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ABSTRACT

"Prediction is very difficult, especially if it's about the future."

--Niels Bohr, Nobel laureate in Physics

"I have seen the future and it is very much like the present, only longer."

--Kehlog Albran, The Profit

And there are many more. The inherent urge, rather I should say the problem of mankind to forecast has been existing since 6th century BC, when Lao Tzu, the Chinese poet said "Those who have knowledge, don't predict. Those who predict, don't have knowledge."

And still in the 20th century AD, we continue to predict the future; possibly because our existence as human beings are so quintessentially dependent on it, and even more in modern days.

Well, I am not quite sure, if the concept of Probability was existing during 6th century BC, but it does exist now, and hence I want to assert one Disclaimer from the very beginning that whatever we do subsequently related to Forecasting is based solely on the "***Observed data***" from the past up to the present, and would be expressed in terms of *Probability*, i.e nothing is guaranteed in prediction with absolute accuracy.

Financial Time series data is quite unique and challenging to model, not least due to the uncertainty and volatility but also because of the potential Risk & Return involved. Modern world is akin to a financial jungle, where Darwin's theory of "***Survival of the fittest***" would be quite felicitous.

In this thesis, we will examine the efficiencies of a LS-SVM (Least Squares Support Vector Machines) methodology and Neural Nets, and compare it with the traditional ARIMA model of forecasting for both in and out of sample data. Then we'll study the effect of Support and Resistance and how those affect the results of the LS-SVM model.

INTRODUCTION

Bayesian probability theory provides a unifying framework for data modelling, where the modeller's aim is to develop probabilistic models that are well-matched to the data, and make optimal predictions using those models. Due to the nature of the time series we are modelling i.e Financial, our aim is not only to come up with a ***Best Estimate*** matching the Observed data, but equally important is to reduce the variance or noise in order to estimate the corresponding risk.

The price of an asset or Instrument traded in the market depends on the relative Demand and Supply. While this is quite a generic statement applicable to any and every class of assets, we would rather not draw ourselves into modelling human behavior (and machines, but then machines are programmed by human), which would be a separate topic on its own right.

The premise of this paper is that many of the important movements in asset prices arise from specific identifiable events, and most of them are macro-economic in nature. For example: CPI rate, Unemployment number, Manufacturing data, House Permits, GDP data etc; and what this does is guide the monetary and fiscal policy of the country, which in turn affects the tradable asset price, Ex: The Treasury 2Y Notes, UK 5 Year Gilts, GBPUSD exchange rate, USDJPY exchange rate. So, potentially there could be multi-levels of hierarchical cause (we say as Parameters which change with time) which affects an asset price.

While each of these contributing factors/ causes could be individually modelled; in this paper we will try to model the actual observed price values $\{y_t\}$, depending on the fitted parameter space $\boldsymbol{\Theta}_t = (\theta_1, \theta_2, .. \theta_n)_t$, which best explains the observed data $\{y_t\}$. In each case, we will keep the Training data and the Test data separate , so we can judge the performance of each model on a practical basis, as our ultimate aim is to find an optimal model which can predict the ***future*** to a reasonable standard. As you have noticed, we are modelling with a dynamic time varying parameter set here, which always adjusts itself according to the latest available data.

We will employ some standard statistical learning techniques of Neural Networks and Support Vector Machine (Gestel, et al., 2001) to come up with an optimal parameter set, and we'll benchmark the performance of the model with the standard ARIMA model, in each case with the same set of out of sample Test data.

The objective of the model would be to predict the next point of the financial time series, both directionally and magnitude wise. Hence, we would run a Classification as well as a Regression SVM model. The Classification would predict whether the next predicted point in the Time series (the Close Price) would be higher or lower compared with the current state, and the Regression would give an indication of the deviation of the predicted Close Price with the actual observed Price. The volatility indicated by the High and Low price could be modelled using GARCH techniques, but for our purpose of forecasting, we will work with the Close Price.

We will use some highly liquid and tradable instruments including Currencies (GBPUSD, AUDUSD), and Equity Indices (S&P500, DAX30).

LS-SVM METHOD OF CLASSIFICATION AND REGRESSION

Basically, the SVM regressor maps the inputs into a higher dimensional feature space in which a linear regressor is constructed by minimizing an appropriate cost function. Using Mercer's theorem, the regressor is obtained by solving a finite dimensional Quadratic Programming (QP) problem in the dual space avoiding explicit knowledge of the high dimensional mapping and using only the related kernel function.

LS-SVM Time Series Model $\mathcal{H}$

Model $y_i = w^T \varphi(x_i) + b + e_i$
Input x, Output $\hat{y}_{MP,N+1} \pm \sigma_{\hat{y}_{MP,N+1}}$
Data $D = \{(x_i, y_i)\}_{i=1}^N$

In Support Vector Machines for nonlinear regression, the data are generated by the nonlinear function which is assumed to be of the following form (1) with model parameters and where e_i is additive noise. For financial time series, the output is typically a return of an asset or exchange rate, or some measure of the volatility at the time index . The input vector may consists of lagged returns, volatility measures and macro-economic explanatory variables. The mapping is a nonlinear function that maps the input vector into a higher (possibly infinite) dimensional feature space . However, the weight vector and the function are never calculated explicitly. Instead, Mercer's theorem is applied to relate the function with the symmetric and positive definite kernel function . For one typically has the following choices: (linear SVM); (polynomial SVM of degree); (SVM with RBF-kernel), where is a tuning parameter. In the sequel of this paper, we will focus on the use of an RBF-kernel. (Gestel, et al., 2001)

$K(x; z) = \exp(-\gamma||\mathbf{x} - \mathbf{z}||^2)$

Taking Lagrangian and enforcing the constraints, we obtain the Karush-Kuhn-Tucker (KKT) system of equations.

$$z_{MP} = \sum_{i=1}^{N} \alpha_i K(x, x_i) + b_{MP}$$

FITTING A RADIAL BASIS KERNEL ON GBPUSD DAILY DATA

The Daily Close Spot rate of GBPUSD, one of the most liquid traded currency pair in the world, is our Data (X).

The Training Data consists of 470 data points starting from Daily Close from 2015 for 3 years , having 16 dimensions / factors. The factors are the daily change of values , for example: Change in High price, Low Price, Change in 8 and 21 Exponential Moving Average, some standard technical indicators like MACD, RSI and Stochastic.

All the factors are normalized to have zero Mean and Unit variance, in order to bring all factors in same basis.

The Output, in the case of Classification SVM , is the **Trend,** which is binary and is defined as TRUE if $(\text{Close Price})_t > (\text{Close Price})_{t-1}$, and vice versa. The SVM-Classification model predicts the next movement in Price at T+ 1, given all Inputs up to T.

Once the Model is fitted, it is tested against the 269 Out of Sample Test data, which consists of Inputs of all similar features for 2018 Daily GBPUSD data.

The Actual data and Result is shown in the Appendix.

The SM Model is found to be predicting about **57%** of the results correctly; which is not massively encouraging, neither entirely disastrous. Hence, it demands some further scrutiny on a case by case basis, on which data points or days its failing to predict the direction, and if there is any significant pattern in those.

The next section will detail those findings.

ROLE OF SUPPORT AND RESISTANCE IN FINANCIAL DATA

Technical Analysis of financial charts is as much as an Art as Science. Charts, which consists of Candlesticks (invented by the Japanese in 17^{th} century), contains a huge amount of information on any given time frame. Typically, Candles for 1 hour,4 Hour, 1 Day and 1W are hugely informative in assessing the trading behavior of the market participants. While there are various theories around "who moves the Market" etc, but Spot FX Currency market is the largest financial market open 24 X 5 and highly liquid, processing about $1.3 trillion on a daily basis (as per the latest BIS survey,2016). The Spot FX market was even bigger of the order of $5 trillion, but various other FX instruments like FXSwap and other derivatives have taken some share of the spot market in recent years, owing to largely institutional hedging activities.

Technical analysis assigns a special importance to the Open, High, Low and Close prices in forecasting the mean and volatility of exchange rates. Candlestick analysis is a popular form of TA that combines Open, High, Low and Close prices for the purpose of charting and forecasting and represents probably the most exhaustive attempt to classify price forecasts according to High Low Close constellations [1]. Within Candlestick analysis, as well as in other forms of TA, the difference between Open and Close prices serves as a measure of the direction and the extent of intraday trends. The difference between High and Low prices marks the intraday trading range and represents a measure of volatility. For many forms of TA, it is the interaction between trend and volatility that is assumed to be informative about future price developments. (Fiess & MacDonald, 2002).

Support and Resistance is a manifestation of human behavior, very much a subject of Behavioral Finance, and being widely accepted in the Technical Analysis (TA) by chartists, but with rather little attention from the academic world. In this paper, we will try to explain their empirical existence, on a statistical footing.

Below is the GBPUSD 1D chart for some time range, where each candle represents a full day of trading. The two horizontal lines drawn in *blue* , represents some **Key levels ,** as anyone can see visually, whether it being Support or Resistance, we don't care at this point of time, but we can see that the market has touched the levels (rather zones) couple of times, and retraced up/down. What this means is, that there has been some heavy Buying/ selling once the market reaches these levels.

In most scenarios, these levels are characterized by the High / Low of the candle.[1]

[1] Candlestick charts were introduced by Japanese rice traders in the 17th century as a graphical way of displaying the different constellations between High, Low, Open and Close prices, where each constellation implies a different forecast (see e.g. Feeny, 1989..).

Candlestick chart analysis, which enjoys a growing popularity amongst practitioners could be interpreted as such an attempt. Candlestick charts derived their name from a special graphical plot of Open, High, Low and Close prices, which has a certain similarity to a candle with its wick and shadow. Candlesticks are comprised of a vertical line that represents the difference between the High and the Low, and a rectangle that measures the difference between the Open and the Close. The rectangle is drawn with the same width, but its length and color depends on the absolute difference between the Open and the Close. If the market closes on a higher level than the opening price rising prices , the rectangle is filled in white/ green. If the Close price lies below the Open ,the rectangle is filled in Black /Red body . If the rectangle is reduced to a horizontal line ,i.e if the market opens and closes at the same price level , the technical pattern is called *Doji*. The difference between the Open and the Close prices thus serves as an indicative measure of the direction and the extent of intraday trends. The difference between High and Low prices marks the intraday trading range and measures volatility. It is the interaction between trend and volatility that is believed to be informative about future price developments. While individual candles provide the chartist with information about the trading activity of a certain time period, combinations of candles form the basis of specific trading signals. (Feeny 1989)distinguishes between 24 different types of individual candles and 34 different candlestick formations, however, non-academic sources claim the existence of more than 100 different candlestick formations. Since Candlestick charts represent an attempt to combine the information of intraday price trends of Open Close with intraday volatility HighLow for the purpose of forecasting, and hence an analysis of the time series properties of these different prices is required

TIME SERIES PROPERTIES OF HIGH, LOW AND CLOSE PRICES

Following from the previous section, one way to illustrate the different dynamics of the High, Low and Close price series is to look at the autocorrelation function (ACF) of the differences between these series. If High, Low and Close had the same time series properties, the difference between the series should be random: the autocorrelation functions of the differences of High and Close, High and Low and Close and Low should contain no significant autocorrelations. However, this is not the case, as demonstrated by Fig. 2, which represents the plot of the ACF of the difference between the High and the Close prices for the first 500 lags of GBPUSD. The slow decay of the ACF is significant and, hence, the differences between the two series are structural and not random in nature. It takes approximately 100 lags before the ACF becomes zero for the first time.

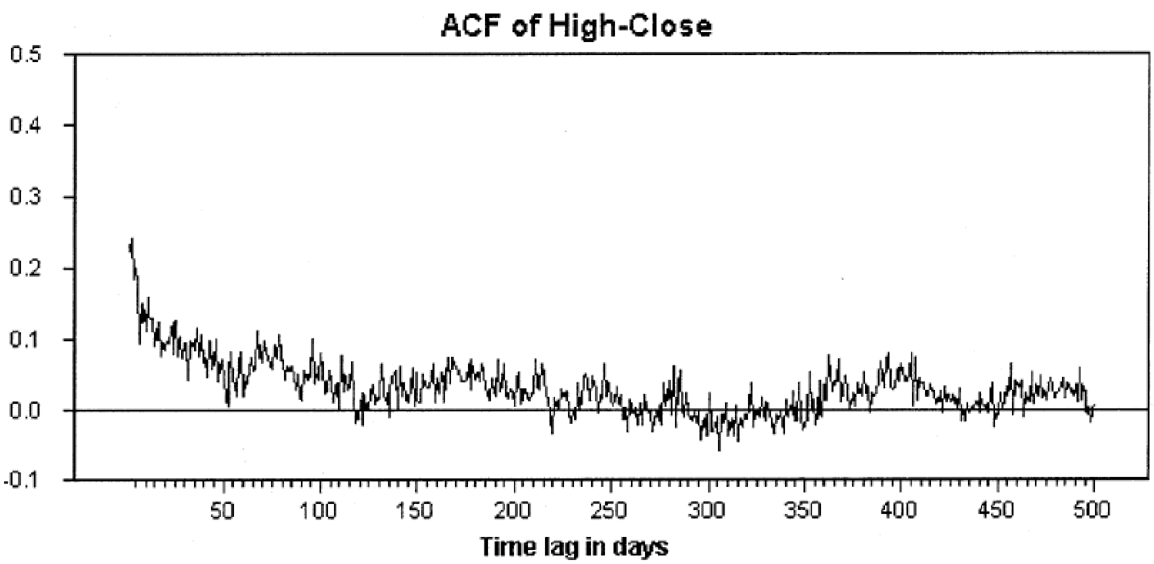


Fig. 1. ACF of the difference between the High and Close series (lag zero omitted) — GBPUSD.

However, the following ACF diagram Fig. 2 between High –Low is a bit different, and we note the rather slow decay in this case. This reflects a higher degree of persistence and requires explanation. One possible explanation could be that High and Low prices do not only determine the intraday trading range, but also often coincide with inter-day Support and Resistance levels and are therefore less likely to change as frequently as Close prices, something which we have seen some evidence of. (Fiess & MacDonald, 2002).

Thus, even though High, Low and Close prices are realizations of the same exchange rate, the three series are in fact random drawings. It is therefore possible to apply a wide range of multivariate time series analysis to investigate the dynamics between these different prices. Before we investigate the dynamics between the series, we propose analyzing the time series properties of the individual series in order to highlight the difference between them. One way to illustrate the different dynamics of the High, Low and Close price Ž. series is to look at the autocorrelation function ACF of the differences between these series.7 If High, Low and Close had the same time series properties, the difference between the series should be random: the autocorrelation functions of the differences of High and

Close, High and Low and Close and Low should contain no significant autocorrelations. However, this is not the case, as demonstrated by Fig. 1, which represents the plot of the ACF of the difference between the High and the Close prices for the first 500 lags of GBPUSD. The slow decay of the ACF is significant and, hence, the differences between the two series are structural and not random in nature. It takes approximately **100** lags before the ACF becomes zero for the first time. The ACF of the difference between High and Low Fig. 2 shows a particularly slow decay and thus reflects a high degree of structure between these two series. This is expected since the absolute difference between High and Low denotes a simple measurement of daily volatility and a slowly decaying ACF therefore indicates the presence of autoregressive conditional heteroscedasticity (ARCH), a widely noted feature of daily exchange rates. Thus, like return-based GARCH models, range-based extreme value estimators seem to have the potential of capturing serial dependencies in the conditional volatility of exchange rates. Our empirical results suggest that extreme value estimators do an even better job. Fig. 3 compares the ACF of absolute returns, with the ACF of the difference between Highs and Lows, and thus allows a direct comparison of extreme value and ClosetoClose volatility estimators. Interestingly, it takes about the same number of lags for both ACFs to become zero. However, the ACF of the difference of Highs and Lows decays at a much slower rate. This reflects a higher degree of persistence and requires explanation. One possible explanation could be that High and Low prices do not only determine the inter-day trading range, but also often coincide with inter-day support and resistance levels and are therefore less likely to change as frequently as Close prices. Since support and resistance points that are not breached during the course of a trading day retain their importance, they provide a proxy for the next day's volatility. This volatility proxy stands a fair chance of being superior to a return based volatility estimate if support and resistance levels are not breached during the next trading day either. Even when support and resistance levels have been breached, the extremes of the new inter-day trading range manifest themselves immediately in new market Highs and/or Lows. This interpretation assigns an inherent forward-looking element to a volatility measure which is based on the previous day's trading range, and also assumes that information is more rapidly incorporated into trading range based volatility estimators than into return-based volatility estimators. Does our data set provide empirical support for this hypothesis? Since lagged correlation reveals the presence of causal relations and information flow structures, an analysis of the difference between the correlation of the trading range and absolute returns, at positive lags and corresponding negative lags, should reveal any asymmetry in the information flow and causality. Strong correlation of time series 1 with time series 2 at a positive lag, indicates information flow from time series 1 to time series 2 where the information manifests itself with a positive lag. Since it is very likely that there might be a third common cause influencing the behavior of both series 1 and 2, we cannot always assume direct causality. However, even in the case of a third common cause, we have to accept that the information flow to series 2 is slower than that to series 1. If two time series are generated on the basis of a synchronous information flow, they have a symmetric lagged correlation function, $\rho_\tau = \rho_{-\tau}$; the symmetry will only be violated by insignificantly small, purely Stochastic deviations. A significant deviation of ρ_τ and $\rho_{-\tau}$ indicates an asymmetric information flow and a causal relation. (Fiess & MacDonald, 2002)

Fig. 4 shows a significant asymmetry in the difference between positive and corresponding negative lags of the two volatility series for USDJPY. As can be seen from Table 1, a similar asymmetry can be found for EURUSD and GBPUSD. This points to the fact that information flows slower to a volatility measure consisting of absolute daily return and indicates that a volatility measure based on the trading range systematically predicts Close-to-Close volatility, at least within an intra-weekly time frame.

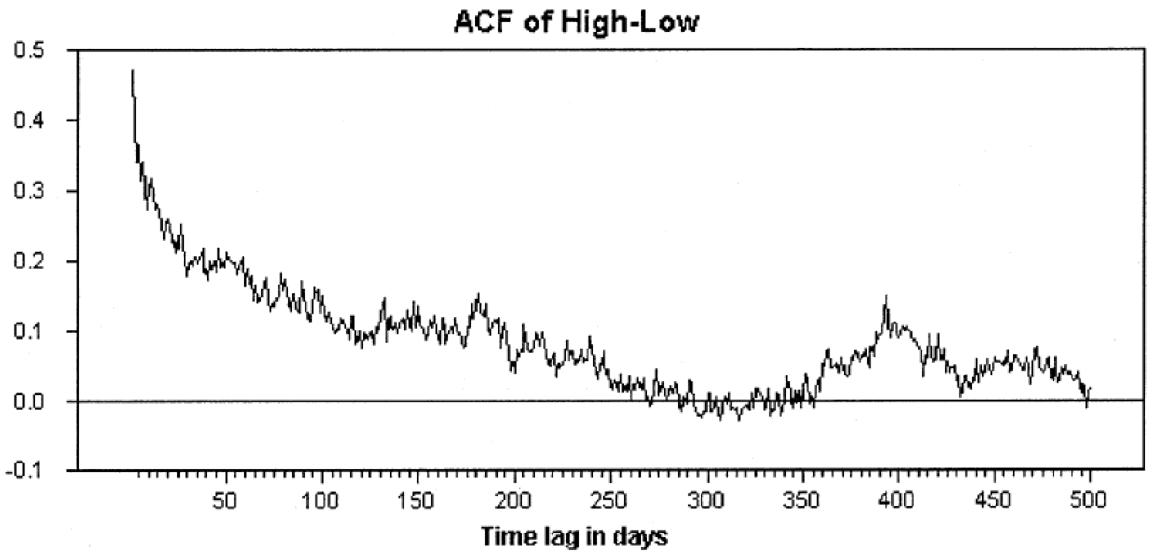


Fig. 2. ACF of the difference between the High and the Low series (lag zero omitted) — GBPUSD.

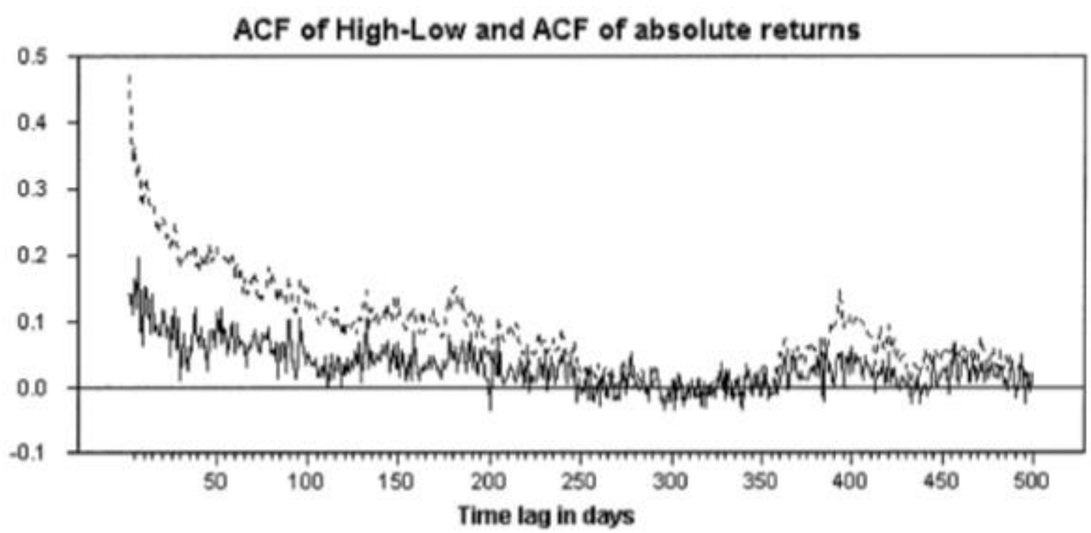


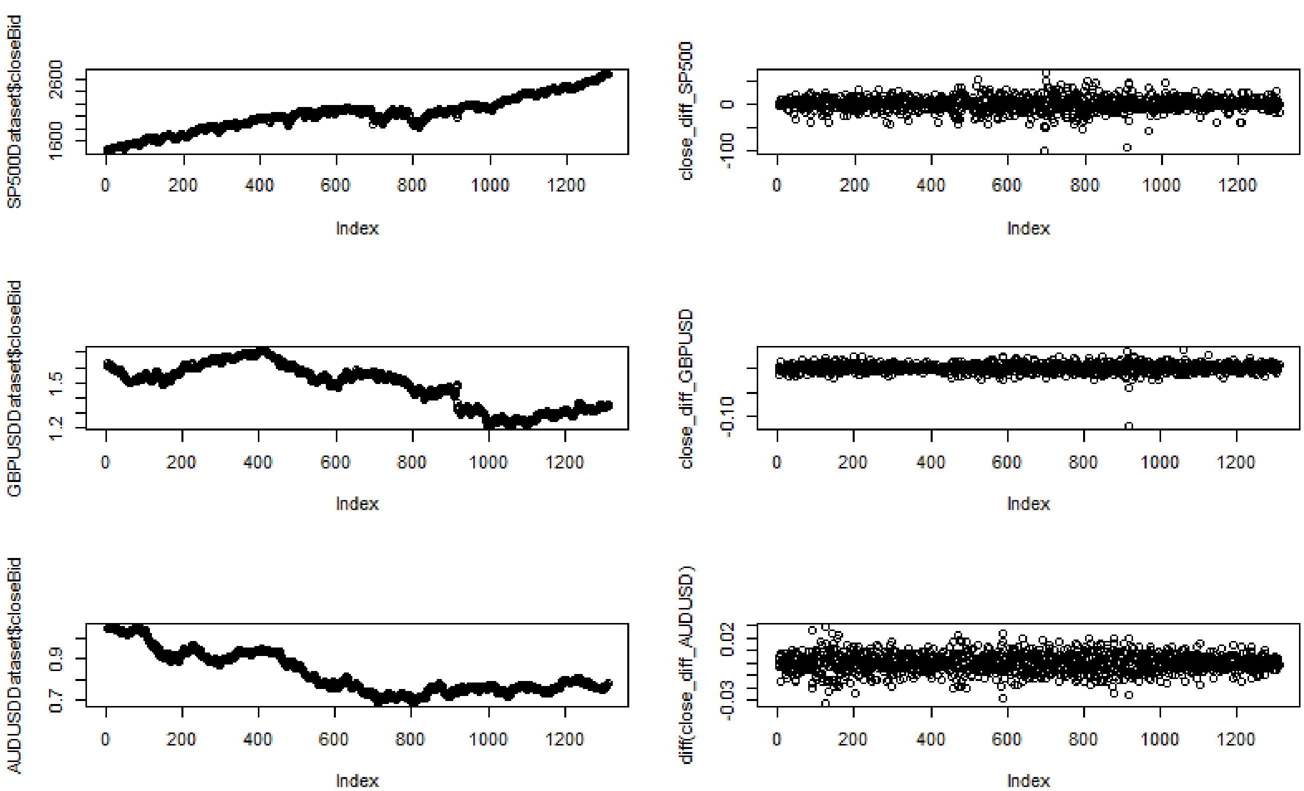
Fig. 3. Autocorrelation function of absolute returns with ACF of difference between High and Low superimposed (dashed line) — lag zero omitted.

Since we are running a SVM model on the differenced data (to make it stationary), the fitted SVM model wouldn't necessarily be able to gauge the levels of Support and Resistance, which are actual levels of price as shown in the chart in Page 4. The results shown in **Appendix A** are purely coming from the SVM model from the Out-of-sample Test data.

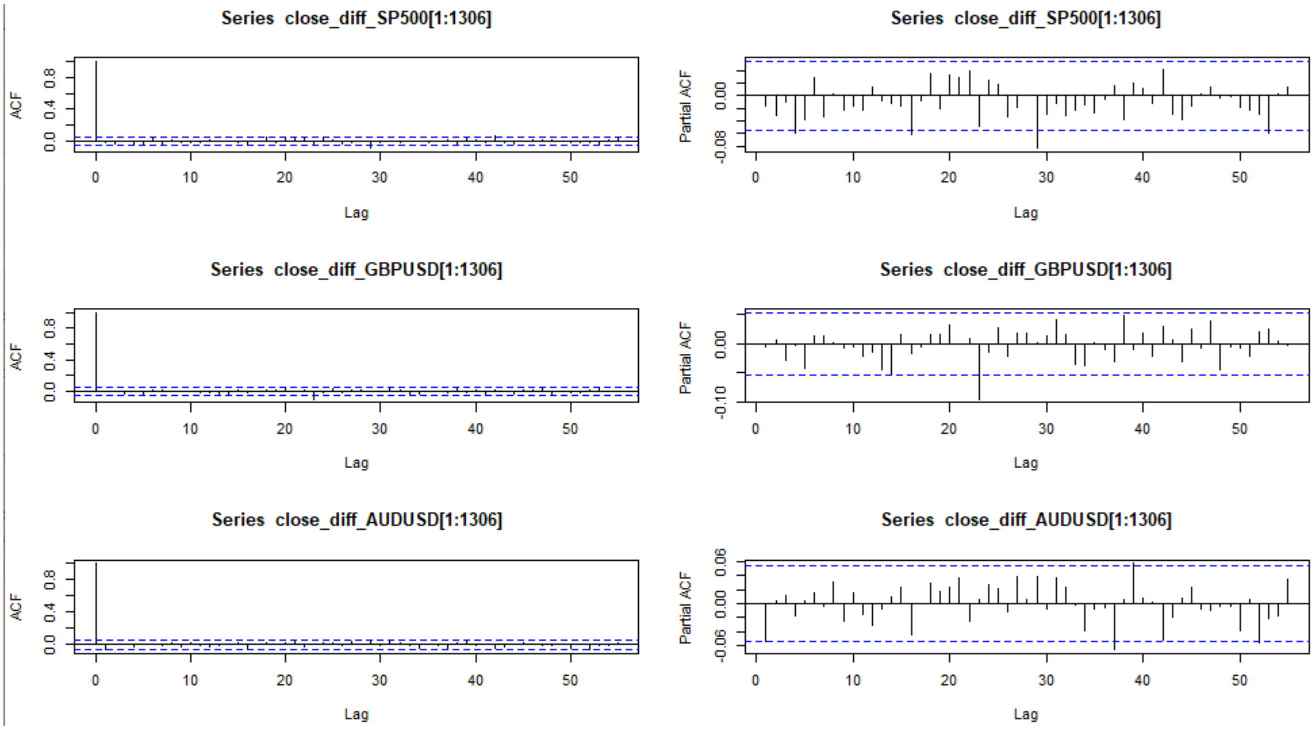
In **Appendix B**, we have tried to explain ***whether,*** some of the mis-classifications could be attributed to the presence of Support and Resistance.

ARIMA MODELLING

The below plots show the daily close prices of S&P500, Spot GBPUSD & Spot AUDUSD from 2012-2017 (which is our training set). The adjacent plots are for the corresponding differenced time series to make it stationary to be used for ARIMA modelling.



The following plots shows the AutoCorrelation (ACF) and Partial AutoCorrelation (PACF) of the above 3 series ; SP500, GBPUSD and AUDUSD.



ARIMA model is constructed in line with the above plots , and the next 10 step ahead predictions are obtained. The sample result for S&P500 is as follows :-

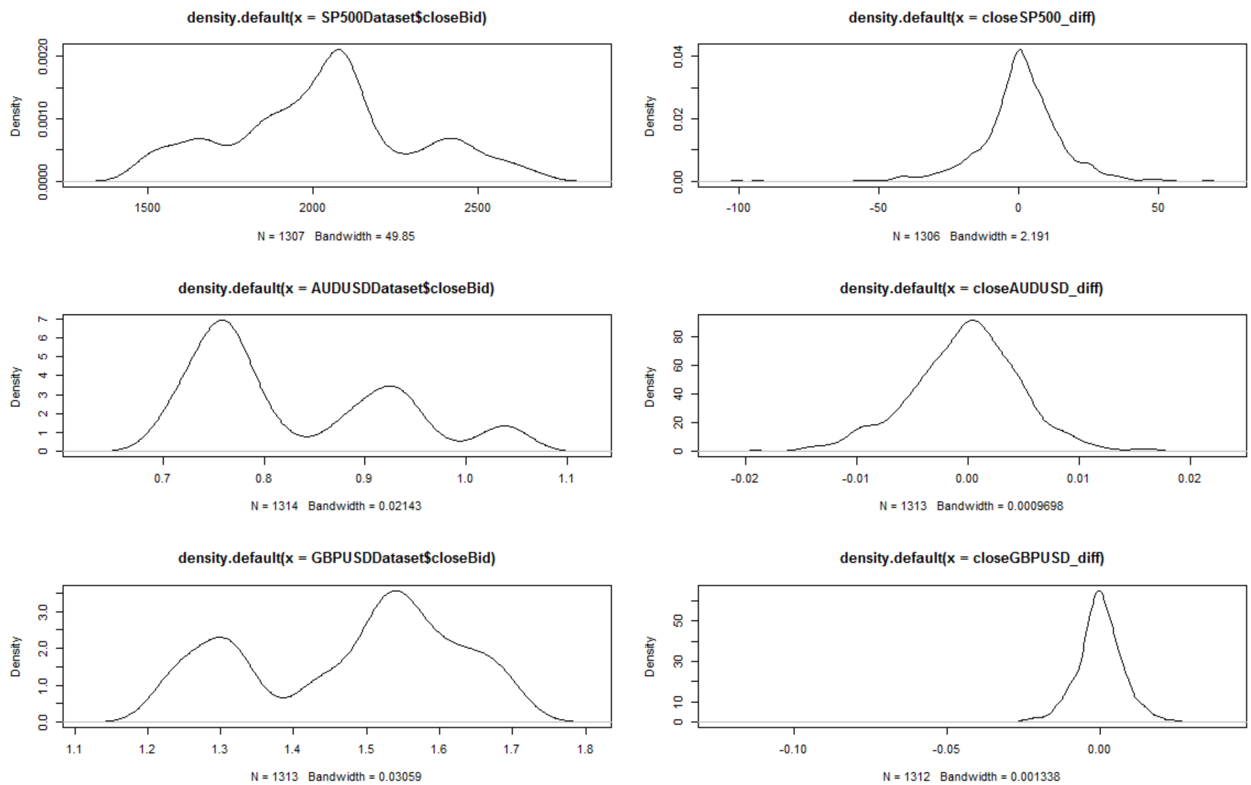
The presence of the standard error component makes it particularly difficult to make a directional forecast.

Time	pred	s.e
01/01/2018 22:00	2664.065912	14.38752102
02/01/2018 22:00	2663.277272	20.22497061
03/01/2018 22:00	2663.204398	24.49720921
04/01/2018 22:00	2663.720984	28.05319099
07/01/2018 22:00	2664.344195	30.88245272
08/01/2018 22:00	2664.956965	33.34310458
09/01/2018 22:00	2662.376398	35.80848097
10/01/2018 22:00	2661.851902	37.99104331
11/01/2018 22:00	2663.841412	40.12369842
12/01/2018 22:00	2663.482941	42.10670094

NON-PARAMETRIC APPROACH

The following plots shows the default density plots of 3 series ; S&P500, Spot GBPUSD and Spot AUDUSD for daily Closing price. The left plot shows the raw closing price which is clearly multi-modal in nature , the corresponding right one is the density plot for the differenced (stationary) series.

Interestingly, we see the differenced series resembles a normal distribution, albeit to a varying degree of skewness.



(Lo, Mamaysky, & Wang, 2000) Any Lo has written some comprehensive text about the Non-Parametric approach and its applicability in Technical Analysis.

Kernel Regression

For the kernel regression estimator, the weight function $\omega t(x)$ is constructed from a probability density function $K(x)$, also called a kernel, satisfying the following properties.

$K(x) >= 0$, $\int K(u)du = 1$.

By rescaling the kernel with respect to a parameter $h>0$, we can change its spread, i.e., let:

$K_h(u) \equiv 1/h\ K(u/h)$, $\int K(u)du = 1$.

and define the weight function to be used in the weighted average (4) as

$w_{t,h}(x) \equiv K_h(x\text{-}Xt)/g_h(x)$

$g_h(x) \equiv f(x) = \frac{1}{T}\sum_{t=1}^{T} Kh(x - Xt)$.

If h is very small, the averaging will be done with respect to a rather small neighborhood

around each of the Xt's. If h is very large, the averaging will be over larger neighborhoods of the Xt's. Therefore, controlling the degree of averaging amounts to adjusting the smoothing parameter h, also known as the bandwidth, and hence choosing the appropriate bandwidth is an important aspect of any local-averaging technique.

Gaussian Kernel is a popular choice among kernels.

$$K_h(x) = \frac{1}{h\sqrt{2\pi}} e^{-\frac{x^2}{2h^2}}$$

VOLUME PROFILE ANALYSIS OF SUPPORT AND RESISTANCE

Volume Profile is an advanced charting study that displays trading activity over a specified time period at specified price levels. The study (accounting for user defined parameters such as number of rows and time period) plots a histogram on the chart meant to reveal dominant and/or significant price levels based on volume. Essentially, Volume Profile takes the total volume traded at a specific price level during the specified time period and divides the total volume into either buy volume or sell volume and then makes that information easily visible to the trader.

One of the major use of Volume Profile is to identify basic Support and Resistance levels.

It is important to note that using Volume Profile as an identifier for support and resistance levels is a reactive method. This means that unlike proactive methods (such as trend lines and moving averages) which are based on current price action and analysis to predict future price movements, reactive methods rely on past price movements and volume behavior. Reactive methods can be useful in applying meaning or significance to price levels where the market has already visited. Basic technical analysis has shown that a support level is a price level which will support a price on its way down and a resistance level is a price level which will resist price on its way up. Therefore, one can conclude that a price level near the bottom of the profile which heavily favors the buy side in terms of volume is a good indication of a support level. The opposite is also true. A price level near the top of the profile which heavily favors sell side volume is a good indication of a resistance level. (https://www.tradingview.com/wiki/Volume_Profile)

The above diagram of Spot AUDUSD shows the volume profile histogram cutting across the price level. The Red line from the highest volume bar across (at 0.67768) the chart highlights the Support and Resistance, where Price has reacted multiple times. As we see, a previous Support becomes Resistance in future and vice-versa; we refer to those levels as *Key Levels*.

TEST OUTPUT AND COMPARISON WITH ACTUAL WITH EXPLANATION:

Spot GBPUSD:

Date	closeBid	CloseChange	Diff(Predi	Actual	HighBid	LowAsk	SVM Output	Diff	Comment
01/01/2018 22:00	1.35873	-0.00739	-1.18%	FALSE	1.35996	1.35066	FALSE	TRUE	
02/01/2018 22:00	1.35134	-0.00739	0.44%	FALSE	1.36122	1.34953	TRUE	FALSE	**Resistance near 1.361**
03/01/2018 22:00	1.35487	0.00353	0.19%	TRUE	1.35593	1.35066	FALSE	FALSE	**Support near 1.3504**
04/01/2018 22:00	1.35609	0.00122	0.21%	TRUE	1.35818	1.35248	FALSE	FALSE	**Support near 1.3504**
07/01/2018 22:00	1.35616	7E-05	-0.06%	TRUE	1.3585	1.35237	TRUE	TRUE	
08/01/2018 22:00	1.35371	-0.00245	-0.14%	FALSE	1.35819	1.35067	TRUE	FALSE	**Resistance around 1.3559**
09/01/2018 22:00	1.3504	-0.00331	0.43%	FALSE	1.35615	1.34825	TRUE	FALSE	**Resistance around 1.3559**

The Comment tries to explain the presence of a Support or Resistance in the vicinity of a price bounce. The Diff column highlights, where there is a mismatch between the directional forecast between the Actual Close change (Actual) vs the predicted from the SVM model (SVM Output).

Below, is the plot joining the key levels of Support and Resistance for GBPUSD covering the Test period. (Jan 2018 – Dec 2018)

Note that, only the significant levels are shown as horizontal lines for clarity. Significant levels are those levels where Price has reacted multiple times. But, all the levels (shown in dots as Green and Red) are key levels. (The below plot is generated using proprietary algorithm for finding key levels in the market, which could be reasonably verified from any chart)

Spot AUDUSD

The table below shows an extract of the result achieved for Spot AUDUSD, and the explanations for some of the misclassifications.

Date	Index	SVMFitted	Actual-AUI	SVM Diff	NNetFitted	Nnet Diff	NNet2 fitte	Nnet2 Diff	Comments
02/01/2018 22:00	1	TRUE	0.00056	TRUE	0.526092	TRUE	0.51946	TRUE	
03/01/2018 22:00	2	FALSE	0.00294	FALSE	0.613942	TRUE	0.640533	TRUE	
04/01/2018 22:00	3	FALSE	-0.00022	TRUE	0.441653	TRUE	0.470661	TRUE	
07/01/2018 22:00	4	FALSE	-0.0022	TRUE	0.517113	FALSE	0.499261	TRUE	
08/01/2018 22:00	5	TRUE	-0.00169	FALSE	0.728735	FALSE	0.733908	FALSE	Resistance around .7873
09/01/2018 22:00	6	TRUE	0.00193	TRUE	0.75298	TRUE	0.741015	TRUE	
10/01/2018 22:00	7	TRUE	0.00495	TRUE	0.728061	TRUE	0.682233	TRUE	
11/01/2018 22:00	8	FALSE	0.00235	FALSE	0.660179	TRUE	0.654554	TRUE	
14/01/2018 22:00	9	FALSE	0.00495	FALSE	0.499638	FALSE	0.476895	FALSE	Support around .7832
15/01/2018 22:00	10	FALSE	-0.00063	TRUE	0.565492	FALSE	0.563315	FALSE	
16/01/2018 22:00	11	FALSE	0.00114	FALSE	0.681416	TRUE	0.674016	TRUE	
17/01/2018 22:00	12	FALSE	0.00285	FALSE	0.532792	TRUE	0.426074	FALSE	
18/01/2018 22:00	13	FALSE	-0.00052	TRUE	0.539829	FALSE	0.481893	TRUE	
21/01/2018 22:00	14	FALSE	0.00224	FALSE	0.64683	TRUE	0.608658	TRUE	
22/01/2018 22:00	15	TRUE	-0.0015	FALSE	0.789375	FALSE	0.791576	FALSE	
23/01/2018 22:00	16	TRUE	0.00624	TRUE	0.78632	TRUE	0.708776	TRUE	
24/01/2018 22:00	17	FALSE	-0.00387	TRUE	0.731242	FALSE	0.630071	FALSE	
25/01/2018 22:00	18	TRUE	0.00856	TRUE	0.743014	TRUE	0.471693	FALSE	Clear Resistance around .8109
28/01/2018 22:00	19	TRUE	-0.00146	FALSE	0.683226	FALSE	0.717579	FALSE	Clear Resistance around .8109
29/01/2018 22:00	20	FALSE	-0.00124	TRUE	0.051711	TRUE	0.066078	TRUE	
30/01/2018 22:00	21	FALSE	-0.00265	TRUE	0.05332	TRUE	0.057442	TRUE	
31/01/2018 22:00	22	FALSE	-0.00193	TRUE	0.051494	TRUE	0.079634	TRUE	
01/02/2018 22:00	23	TRUE	-0.01161	FALSE	0.083401	TRUE	0.126296	TRUE	
04/02/2018 22:00	24	TRUE	-0.00438	FALSE	0.530286	FALSE	0.321949	TRUE	
05/02/2018 22:00	25	TRUE	0.00289	TRUE	0.342059	FALSE	0.223856	FALSE	Support around .7852

The following chart extract from OANDA (FX Broker) highlights the presence of Support & Resistance around the marked price points.

Spot AUDUSD is modelled using both SVM & Neural Nets, using multiple parameters. While the SVM model achieved a directional accuracy of around 54%, the Neural nets with 3 and 4 hidden nodes (single layer) achieved an accuracy pf around 67% !

> **summary(nnetAUD2)**

```
a 16-4-1 network with 73 weights
options were - decay=0.3
 b->h1  i1->h1  i2->h1  i3->h1  i4->h1  i5->h1  i6->h1  i7->h1  i8->h1  i9->h1 i10->h1 i11->h1 i12->h1 i13->h1 i14->h1 i15->h1 i16->h1
  0.94   0.41  -0.55  -0.47  -0.32  -0.21  -0.38  -0.41   0.11  -0.07  -0.35  -0.34  -0.79  -0.62   0.41  -0.11   0.25
 b->h2  i1->h2  i2->h2  i3->h2  i4->h2  i5->h2  i6->h2  i7->h2  i8->h2  i9->h2 i10->h2 i11->h2 i12->h2 i13->h2 i14->h2 i15->h2 i16->h2
 -0.27   0.32  -0.17   0.49   0.00   0.54   0.58   0.39  -0.88  -0.77  -0.88  -0.31  -0.36  -0.23  -0.12   0.00   0.24
 b->h3  i1->h3  i2->h3  i3->h3  i4->h3  i5->h3  i6->h3  i7->h3  i8->h3  i9->h3 i10->h3 i11->h3 i12->h3 i13->h3 i14->h3 i15->h3 i16->h3
  0.35  -0.29   0.47  -0.60  -0.72  -0.38  -0.55  -0.72   1.04   0.67   0.72  -0.21   0.18   0.36  -0.87  -0.30   0.09
 b->h4  i1->h4  i2->h4  i3->h4  i4->h4  i5->h4  i6->h4  i7->h4  i8->h4  i9->h4 i10->h4 i11->h4 i12->h4 i13->h4 i14->h4 i15->h4 i16->h4
  0.03  -0.26   0.05   0.33   0.64   0.01   0.19   0.44  -1.23  -0.78  -0.44   0.28   0.87   0.08   0.10  -0.03  -0.02
 b->o h1->o h2->o h3->o h4->o
-0.18  1.82 -1.81  2.15 -2.22
```

Spot GBPUSD on the other hand didn’t go over 55% using Neural nets. Perhaps the Brexit uncertainty since June 2016 was too hard to be modelled.

However, we also note that S&P500 also didn’t do very well in terms of directional forecast, and was below 55%.

CONCLUSION

In modern days, forecasting financial markets have been particularly difficult owing to the geo-political events. Rather than actual forecasts(signals), traders and speculators have been increasingly focused on the Risk Management, which means the Volatility (noise)also plays a very important role in making an optimal investment/ trading decision. In this paper, I have tried to model three of the most liquid trading instruments , and it seems to have forecasted (T+1)well in case of some (AUDUSD particularly) using SVM with RBF-Kernel and Neural Nets classification techniques. The Machine learning models of LS-SVM with RBF-kernel and Neural Nets are found to be having a better out of sample performance than the ARX and AR model with respect to the Directional Accuracy, where the predictive performance of the ARX is mainly due to lagged values. Technical Analysis is a huge subject and there are over hundreds of documented patterns, we have explored the technical measures based on the Price action (on multiple time frames)here and not on the geometric shapes of the charts (which in its own right is an entirely different subject).Given, the variates come from the technical analysis of the charts, we have some ground to believe that some of the traditional charting measures like Exponential Moving Average, RSI, MACD Histogram, Stochastic are fairly relevant in forecasting the next price move (albeit not to an astonishing degree of accuracy).

Market behavior is largely controlled by humans (even the Algorithms are devised by humans), and humans react to external events, and they tend to remember history as well (within a certain period). Perhaps, therefore the directional misclassifications could be explained based on the popular Support-Resistance theory, which are well established in the charting world, and have been shown to be statistically relevant as well.

Based on the findings, we can conclude that Technical Analysis and pattern recognition using Machine learning with a bit of Econometric analysis is relevant in predicting and explaining the next market move to a varying degree of accuracy.

APPENDIX A

Training Input Data

(Normalized with zero Mean and Unit Variance):-

highChang	LowChang	ema8-21	ema21-50	close-ema	close-ema	close-ema	closeW-e	closeW-e	closeW-e	ema8-21-\	ema21-50	rsiChange	volume	macdHist	stochastic
1.203691	1.235405	0.252158	-0.49293	1.280898	0.908978	0.384747	0.328745	-0.276	-0.14186	-0.84275	0.103026	1.047981	-0.50733	1.255462	0.466123
-0.45056	0.353435	0.325829	-0.43188	0.498896	0.474892	0.119452	0.622836	0.00417	0.052186	-0.63847	0.116401	-0.95768	-0.7013	1.21773	-0.06382
-0.81344	-1.36046	0.180452	-0.43454	-0.60474	-0.27012	-0.38612	0.622836	0.00417	0.052186	-0.63847	0.116401	-1.6078	-0.72125	0.838113	-1.11227
-0.29136	-0.75104	0.218095	-0.3915	0.277773	0.283884	0.009041	0.622836	0.00417	0.052186	-0.63847	0.116401	1.194465	-0.23258	0.791175	-1.10296
2.286417	1.515991	0.524371	-0.26636	1.691693	1.302091	0.756843	0.622836	0.00417	0.052186	-0.63847	0.116401	1.890674	-0.31434	1.174436	0.195094
0.127887	1.705431	0.721034	-0.1587	1.266723	1.149355	0.703811	0.622836	0.00417	0.052186	-0.63847	0.116401	-0.1027	-0.70293	1.341173	1.256949
-0.44957	-0.39003	0.715633	-0.10316	0.309471	0.567238	0.335731	-0.67766	-0.76096	-0.48607	-0.6805	0.060297	-1.11231	-0.74064	1.169883	0.549205

Input Attributes:

highChange - Change in high price between T & T-1
LowChange – Change in Low price between T & T-1
ema8-21 - Diff of 8 & 21 Exponential Moving Avg at T
ema21-50 – Diff of 21 & 50 Exponential Moving Avg at T
close-ema8 – Diff of Close & 8 EMA at T
close-ema21– Diff of Close & 21 EMA at T
close-ema50– Diff of Close & 50 EMA at T
closeW-ema8– Diff of Weekly Close & Weekly 8 EMA at T
closeW-ema21– Diff of Weekly Close & Weekly 21 EMA at T

closeW-ema50– Diff of Weekly Close & Weekly 50 EMA at T
ema8-21-W– Diff of Weekly 8 & 21 EMA at T
ema21-50-W– Diff of Weekly 21 & 50 EMA at T
rsiChange – Change of RSI indicator between T & T-1
volume – Change of volume between T & T-1
macdHist – Change of MACD histogram indicator between T & T-1
stochastic – Change of Stochastic indicator between T & T-1

Training Output (Differenced to make stationary):-

No	TREND	closeChange
1	FALSE	-0.00767
2	FALSE	-0.01514
3	TRUE	0.01111
4	TRUE	0.02208
5	FALSE	-0.00091
6	FALSE	-0.01036

APPENDIX B

SVM & Neural Net R program:-

```
require("e1071")
require("car")
library(car)
library(ggplot2)
library(nnet)
GBPUSD_D<-data.frame(read.csv("/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-codes/Research Data/GBPUSD_D_SVMTraining_CloseChange5.csv", header = TRUE))
TrainingOutput_D<-read.csv("/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-codes/Research Data/GBPUSD_D_SVMTraining3_Trend.csv", header= TRUE)
summary(GBPUSD_D)
GBPUSD_D_TestData <- data.frame(read.csv("/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-codes/Research Data/GBPUSD_D_SVMTestGrid2.csv", header= TRUE))


#S&P500
SP500_D <- data.frame(read.csv("/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-codes/Research Data/SPX500_USD_2.csv", header = TRUE))

#SP500_D_TestData <- data.frame(read.csv("/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-codes/Research Data/AUDUSD_D_SVMTestGrid2.csv", header = TRUE))
```

```
#AUDUSD Training & Test data
AUDUSD_D <- data.frame(read.csv("/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-codes/Research Data/AUD_USD_D_SVMTraining2.csv", header = TRUE))
AUDUSD_D_TestData <- data.frame(read.csv("/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-codes/Research Data/AUDUSD_D_SVMTestGrid2.csv", header = TRUE))

#TEst Data to tune:

TestData <- read.csv("/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-codes/Research Data/SVM_TestData_ALL.csv", header = TRUE)

x <- matrix(data = GBPUSD_D, nrow = 469, ncol = 16)
y_GBPUSD <- as.factor(TrainingOutput_D$TREND)
y_reg <- TrainingOutput_D$closeChange
x_test <- matrix(data = GBPUSD_D_TestData, nrow = 258, ncol = 16)

x_AUDUSD <- matrix(data = AUDUSD_D, nrow = 469, ncol = 16)
y_AUDUSD <- TrainingOutput_D$AUDUSD
y_AUDUSD_reg <- y_AUDUSD > 0
AUD_numeric <- as.numeric(y_AUDUSD_reg)
AUDUSD_D_normalized_df <- data.frame(AUD_numeric, scale(AUDUSD_D))
x_test_AUDUSD <- matrix(data = AUDUSD_D_TestData, nrow = 258, ncol = 16)


x_SPX500 <- matrix(data = SP500_D[,-1], nrow = 729, ncol = 15)
y_SPX500_reg <- (diff(SP500_D$closeBid) > 0)
SP500_numeric <- as.numeric(y_SPX500_reg)[1:472]
y_SPX500_reg_training <- (diff(SP500_D$closeBid) > 0)[1:472]
SPX500_D_normalized_df <- data.frame(SP500_numeric, scale(AUDUSD_D))
x_test_AUDUSD <- matrix(data = AUDUSD_D_TestData, nrow = 258, ncol = 16)

obj<-tune(svm, y_reg ~., data = GBPUSD_D, ranges = list(gamma = 2^(-2:2), cost = 2^(1:4)))
obj
objAUD <-tune(svm, y_AUDUSD_reg ~., data = AUDUSD_D, ranges = list(gamma = 2^(-3:3),
cost = 2^(1:4)))
objAUD

#Do SVM classification based on Close price change , +ve or -ve
svmfit2 <- svm(y_reg ~ . ,data = GBPUSD_D, kernel = "radial", cost = 4,gamma= 0.5
        )
summary(svmfit2)
```

```
svmfitAUD <- svm(y_AUDUSD_reg ~ . ,data = AUDUSD_D, kernel = "radial", cost = 50,gamma= 0.3
            )
summary(svmfitAUD)
#Do SVM Regression based on Close Price change
svmfitAUD_reg <- svm(y_AUDUSD_reg ~ . ,data = AUDUSD_D, kernel = "radial", cost = 20,gamma= 0.5, type = "C-classification")
print(svmfitAUD_reg)

#Do Neural net now
SP500_D_normalized_df <- data.frame(AUD_numeric, scale(AUDUSD_D))
tuneobjAUD <-tune(nnet, AUD_numeric ~., data = AUDUSD_D_normalized_df, ranges = list(decay = seq(from = 0.1, to = 0.5,by=0.1),
                                                    size = seq(from = 3, to = 10 ,by=1)))
summary(tuneobjAUD)
#- best parameters found for NNET:
#decay size
#0.4    3
nnetAUD <- nnet(AUD_numeric ~., data = AUDUSD_D_normalized_df, size = 3 , decay = 0.3)
summary(nnetAUD)
#Try another combi
nnetAUD2 <- nnet(AUD_numeric ~., data = AUDUSD_D_normalized_df, size = 4 , decay = 0.3)
summary(nnetAUD2)

# Run SPX500 regression
spxvariates <- SP500_D[,-1][-730,] # This line picks up the dataset omitting the 1st column 'closeBId' which is the y,
# and then ommits the last row of the dataset to match the same no. of elements of y and x
spxvariates_training <- SP500_D[,-1][1:472,]
objSPX <-tune(svm, y_SPX500_reg ~., data = spxvariates,
            ranges = list(gamma = 2^(-3:3), cost = 2^(1:4),type = "C-classification"))
SP500_D_normalized_df <- data.frame(SP500_numeric, scale(spxvariates_training))
tuneobjSP500 <-tune(nnet, SP500_numeric ~., data = SP500_D_normalized_df, ranges = list(decay = seq(from = 0.1, to = 0.5,by=0.1),
                                                          size = seq(from = 3, to = 10 ,by=1)))
summary(tuneobjSP500)

# Train on FULL dataset
svmfit_reg_spx500 <- svm(y_SPX500_reg ~ . , data = spxvariates, kernel = "radial",
                  cost = 50, gamma= 0.5, type = "C-classification", scale = TRUE)
```

```
print(svmfit_reg_spx500)
#Train on ONLY training data
svmfit_reg_spx500_training <- svm(y_SPX500_reg_training ~ . , data = spxvariates_training,
kernel = "radial",
                    cost = 5, gamma= 0.5, type = "C-classification", scale = TRUE)

print(svmfit_reg_spx500_training)
# best parameters:
 # decay size
#0.4    4
nnetSP500 <- nnet(SP500_numeric ~., data = SP500_D_normalized_df, size = 4 , decay = 0.4)
summary(nnetSP500)

#Run basic Linear regression
linear <- lm(TrainingOutput_D$closeChange ~ ., data = GBPUSD_D)
summary(linear)

#AUD Linear Reg
linearAUD <- lm(TrainingOutput_D$AUDUSD ~ ., data = AUDUSD_D)
summary(linearAUD)

plot(TrainingOutput_D$closeChange, GBPUSD_D$highChange)
lines(TrainingOutput_D$closeChange, GBPUSD_D$rsiChange, type = 'l')
lines(TrainingOutput_D$closeChange, GBPUSD_D$closeW.ema8, type = 'l')

#ggplot(data = GBPUSD_D, aes(x=GBPUSD_D$closeChange),
#scale_colour_manual(values=c("black", "orange"))
  #                    ) + geom_line(aes(y= GBPUSD_D$rsiChange, colour = rsiChange))
#+ geom_line(aes(y= GBPUSD_D$LowChange, colour = LowChange ))

beta <- drop(t(svmfit$coefs) %*% x[svmfit$index, ])
beta0 <- svmfit$rho

# Try prediction
# RESULT : 138 out of 258 records correctly classified, 53.4% !!

GBPUSD_D_TestData <- data.frame(read.csv("/Users/Shuvadip_Barcap/Documents/MSc-
Stat/Stat-R-codes/Research Data/GBPUSD_D_SVMTestGrid2.csv", header= TRUE))
pred <- predict(svmfit,newdata = GBPUSD_D_TestData)
pred_samedata <- predict(svmfit,newdata = GBPUSD_D)
pred_reg <- predict(svmfit_reg,newdata = GBPUSD_D)
summary(pred)
```

```
summary(pred_reg)

# SPX500 Testing
SPX500_D_TestData <- SP500_D[,-1][472:730,] # Picking the rows
#pred <- predict(svmfit_reg_spx500,newdata = SPX500_D_TestData)
pred_spx500reg <- predict(svmfit_reg_spx500,newdata = SPX500_D_TestData)
pred_spx500reg_test <- predict(svmfit_reg_spx500_training,newdata =
scale(SPX500_D_TestData))

#AUDUSD prediction
AUDUSD_D_TestData <- data.frame(read.csv("/Users/Shuvadip_Barcap/Documents/MSc-
Stat/Stat-R-codes/Research Data/AUDUSD_D_SVMTestGrid2.csv", header= TRUE))
predAUDUSD_reg <- predict(svmfitAUD_reg,newdata = AUDUSD_D_TestData)
summary(predAUDUSD_reg)
#NNEt AUDUSD prediction using a 16-3-1 network & 16-4-1 , Use NORMALIZED DATA explicitly
as Nnet doesn't normalize by default
predAUDUSD_nnet <- predict(nnetAUD,newdata = scale(AUDUSD_D_TestData))
predAUDUSD_nnet2 <- predict(nnetAUD2,newdata = scale(AUDUSD_D_TestData))
summary(predAUDUSD_nnet)
summary(predAUDUSD_nnet2)

#NNet SP500 prediction using 15-4-1 network
predSP500_nnet <- predict(nnetSP500,newdata = scale(SPX500_D_TestData))
summary(predSP500_nnet)

#Writing to Output file
#GBPUSD
write.table(pred, file = "/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-codes/Research
Data/Output_SVM_classification.csv", sep = ",")
write.table(pred_reg, file = "/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-
codes/Research Data/Output_SVM_regression3_normalized.csv", sep = ",")
#AUDUSD
write.table(predAUDUSD_reg, file = "/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-
codes/Research Data/OutputAUD_SVM_classification.csv", sep = ",")
write.table(predAUDUSD_nnet, file = "/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-
codes/Research Data/OutputAUD_NNET_classification.csv", sep = ",")
# Best prediction 173/258 records , 67%
write.table(predAUDUSD_nnet2, file = "/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-
codes/Research Data/OutputAUD_NNET_classification2.csv", sep = ",")
# About 50% classified correctly for SP500
write.table(predSP500_nnet, file = "/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-
codes/Research Data/OutputSP500_NNET_classification.csv", sep = ",")
```

```
# Plot the predicted vs Actual
#1) comparsion: Test dataset same as Training
#2) comparsion2: Diff datset Test vs Training
comparison <- data.frame(read.csv("/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-codes/Research Data/GBPUSD_D_SVMTraining3_Trend.csv", header= TRUE))
closechange < - comparison$CloseChange
comparison2 <- data.frame(read.csv("/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-codes/Research Data/ActualResult.csv", header= TRUE))
#summary(pred)
summary(pred_spx500reg)
summary(pred_spx500reg_test)
#Writing to Output file
#write.table(pred, file = "/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-codes/Research Data/Output_SVM_classification.csv", sep = ",")
write.table(pred_spx500reg, file = "/Users/Shuvadip_Barcap/Documents/MSc-Stat/Stat-R-codes/Research Data/Output_SVM_SPX500regression.csv", sep = ",")
```

ARIMA Modelling

```
library(tseries)

library(car)

library(forecast)

SP500Dataset<-data.frame(read.csv("\\\\UBSPROD.MSAD.UBS.NET\\userdata\\BASUSHU\\Home\\Documents\\MSc-Stat\\Datasets\\SPX500_USD_2013-17.csv", header= TRUE))

AUDUSDDataset<-data.frame(read.csv("\\\\UBSPROD.MSAD.UBS.NET\\userdata\\BASUSHU\\Home\\Documents\\MSc-Stat\\Datasets\\AUD_USD_2013-17.csv", header= TRUE))

GBPUSDDataset<-data.frame(read.csv("\\\\UBSPROD.MSAD.UBS.NET\\userdata\\BASUSHU\\Home\\Documents\\MSc-Stat\\Datasets\\GBP_USD_2013-17.csv", header= TRUE))

acf(SP500Dataset$closeBid)
```

```
acf(AUDUSDDataset$closeBid, lag.max = 55)
#Stationarity is achieved by differentiating once
closeSP500_diff <- diff(SP500Dataset$closeBid)
closeAUDUSD_diff <- diff(AUDUSDDataset$closeBid)
closeGBPUSD_diff <- diff(GBPUSDDataset$closeBid)

par(mfrow=c(2, 2))
plot(SP500Dataset$closeBid[1:472])
plot(close_diff[1:472])
# Significance found at 52 lag !
acf(closeAUDUSD_diff, lag.max = 55)
pacf(closeAUDUSD_diff, lag.max = 55)

acf(closeAUDUSD_diff[1:520], lag.max = 55)
pacf(closeAUDUSD_diff[1:520], lag.max = 55)
fitarimaSP500 <- arima(SP500Dataset$closeBid, order = c(29,1,0))
fitarimaGBPUSD <- arima(GBPUSDDataset$closeBid, order = c(22,1,0))
fitarimaAUDUSD <- arima(closeAUDUSD_diff, order = c(38,0))

par(mfrow=c(3, 2))
plot(density(SP500Dataset$closeBid))
plot(density(closeSP500_diff))
plot(density(AUDUSDDataset$closeBid))
plot(density(closeAUDUSD_diff))
plot(density(GBPUSDDataset$closeBid))
plot(density(closeGBPUSD_diff))
```

Try Prediction

predSP500=predict(fitarimaSP500 ,n.ahead=10)

write.table(predSP500, file = "\\\\UBSPROD.MSAD.UBS.NET\\userdata\\BASUSHU\\Home\\Documents\\MSc-Stat\\Outputs\\Output_ARIMA_SP500.csv", sep = ",")

APPENDIX - C

Test Data: Spot AUDUSD 2018 Daily

highChange	**LowChange**	**ema8-21**	**ema21-50**	**close-ema8**	**close-ema21**	**close-ema50**	**closeW-ema8**	**closeW-ema21**	**closeW-ema50**	**ema8-21-W**	**ema21-50-W**	**rsiChange**	**volume**	**macdHist**	**stochastic**
0.00196	0.0018	0.006630258	0.000603425	0.006987014	0.013617272	0.014220697	0.013481989	0.01331229	0.017429812	-0.000169699	0.004117522	1.971152903	3146	3.03E-05	-1.562742658
2.00E-05	0.0015	0.007018529	0.001312632	0.0058699	0.012888429	0.014201061	0.013481989	0.01331229	0.017429812	-0.000169699	0.004117522	0.46928815	-1932	-9.27E-05	-0.47720995
0.00217	0.0093	0.007537336	0.002079382	0.006852145	0.014389481	0.016468863	0.013481989	0.01331229	0.017429812	-0.000169699	0.004117522	2.361456901	78	-1.84E-05	1.23319125
0.0081	0.0203	0.007723012	0.002730306	0.005158335	0.012881346	0.015611653	0.013481989	0.01331229	0.017429812	-0.000169699	0.004117522	-0.576277482	1521	-0.000177836	0.969609751
-0.0002	-0.00082	0.007409388	0.003175391	0.002300927	0.009710315	0.012885705	0.014639324	0.016956627	0.021876878	0.002317302	0.004920251	-5.700761172	-3304	-0.000399675	-2.180621838
-0.0007	-0.00191	0.00681603	0.0034654	0.00047516	0.00729119	0.01075665	0.01463932	0.01695662	0.021876878	0.00231730	0.0049202	-4.111324	1562	-0.0004	-6.12229

8			63	5	5	8	4	7		2	51	253		89196	8505
0.00024	6.00E-05	0.06512221	0.03806237	0.01870684	0.08382905	0.012189142	0.014639324	0.016956627	0.021876878	0.02317302	0.04920251	2.218840115	5130	-0.00029150 1	-5.415595588
0.00273	0.0282	0.06815846	0.04346196	0.05304977	0.012120823	0.016467019	0.014639324	0.016956627	0.021876878	0.02317302	0.04920251	4.830914337	-873	3.82E-05	1.593084384
0.00303	0.00118	0.07201423	0.04923803	0.05953871	0.013155293	0.018079097	0.014639324	0.016956627	0.021876878	0.02317302	0.04920251	1.932346978	1483	7.47E-05	5.639901644
0.00538	0.00506	0.07978569	0.05666637	0.08480788	0.016459358	0.022125995	0.01744503	0.022496934	0.028503471	0.05051903	0.06006537	3.479491145	508	0.00025708 8	4.79996367
-0.00036	0.0038	0.08284156	0.0626269	0.06106169	0.014390325	0.020653015	0.01744503	0.022496934	0.028503471	0.05051903	0.06006537	-1.523036299	-3805	-1.20E-06	-0.633980873
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		54777	39525		5918	95442	61887	8979	4052	7092	5073	9		7	3
0.00245	0.00432	-0.003644493	-0.005650633	0.002939113	-0.00070538	-0.006356013	-0.00459245	-0.015126344	-0.025752912	-0.010567099	-0.010626568	3.178872971	-4280	0.000568456	12.94604213
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0.0024	0.00131	-0.0	-0.0	-0.0	-0.0	-0.01	-0.0	-0.02	-0.03	-0.01	-0.01	3.71150	279	0.0002	5.52066

3		05063357	06807058	01938068	07001424	3808482	07189401	0666126	6566358	3476724	5900233	9986		46952	2053
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