FINDING THE IDENTICAL TWIN

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ABSTRACT

In this paper we examine correlation and mean reverting behavior of Dow Jones Industrial Average, with ten stock markets from Asia, Europe and America. Along with correlation test, Augmented Dickey Fuller Test is conducted to test the mean reverting behavior of time series. We found that all the markets are positively correlated with DJIA. We also confirm that high degree of correlation does not result in mean reversion between two time series.

KEYWORDS: Mean Reversion, Correlation, Pairs Trading, Stock Market, World Market, Portfolio Management, Stock Investing, ADF Test, Augmented Dickey Fuller Test, Time Series

Introduction:

Today in the era of globalization action of one economy has impact on the financial markets of other economy. The markets for goods and services have become internationalized through various trade promotional measures of various countries. Migration of labor and the trans-location of production and distribution operations in other countries is a common phenomenon.

Similarly, the market for common stock investment internationally has become very popular.

Institutional and individual investors have started diversifying their investments in the stocks of other countries to enhance the chance of superior returns. BRICS countries are the best examples of investing in growth stories during last decade. The availability of instruments like ADRs and GDRs have made it easier for investors to trade international stocks in their own country, in their own time and in their own currency. The prices of stocks in the markets around the world do not move together synchronously because the economic systems in which the markets are located have dissimilar environments in the terms of taxation, industrial growth, monitory policy, political stability and other economic factors. Low-level of co-movement of stock prices offer the investors' benefit of diversifying their holdings across the various markets located in different economies. On the other hand synchronized price movement between markets can provide opportunity for pairs trading.

The purpose of this study is to find them statistically synchronized market with US. World markets are integrated to a large extent today. Most of the times movement in one market spills over to the other markets. The US stock market crash in 2008 resulted in collapse of almost all the markets across the world. Many researchers have studied the correlation between world markets and have found positive relationship to be present. Majority of such studies have used correlation test which does not reflect the mean reverting behavior of two time series.

Carol Alexander[1] has rightly said *"Trying to model the complex inter-dependencies between financial with so restrictive concept of correlation is like trying to surf the internet with IBM AT"*. In this paper we study the correlation and mean reverting relationship of US market with other leading markets of the world by using Augmented Dickey Fuller Test.

Literature Review:

"Just like a drunk man leaving a bar follows a random walk. His dog also follows a random walk on its own. The path will diverge……Then they go into a park where dogs are not allowed to be untied. Therefore the drunk man puts a strap on his dog and both enter into the park. Now, they share common direction, their paths are co-integrated."(Murry, 1994)[7]

(Bharand Hamori, 2006)[10] studied the relationship between Japanese and Asian emerging equity markets. They studied the stock return characteristics for Japan and Asian emerging markets using monthly return to capture the change in mean-variance in a two state framework. An unobserved Markov process drives the evolution of the states. The approach allows both the mean and the variance to depend on the unobserved states and the model is estimated in one step. The propensity of any market to stay in a particular state is inferred from the estimated model parameters.

(Raju and Ghosh, 2004)[11] studied daily average returns and daily volatility across markets varying over time and space. The study found that some countries like US provide as high as 0.04 percentage return while some of the emerging markets such as Indonesia recorded negative returns of 0.01percentage. According to them, India is a bright spot. In the sample period Indian investors could obtain as high as 0.04 percentage return with a moderate volatility of 1.89 percent. It was interesting to note that the countries such as UK, France, Germany and Australia provided low return and high volatility (as compared to the US). There turns on portfolio of stocks (index) are more or less normally distributed. The study concluded that the emerging market countries like Indonesia, Brazil, and South Korea exhibited high intra-day volatility. Among these countries, Brazil had higher intra-day volatility. Compared to emerging market and some of the developed markets-India experienced low intra-day volatility.

(Sharma, 2011)[9] has found significant relationship between Asian markets and US. In the same study China was found to be the least positively co-related to US.

(Gatev et al, 2006)[5] examined a hedge fund trading strategy based on the notion of co-integrated prices in a reasonably efficient market. They could find pairs that could give robust profits. However they ruled out mean reversion as an explanation for pairs trading.

(Nath, 2003)[8] created a pairs trading strategy for the highly liquid US government debt securities secondary market. He could successfully profit from the short-lived mis-pricing of bonds.

(Chen et. al, 2010)[3] studied equity-based pairs trading strategy. They also found that a trading strategy based on stocks that deviate from their pairs generate a significant abnormal returns.

(Carol Alexander, Co-integration and asset allocation: A new active hedge fund strategy)[2] has defined co-integrations: Two time series x_t and y_t are co-integrated if, and only if, each is $I(1)$ and a linear combination $X_t - \alpha - \beta Y_t$, where $\beta_{1 \neq} 0$ is $I(0)$.

(Granger, 1988)[6] introduced the case $y_t = \alpha + \beta x_t + u_t$, where the individual time series are I(1) but the error term, u_t, is I(0). That is, the error term might be auto correlated but, because it is stationary, the relationship will keep returning to the equilibrium or long run equation $_t = \alpha + \beta x_t$.

(Herlemont, 2004)[4] proposed a novel approach to find the right pair of stocks or time series for pairs trading. He proposed to use Dickey-Fuller test for determining stationarity in the log ratio of two time series.

Materials and Methods

The study is conducted for the period of 2000 trading sessions ending on 30th October 2015.

This period is sufficient to examine the correlation and mean reversion as during the period many major events like depression, recession, boom, war and financial meltdown have taken place.

3000 trading days daily data of DJIA is tested for correlation and ADF statistics with FTSE 100, CAC 40, DAX, Shanghai Composite, Hang Sang, BSE30, Nikkei225, Straits Times, Bovespa and MerVel. The data has been collected from www.yahoo.com.

Methodology

The challenge in this methodology is identifying markets that tend to move together with DJIA and therefore make potential pairs. Our aim is to identify the market with mean reverting relative prices. To find out if two markets are mean reverting the test conducted is Dickey-Fuller test of the log ratio of the pair[4].

A Dickey-Fuller test for determining stationarity in the log-ratio $y_t = log A_t - log B_t$[4] of market prices A and B

$\Delta y_t = \mu + \gamma y_{t-1} + \varepsilon_t$ [4], here we are regressing Δy_t on lagged values of y_t.

The null hypothesis is that $\gamma = 0$, which means that the process is not mean reverting. The more negative the ADF statistic value and lesser is the p-value more chance that it is stationery. A p-value of 0.01 means that there is 1% chance that stationarity of a process cannot be rejected.

By calculating the ADF statistic of DJIA with other world markets, we will know the most stationery time series with it. The market with the most negative ADF value with DJIA will be closest mean reverting time series.

The correlation test is calculated as follows:

$$\rho = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}}.$$

The correlation of 1 means a perfectly positive correlation and correlation of -1 means perfectly negative correlation.

Results

	ADF Test Statistic	P Value	Correlation
FTSE100	-2.094	0.538	0.90
CAC40	-2.590	0.328	0.738
DAX	-3.262	0.077	0.784
Shanghai Composite	-0.979	0.942	0.530
Hang Sang	-0.578	0.978	0.648
BSE30	-2.140	0.518	0.413
Nikkei225	-2.45	0.386	0.664
Straits Times	-1.838	0.647	0.790
Bovespa	-2.026	0.567	0.328
MerVel	-3.211	0.086	0.541

Discussion (Findings)

a) The most negative ADF test statistics -3.262 is found with DJIA-DAX time series.

b) The highest degree of correlation 0.90 is found between DJIA-FTSE 100 time series followed by DJIA-Straits Times.

c) The lowest p-value 0.077 is found with DJIA-DAX time series followed by DJIA-MerVel time series. This signifies that there is 7.7% chance that DJIA-DAX is non-stationary or there is 92.30% chance of DJIA-DAX being mean reverting.

d) The second most negative ADF test statistics is found with DJIA-MerVel times eries.

e) All the markets are found to have positive correlation with DJIA.

f) The lowest degree of correlation is found between DJIA-Bovespa time series followed by BSE30.

g) The least mean reverting pattern is found to be present with DJIA-HangSang time series.

Conclusion

From the findings we conclude that all the markets tested in the study have positive correlation with DJIA. This signifies that the movement of DJIA will have positive impact on the world markets. Based on ADF test statistics we conclude that DAX and MerVel are the most closely associated with DJIA and they have mean reverting pattern present at more than 90% confidence interval. This makes them eligible for pairs trading, however careful consideration should be given as the required level of significance for pairs trading is 1%. We also conclude that high degree of correlation does not result in mean reverting pattern.

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