

University of Illinois at Urbana-Champaign

Econ 506: Applied Econometrics

Final Project

An Empirical Analysis of relationship between Stock Index  
Price and Economic Variables in United States

By

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## Abstract

In the macroeconomic theory, there is a strong link between stock price and economic activities. The purpose of this research is to find the economic variables which can effect stock price efficiently. The variables that are selected in this research are seasonally adjusted gross domestic product in US from 2005 to 2014 (GDP), U.S. Dollar Index, the inflation represented by Consumer Price Index, the Federal funds rate in United States and risky free rate represented by 3-month T-Bill. And Dow Jones U.S. Total market index (2005-2014) is selected as the stock index. The research contains multiple linear regression model, and after test of the model, the data proves that there exist strong relationship between these four variables and stock index during the period of steady economic development, but the link is unapparent during the economic crisis.

## Introduction

As a general knowledge, stock is a barometer of the economy. It is one of reflections for the development of economy. Many scientists have analyzed the relationship between stock price and economic variables. One of the most important purpose of these research is to do a better forecasting for the future economic development. In the real world, the change in stock price is impacted by many factors, the question is whether some variables are more important than others to stock market. As a general speaking, a country's gross domestic product has a high positive correlation with the country's stock market. It is proved that when the GDP is increasing steadily, the stock index will at a high level and increase constantly. On the other hand, the development of economy is cyclical, there are many different periods in on cycle. So the link between the economic variables and stock price is the same or different should be considered. One of the interesting phenomenon is that during the steady economic development period, the relationship between stock price and interest rate of bank is negative. However during and after the economic crisis, the relationship is positive, it means although government will produce policies to decrease the interest rate of bank, consumers do not want to invest because of the weaken economic environment. Therefore, it is meaningful to do some research to find the real relationship between some efficient variables and stock price in different periods.

In this paper, the research select US stock market and Dow Jones U.S. Total market index as sample. Because US stock market is the most developed stock market in the world, whether the size of the market or the number and species of the shares issued are the NO.1 in the world, it is sufficiently representative. And on the other hand, Dow Jones U.S. Total market index is the most extensive use and influential stock index in the world, it can reflect the change of stock

price promptly. The aim of this research is to explore the relationship between six variables (GDP, U.S. Dollar Index, the inflation represented by Consumer Price Index, the Federal funds rate in United States and risky free rate represented by 3-month T-Bill) and stock price in different periods.

### Literature review

Many researches have been done to explore the relationship between economic variables and stock price. The most popular model that used to analyzed the relationship between the variables and stock price is CAPM, which was explored by William Sharpe, John Lintner, Jack Treynor and Jan Mossin (1978). In this model market is the only factor that can impact the stock returns. Although CAPM is used widely, it is just a single-factor model and ignores many other factors. As time goes by, more and more researchers prefer multiple-model to do this research. Husain and Mahmood (2001) took a number of measures for economic liberalization, privatization, relaxation of foreign exchange controls, and in particular the opening of the stock markets to international investors. Their exploration helped developing countries to complete the management of stock price. In the research paper of Tangitprom (2001), the unemployment rate, the interest rate on government bonds and CPI are included. The result shows that except the unemployment rate, the other two macroeconomic variables can impact the stock return significantly.

GDP is one of most popular variables that many researchers prefer to consider. Banjeree (2005) analyzed leading indicators for the change of stock price in Euro area and concluded that “GDP

is the most important indicator over time”. Camba-Mendez (2001) used an automatic leading indicator model tested on France, Germany, Italy and the United Kingdom’s stock market. The result is that the GDP is strong link to the change of index in stock market.

Exchange rate is a controversial variables, there is debating over time. In the research of Franck and Young (1972), the result showed that there was no significant relationship between exchange rate and stock price dynamics. Rahman and Uddin (2009) supported Franck and Young (1972)’s opinion. In the examination, Bangladesh, India and Pakistan were selected as sample. And the result shows that in these three emerging Asia countries, there was no con-integrating relationship between stock prices and exchange rate. However Aggarwal (1981) stand on the other statement, according to the data analyzing for the exchange rate of US Dollar and US stock price, there exists a positive correlation. Nath and Samanta (2003) studied the dynamic relation between exchange rates and stock prices for India. Their empirical result suggested that the positive association between the stock market and the real exchange rate implies that the degree of exchange rate flexibility has a role to play in that relationship.

Interest rate is the first variable to be concerned. In the economic theory of Fisher (1930), the expected nominal interest rates on financial assets should have a linear one-to-one movement with expected inflation. Hasan (2008) suggests that higher interest rates can reduce the demand for equity instruments by increasing the demand for fixed income instruments.

According to the researches above, there are different results about the relationship between economic variables and stock index. In this paper, based on the data analyzing results, we will find the efficient variables that impact stock price in different periods.

### Data set

The data we use almost retrieved from FRED, Federal Reserve Bank of St. Louis ranging from 2005 to 2014. The model we choose is the multiple linear regressions showed below.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \varepsilon$$

Dependent variables:

Y: DJIA: Dow Jones Industrial Average quarterly data from 2005 to 2014.

Independent variables:

$X_1$ : GDP: Gross Domestic Product, Billions of Dollars, Quarterly for United States.

$X_2$ : FFR: Effective Federal Funds Rate, Percent, Quarterly for United States.

$X_3$ : CPI: Consumer Price Index: Total All Items for the United States

$X_4$ : USI: Trade Weighted U.S. Dollar Index: Major Currencies.

$X_5$ : DJIA\_LQ: Dow Jones Industrial Average quarterly data from last quarter.

$X_6$ : 3MTB: 3-Month Treasury Bill: Secondary Market Rate.

$\varepsilon$ : Error terms that assume to be identical and independent with normal distribution.

## Summary statistics

The R studio has run the OLS regression and the result is showed below.

lm(formula = DJIA ~ GDP + FFR + CPI + USI + DJIA_LQ + X3MTB, data = DATA)				
Residuals:				
Min	1Q	Median	3Q	Max
-1146.39	-276.58	2.04	369.10	784.21
(Intercept)	2.191e+04	1.054e+04	2.078	0.046105 *
GDP	3.037e+00	7.983e-01	3.804	0.000627 ***
FFR	-1.286e+03	5.121e+02	-2.512	0.017427 *
CPI	-5.123e+04	1.847e+04	-2.774	0.009290 **
USI	-1.440e+02	4.065e+01	-3.544	0.001274 **
DJIA_LQ	5.302e-01	1.205e-01	4.399	0.000119 ***
X3MTB	1.574e+03	5.417e+02	2.905	0.006710 **
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				
Residual standard error: 500.8 on 31 degrees of freedom				

Multiple R-squared: 0.9568

Adjusted R-squared: 0.9484

F-statistic: 114.4 on 6 and 31 DF, p-value: < 2.2e-16

Full model

Estimated coefficients of each independent variable are added in the model based on the result from R studio. The numbers in the brackets are standard error.

$$Y = 21910 + 3.037X_1 - 1286X_2 - 51230X_3 - 144X_4 + 0.5302X_5 + 1574X_6 + \varepsilon$$

(10540)    (0.7983)    (512.1)    (18470)    (40.65)    (0.1205)    (541.7)

Y: DJIA,  $X_1$ : GDP,  $X_2$ : FFR,  $X_3$ : CPI,  $X_4$ : USI,  $X_5$ : DJIA\_LQ,  $X_6$ : 3MTB,  $\varepsilon$ : Error terms

The result shows that all the independent variables are significant, which means that null hypothesis has been rejected that  $\beta=0$  based on t-test.

Also, F-test shows significant result, which means that the full model is better than the reduced model that only contains intercept.

And,  $R^2=0.9568$  means that nearly 96% variation of Dow Jones Industrial Average can be explained by the variables chosen by this model.

### Test for the model

#### 1. Anova test



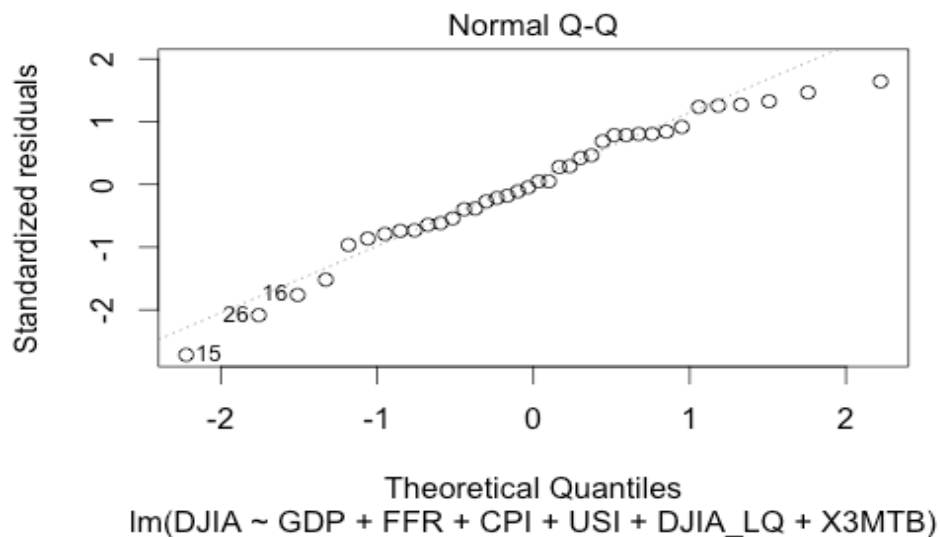
This is exactly the same method that R studio uses to run the F-test, since all the variables are significant, none of them should be deleted. So reduced model only contains intercept, which  $Y=\beta_0$ . Run the anova test and result is below, the result is the same with the F-test showed in the summary of OLS produced by R studio.

Analysis of Variance Table					
Model 1: DJIA ~ 1					
Model 2: DJIA ~ GDP + FFR + CPI + USI + DJIA_LQ + X3MTB					
Res.Df	RSS	Df	Sum of Sq	F	Pr(>F)
1	37	179925333			
2	31	7773559	6 172151774	114.42	< 2.2e-16 ***
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

## 2. Normality of error

Since the assumption that error should follow normal distribution with constant variance, test should be applied to check whether residuals met these assumptions, otherwise, result computed by this model should not be correct.

First, the Normal Q-Q plot is applied to check normality of error, which can be obtained from R studio. Y-axe is standardized residuals and X-axe is quintile of standard normal distribution. If the residual meet the assumption of normality, the plot will be basically on the same line. These residuals are roughly normal distributed based on the graph showed below. Preliminary conclusion can be made that this model don't have problem with non-normality.



Then, Jarque–Bera test has been run to determine whether error flows normal distribution, although JB-test works relatively well on testing large sample.

The Jarque–Bera test is a joint hypothesis test that check whether a sample's skewness and kurtosis matching a normal distribution. The test statistic is defined as

$$JB = \frac{n}{6} \left( S^2 + \frac{1}{4}(K - 3)^2 \right)$$

skewness	-0.499065313
kurtosis	0.004650481
JB	5.251391427
X2	5.99147

JB test can be run by R studio by certain package, the result is showed below. Since JB statistics is smaller then  $\chi^2$ , this means that null hypothesis has been rejected and conclusion can be made that error is normal distributed.

### 3. Autocorrelation

Durbin-Watson test

data: DJIA ~ GDP + FFR + CPI + USI + DJIA\_LQ + X3MTB

DW = 1.2554, p-value = 0.0004145

alternative hypothesis: true autocorrelation is greater than 0

R studio can run Durbin-White test. The result is showed below. According to the DW table, which n=38 and k=6, dL=0.966 and dU=1.658. Since dL<1.2554<dU, the DW test goes to

inconclusive during this area. Also,  $1.2554 < 4-dL$ , so the error terms are not negatively auto-correlated.

#### 4. Heteroskedasticity

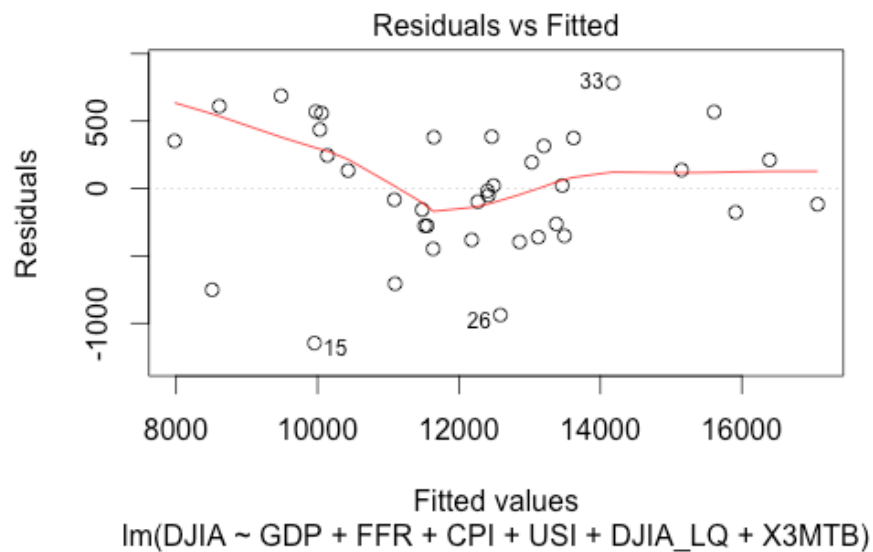
studentized Breusch-Pagan test

data: DJIA ~ GDP + FFR + CPI + USI + DJIA\_LQ +  
X3MTB

BP = 11.9598, df = 6, p-value = 0.06287

One the the most important assumption that OLS model made is that error should have constant variance. R studio run the Breusch–Pagan test to check whether error terms has problem with heteroskedasticity. Since the  $p\text{-value}=0.06287 > 0.05$ , this model doesn't have problem with non-constant variance.

Also, diagnostic plot can be obtained from R studio. Plot roughly line symmetrically on the two side of X-axle, except for some potential outliers, so assumption of constant variance of errors can be met in this model.



Prediction

Data have been gathered on 10/1/2014 of each independent variable. Plug these data into the model and compare the predicted data with historical data of DJIA. The error between predicted data and historical data is -2.139%, which is reasonably low and acceptable. So, this model is efficient and works relatively well during 2005 to 2014.

date	GDP	FFR	CPI	USI	DJIA_LQ	3MTB
10/1/14	17703.7	0.1	1.087038239	82.5939	16954.39	0.02

DJIA	Predicted DJIA
17344.8	16973.78

#### Limitation of this model

Although this model takes the financial crisis began in 2007 into consideration and works relatively well in prediction, however, if the time period expands to include Dot-com bubble began in 2000, this model doesn't perform very well if the data added to this model that begins from 1/1/2000. The R studio summary only shows significant in DJIA\_LQ, which means that Dow Jones Industrial Average only connected with its index from last quarter, another variables seem to be irrelevant to variation of DJIA.

Also, GDP data are only available on quarterly basis. That's the reason why this model only considers a population of 38. Improvement can be applied to this model that import price index can be a substitution of GDP, which are available to public monthly.

```
lm(formula = DJIA ~ GDP + FFR + CPI + USI + DJIA_LQ + X3MTB,
   data = Data1)
```

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	1.059e+03	4.186e+03	0.253	0.801
GDP	5.535e-01	4.117e-01	1.345	0.184
FFR	-4.790e+02	4.398e+02	-1.089	0.281
CPI	-8.466e+03	8.871e+03	-0.954	0.344
USI	5.882e+00	1.695e+01	0.347	0.730
DJIA_LQ	8.978e-01	8.402e-02	10.685	7.88e-15 ***
X3MTB	5.512e+02	4.837e+02	1.140	0.260
F-statistic: 119.8 on 6 and 53 DF, p-value: < 2.2e-16				

### Conclusions

This model tries to find potential relationship between stock index price and other economic variables during recent years including global Financial Crisis began in 2007, the full model is showed below.

$$Y = 21910 + 3.037X_1 - 1286X_2 - 51230X_3 - 144X_4 + 0.5302X_5 + 1574X_6 + \varepsilon$$

(10540) (0.7983) (512.1) (18470) (40.65) (0.1205) (541.7)

Y: DJIA,  $X_1$ : GDP,  $X_2$ : FFR,  $X_3$ : CPI,  $X_4$ : USI,  $X_5$ : DJIA\_LQ,  $X_6$ : 3MTB,  $\varepsilon$ : Error terms

Interpretation:

GDP and Dow Jones Industrial Index is positively related, a unit increase in GDP of United State results in DJIA increasing about 3.037 units.

If Federal Fund Rate increase 1%, the DJIA will approximately drop 12.86 units. This means that if bank raise interest rate, more money will be deposit in the banking system rather than investing in stock market.

Consumer Price Index results in dropping 512.3 of DJIA when it increases 1%.

U.S. Dollar Index is negative related with DJIA, approximate 144 drop in DJIA if U.S. Dollar Index increase one unit.

DJIA from last quarter is a good indicator to DJIA of this quarter, about 0.5302 increasing in this quarter if the data from last quarter increased 1 unit.

1% increase in 3-Month Treasury Bill will lead to 15.74 increasing in DJIA.



## Discussion

According to the multiple linear regression model, the results of the data analyzing of the relationship between stock index and the variables (GDP, FFR, CPI, USI, DJIA\_LQ and 3MTB) revealed that:

- All of the variables have a strong link with stock price. According to the t-test, the t-values' probability  $> [t]$  are 0.000627(GDP), 0.017427(FFR), 0.009290(CPI) and 0.001274(USI). All of the t-value are significant. So these four economic variables can impact the exchange of stock index efficiently.
- Seasonally adjusted GDP growth and the stock index from last quarter (t-1) are the most significant factors that can impact the change of stock index. And Federal Fund Rate (FFR) has the least influence on the stock index.
- Seasonally adjusted GDP growth and the stock index from last quarter (t-1) have positive relationship with stock index. And FFR, CPI and USI have negative relationship with stock index.
- During the steady economic development period, the relationship between the stock index and the economic variables is significant. However, during the economic crisis (Dot-com bubble began in 2000), the change of the stock index is only related to the index from last quarter.

Our empirical study on the US economic variables and Dow Jones Industrial Average shows that we can find the most influential sectors of the stock index. What's more, our analysis reveals the time frame of influence, i.e. we can find a number of quarters this influence continues.

The results support our hypothesis that GDP, FFR, CPI, USI, DJIA\_LQ and 3MTB are strong linked with the stock index. And the analyzing also provides additional useful information that the relationship is different in different economic development periods.

Based on the research, the results prove that stock index is one of the most important measure to predict the development of economy. The consumers and governments can forecast GDP changes from the stock index. More research has to be done to examine the relationship between stock market and economic variables, and more variables should be considered in the future research.

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