PROJECT REPORT

FE 541 – APPLIED STATISITCS

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1.   Title

A Study of relationship between Currency and Macroeconomic Indicators

2.   Team Members

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3.   Project Thesis:

Currencies are one of the most volatile commodities present worldwide. Currency movement are looked at by politicians, investors, and the general public worldwide as an indicator of the economic progress of a country.

Given the importance of currency movements, the ability to predict the movement of currency prices can be of considerable utility. The objective of our project is to test the relationship of key exchange rate drivers with currencies and check whether these rate drivers can be used to predict currency movements over time.

Exchange Rate Drivers

Economists generally consider the following factors as key exchange rate drivers:

1. Movement in interest rates
2. Movement in inflation; and
3. Movement in trade

In addition to the above, the following factors would also play an important role in currency movements as they affect the foreign exchange balance of countries:

4. Movement in GDP growth
5. Movement in Outstanding Debt

Relationship between exchange rate drivers and Currency

We would have all come across news headlines describing the sudden movement in currency prices due to any of the above factors. The objective of our project is to determine the nature of relationship between the above exchange rate drivers and currency movement and the time period over which the above factors have an impact on currency movements.

Given that currencies are very volatile and may not be stationery variables, our objective is not to predict daily currency price but to understand if these exchange rate drivers impact currency movement over longer periods say quarterly or yearly basis.

Currency in Focus – US Dollar

For the purpose of this project, we shall focus on US Dollar which can be considered as a stable currency given that it is the reserve currency of the word.

Generally currency prices are always measured with respect to other currencies and this poses a problem as a relative currency price may be affected by macroeconomic changes of either country and this would not show whether the macroeconomic changes of a particular country did impact the currency price.

In order to overcome this problem, we will be using the Bloomberg Dollar Spot Index (BBDXY). BBDXY tracks the performance of a basket of leading global currencies versus the U.S. dollar. Thus, we can measure the value of US Dollar in comparison to a wide range of currencies, thus reducing the impact of changes in other countries and increasing the impact of changes in US.

4.   Data Description:
Source: Bloomberg

In order to examine the relationships described above, we shall be using the Bloomberg Terminal to download information with respect to the each of the factors. We have described below the data we plan to use to conduct our analysis.

Factor (Bloomberg Key)	Description
Dollar Movement (BBDXY)	Movement of US Dollar value
Interest Rate (FDTR Index)	This captures the changes in the Fed base rates which reflect the interest rates in USA.
Inflation (CPI YoY Index)	We shall use the CPI Index as the measure of inflation
Public Debt (DEBPTOT Index)	This captures the movement in outstanding debt of USA
GDP Performance (GDP CURY Index)	This captures the movement in GDP performance of USA
Current Account Balance (USNCBAL Index)	This provides us information with respect to the currency balances and the changes in external trade of USA

With respect to the above factors, we downloaded quarterly and yearly data from 2004 to 2019. A key aspect we shall be paying regard to in our analysis is the manner of using the above factors in our analysis.

Inflation and GDP

With respect to inflation and GDP, we shall be analysing GDP growth rate/ inflation rate for the respective periods as well as percentage changes in GDP/ inflation as this may also have an impact on currency movement.

Public Debt and Current Account Balance

However, unlike GDP and inflation, for Public Debt and Current Account Balance, we shall be analysing only percentage change in Public Debt and Current Account Balance. This is because a currency price movement may not be determined by the amount of public debt// current account balance and rather by the percentage change in these factors.

Our goal is to understand if a certain percentage increase/ decrease in public debt and current account balance over the period has an impact on the currency movement over the quarter.

Interest Rates

Interest Rates are similar to GDP and inflation but however vary on a key aspect. The percentage of change in interest rate is determined by the Fed and thus is a much more stable variable. With respect to interest rates, we shall be analysing the interest rate prevailing over the period as well as based on change in interest rates during a period.

For this purpose, based on amount of increase in basis points the interest rate change shall be classified as follows:

Change in Basis Points	Category
Reduction of higher than 50 bp	-3
Reduction of 50 bp	-2
Reduction of 25 bp	-1
No change	0
Increase of 25 bp	1
Increase of 50 bp	2
Increase of higher than 50 bp	3

5.   Approach and Methodology

We plan to undertake the following steps in our analysis of the relationship between exchange rate drivers and US Dollar:

Steps	Particulars
Step 1	Study the distribution of each variable to understand the distribution of each variable
Step 2	Create Scatter plots between each predictor variable and US Dollar
Step 3	Compute the correlation coefficient between each variable and US Dollar
Step 4	Use linear regression to test the statistical importance of each variable in predicting US Dollar movement
Step 5	Use a stepwise linear regression model to identify which predictor variables create the most optimum model to predict currency prices
Step 6	Test the validity of the both the above models

We shall be conducting the above analysis for quarterly and yearly data to understand the time periods over which exchange rate drivers have impact on exchange rates.

6.   Data Analysis

6.1   Analysis of Distribution of all predictor and response variables
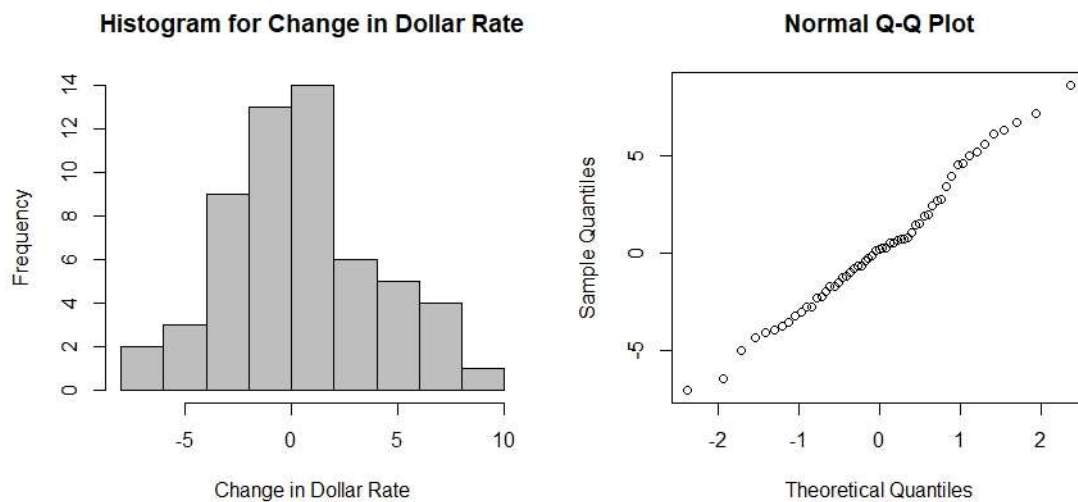
Distribution for Change in Dollar Price for Yearly data

Histogram for Change in Dollar Rate   **QQ Plot of Dollar Rate**
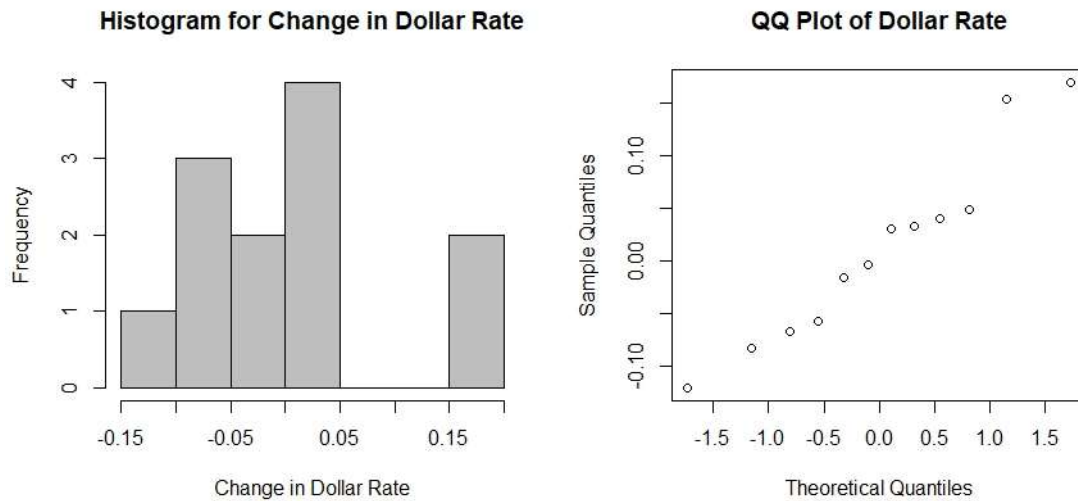
Comments

The histogram and qq-plot show that the distribution of dollar movement is not normal and slightly right skewed.

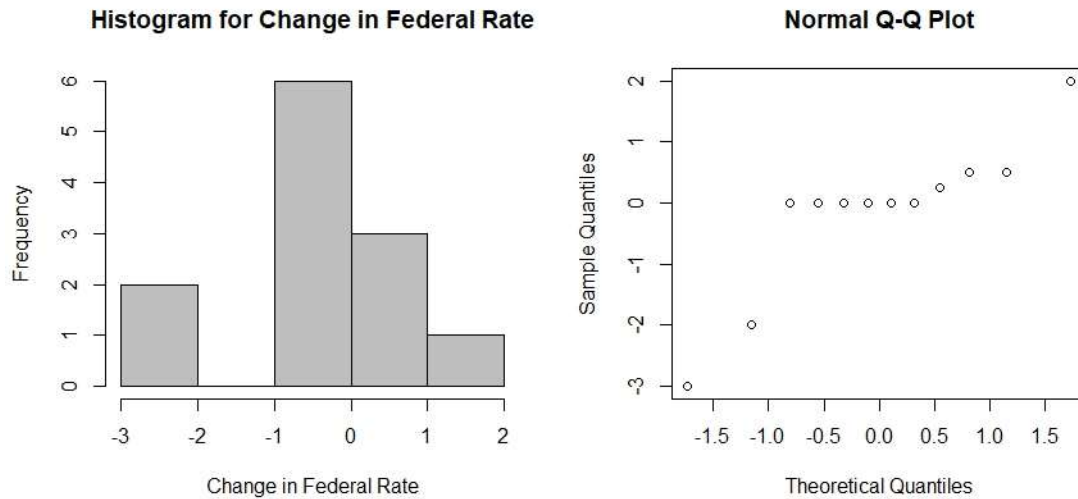*Distribution for Change in Dollar Price for Quarterly data*

Histogram for Change in Dollar Rate   **Normal Q-Q Plot**

Comments

The histogram and qq-plot show that the distribution of dollar movement is normal. Quarterly data has more data points and this increase in data points seems to create a normal distribution in change in dollar price around 0%.
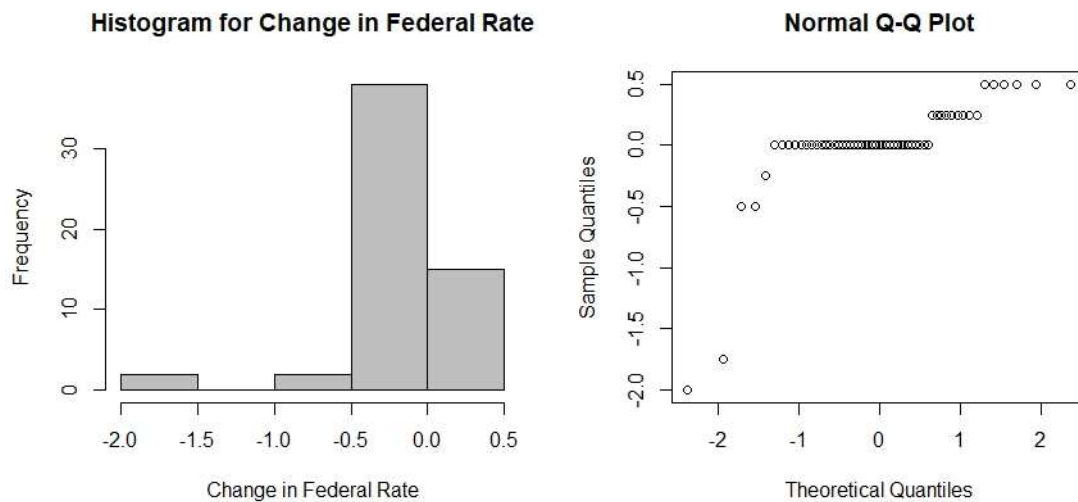
Distribution for Change in Federal Rate for Yearly Data

Histogram for Change in Federal Rate

Normal Q-Q Plot

Comments

The histogram shows that the distribution not normal. The qq-norm also clearly indicates that the distribution is not normal.

Distribution for Change in Federal Rate for Quarterly Data

Histogram for Change in Federal Rate

Normal Q-Q Plot

Comments

Similarly, the histogram shows that the distribution not normal and heavy tailed. The qq-norm also clearly indicates that the distribution is not normal.

Distribution for Federal Rate for Yearly Data

Histogram for Federal Rate
Normal Q-Q Plot
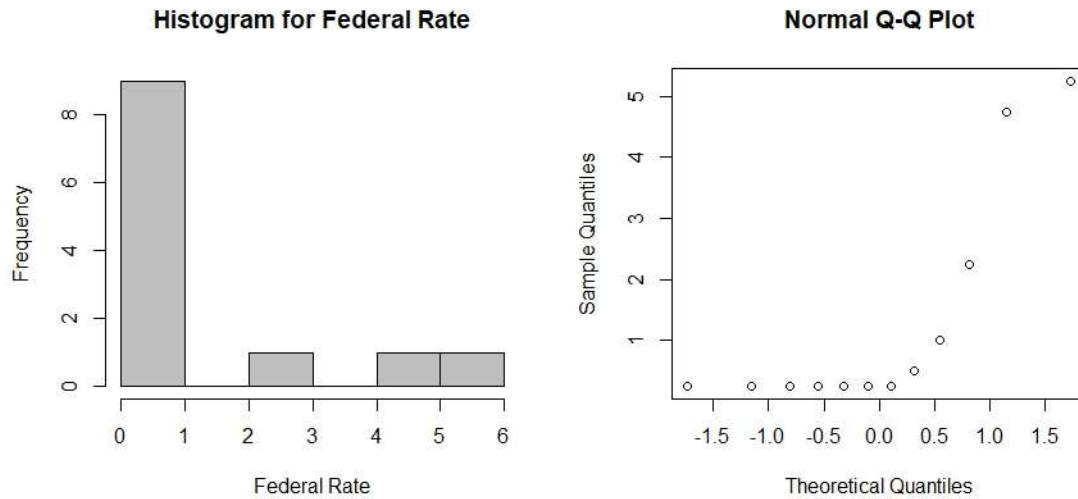
Comments

The distribution of Federal Rate yearly data is heavily right skewed. Further, analysis show that the Federal Rate during the years post the recession were maintained at zero and this is the reason for the skewness.

We believe that these instances may be normal in forthcoming years given the fears of recession and therefore, we believe that this data should be included in our analysis.
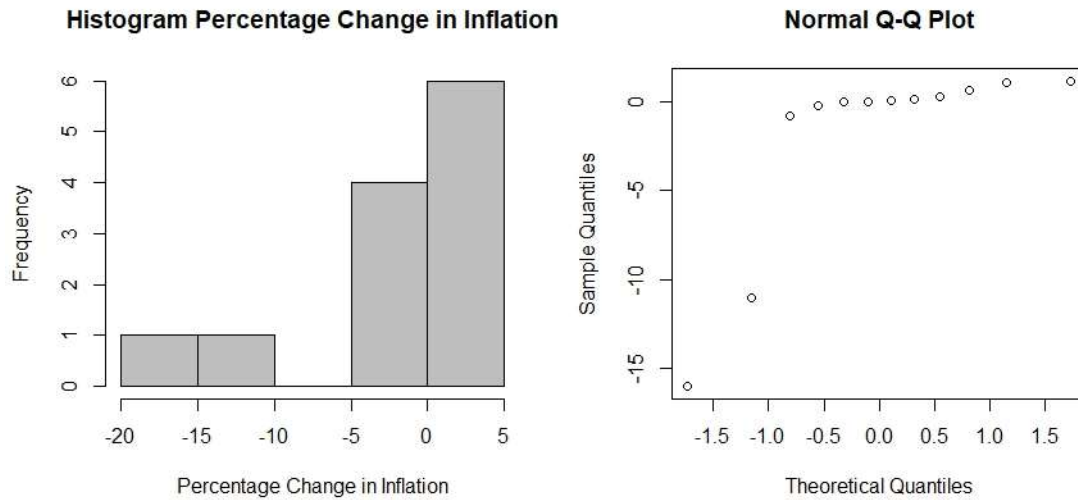
Distribution for Federal Rate for Quarterly Data

Histogram for Federal Rate
Normal Q-Q Plot
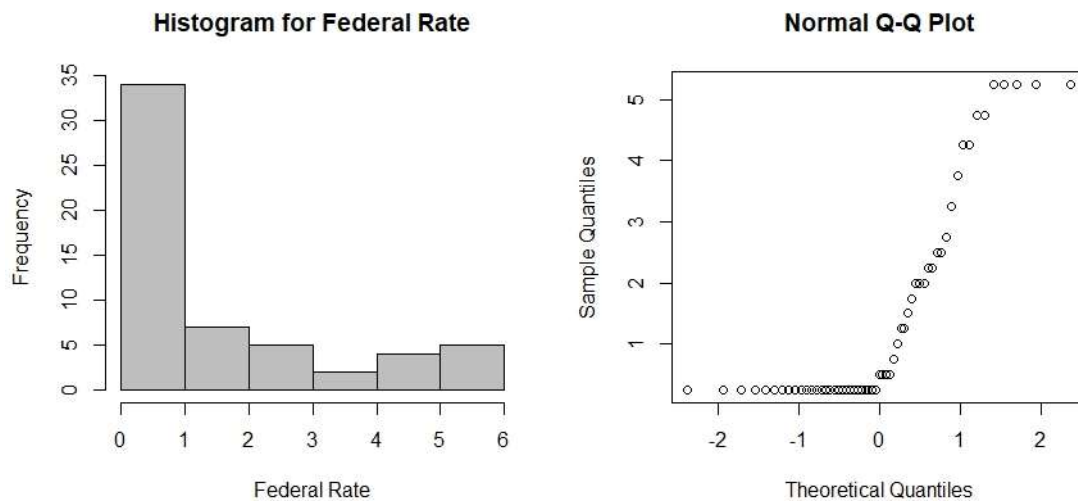
Comments

The data is similar to yearly data and we refer to our comments above.

Distribution for Percentage Change in Inflation for Yearly Data

Histogram Percentage Change in Inflation

Normal Q-Q Plot

Comments

The histogram and qq-plot show that the Change in Inflation yearly data is heavily left skewed. This shows that generally there exists a positive change in inflation which is consistent with the general understanding of behaviour of inflation

Distribution for Percentage Change in Inflation for Quarterly Data

Histogram Percentage Change in Inflation
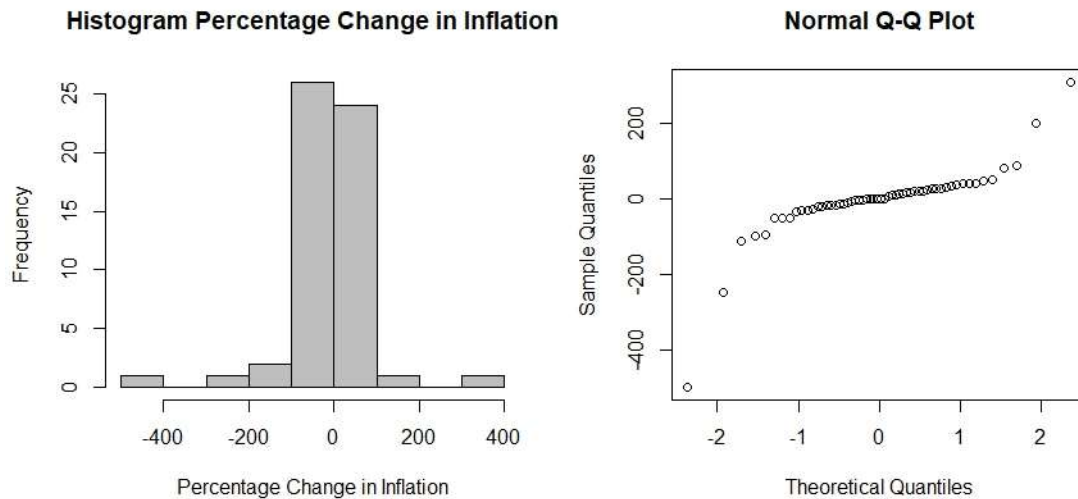
Normal Q-Q Plot

Comments

The histogram and qq-plot show that the Change in Inflation quarterly data is slightly normal with a high peak around a mean of 0%. This shows that there a number of ups and down in quarterly inflation data but it stabilizes on a yearly basis.

Distribution for Inflation rate for Yearly Data

Histogram for Inflation
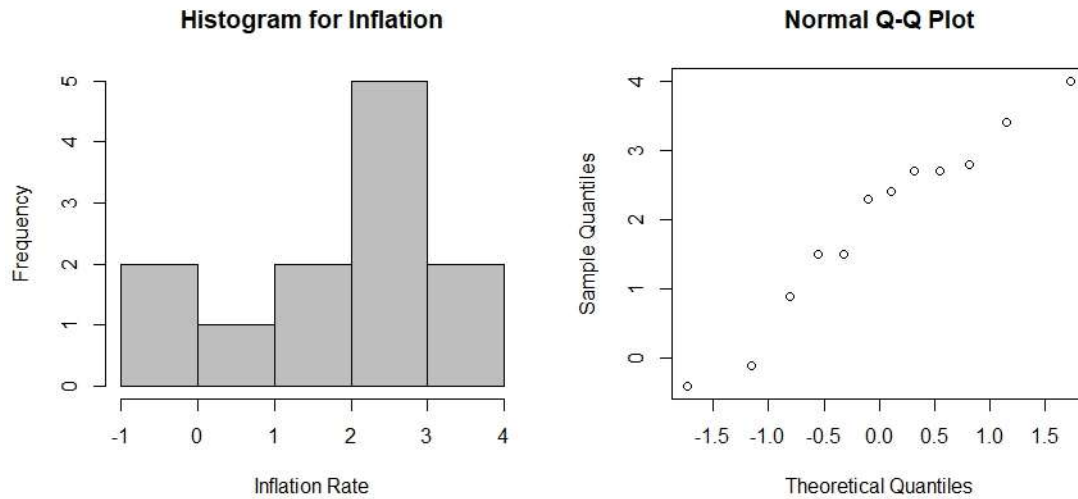
Normal Q-Q Plot

Comments

The histogram shows that inflation rate is generally concentrated around 2-3% which is the expected level of inflation in USA. The qq-plot shows the inflation data is approximately normal.
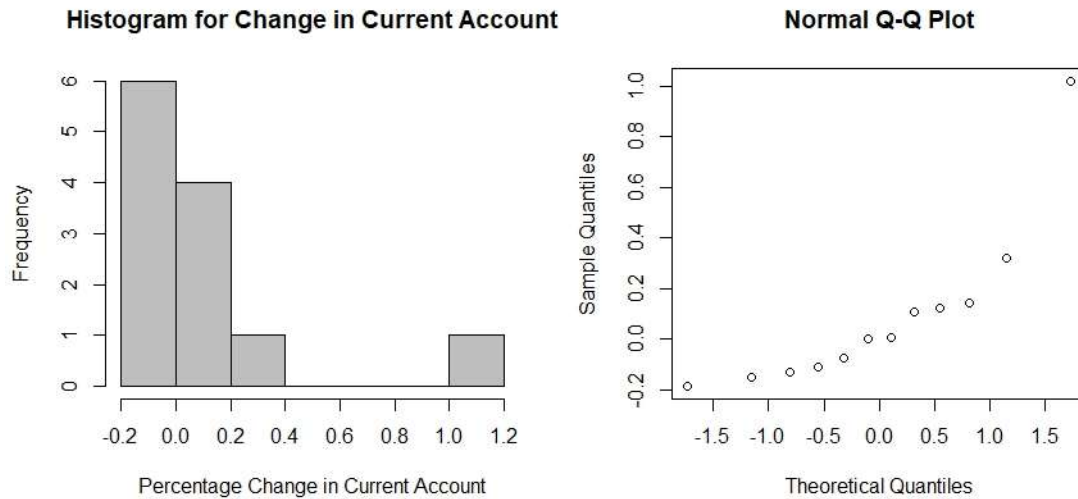
Distribution for Inflation rate for Quarterly Data

Histogram for Inflation Rate

Normal Q-Q Plot
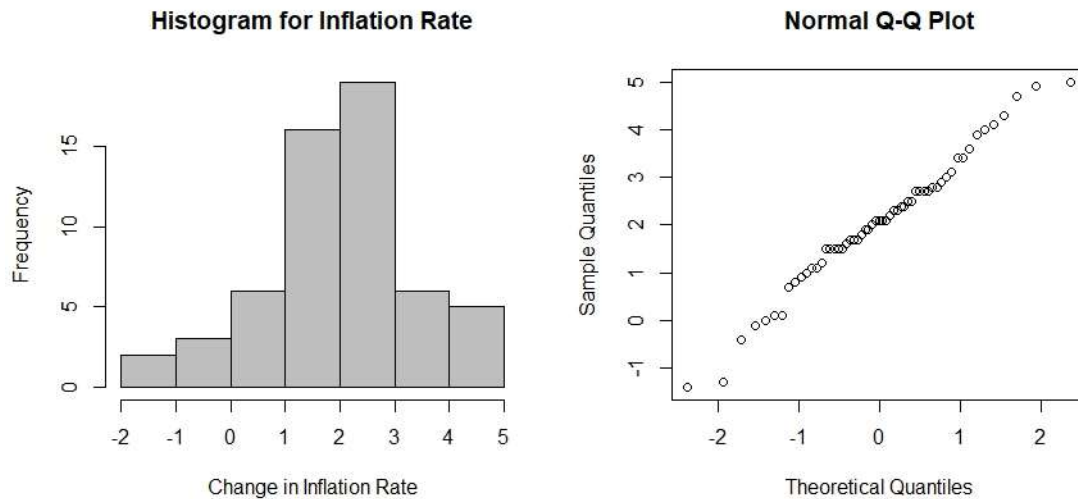
Comments

Same Comments as yearly data.

Distribution for Percentage Change in Current Account for Yearly Data

Histogram for Change in Current Account

Normal Q-Q Plot

Comments

The histogram shows that current account balance change is generally concentrated around 0% with a heavy right skew which is also backed by the qq-plot.

Distribution for Percentage Change in Current Account for Quarterly Data

Histogram Change in Current Account

Normal Q-Q Plot
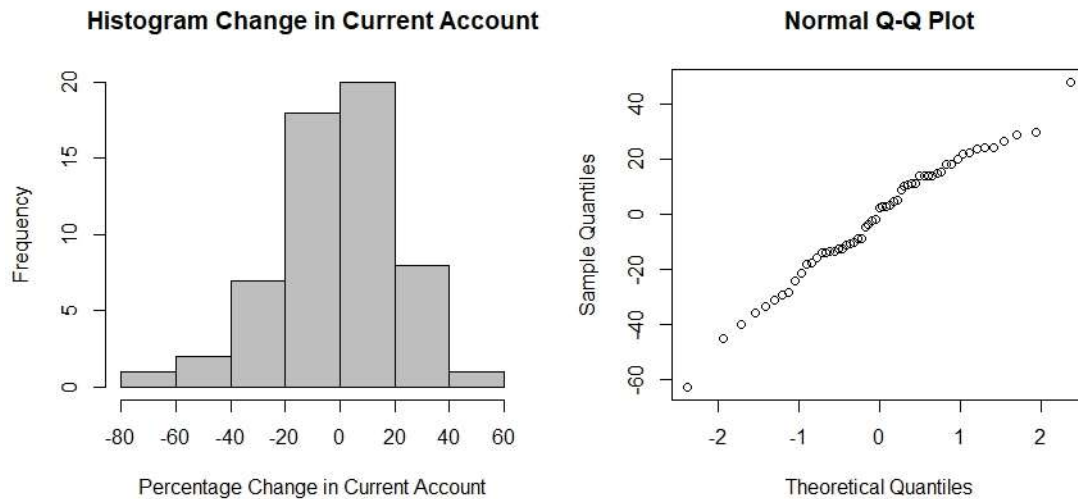
Comments

On quarterly basis the data is much more normal. Thus, quarterly changes seem to have more erratic ups and downs while stabilizing in the long term.

Distribution for Percentage Change in Public Debt – Yearly Rate

Histogram for Change in Public Debt

Normal Q-Q Plot
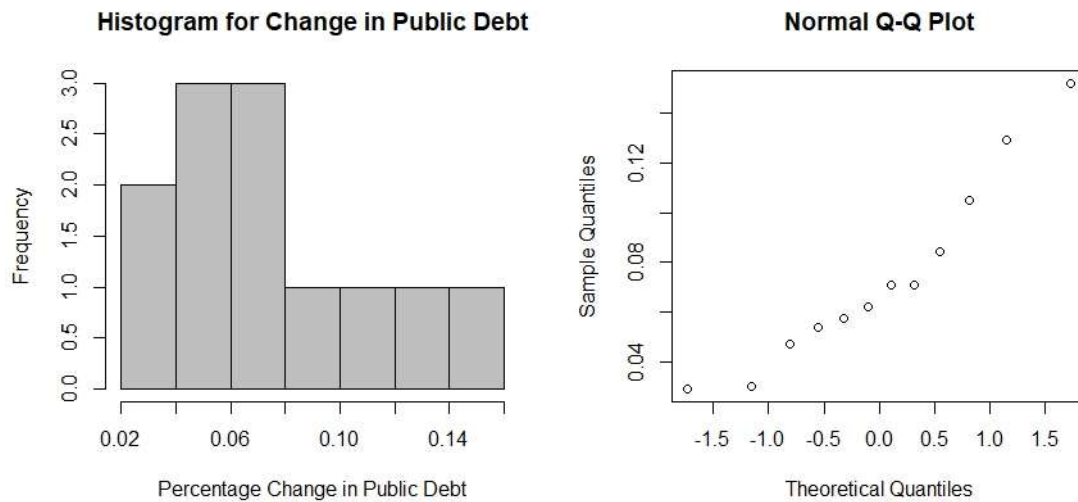
Comments

The percentage change in public debt seems to be slightly right skewed with most data being centred around 6% change.

Distribution for Percentage Change in Public Debt – Quarterly Data

Histogram for Change in Public Debt

Normal Q-Q Plot
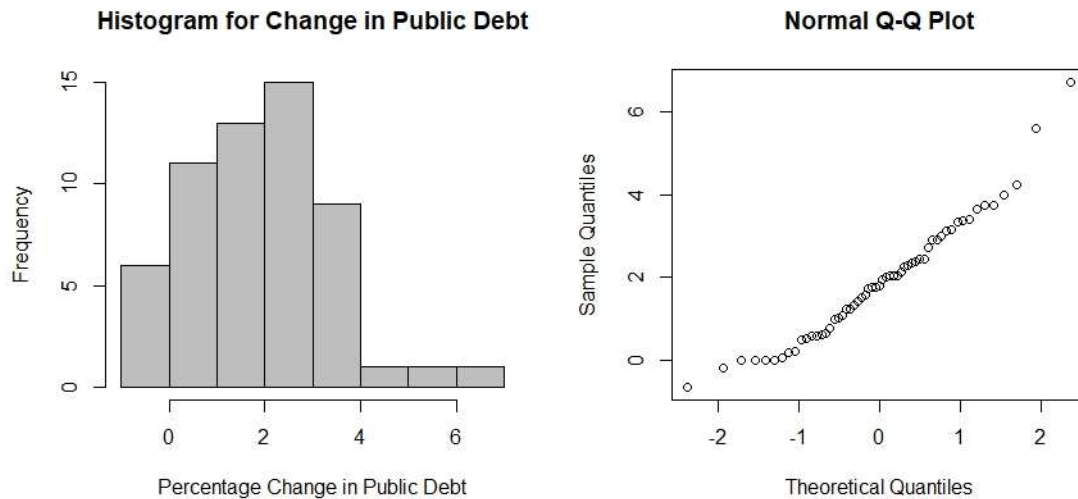
Comments

The percentage change in public debt on a quarterly basis again is slightly more normal compared to the yearly data. The change seems to be concentrated between -2 to 4 %

D*istribution for Percentage Change in GDP for yearly data*

Histogram for Percentage Change in GDP

Normal Q-Q Plot
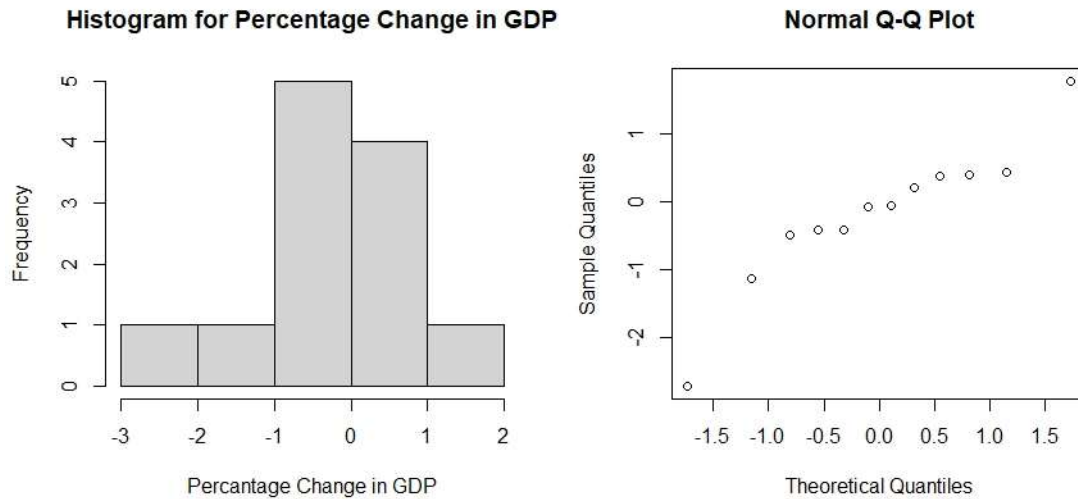
Comments

The percentage change in GDP on a yearly basis is concentrated around 0 % with a slightly normal distribution

Distribution for Percentage Change in GDP for quarterly data

Histogram for Percentage Change in GDP

Normal Q-Q Plot
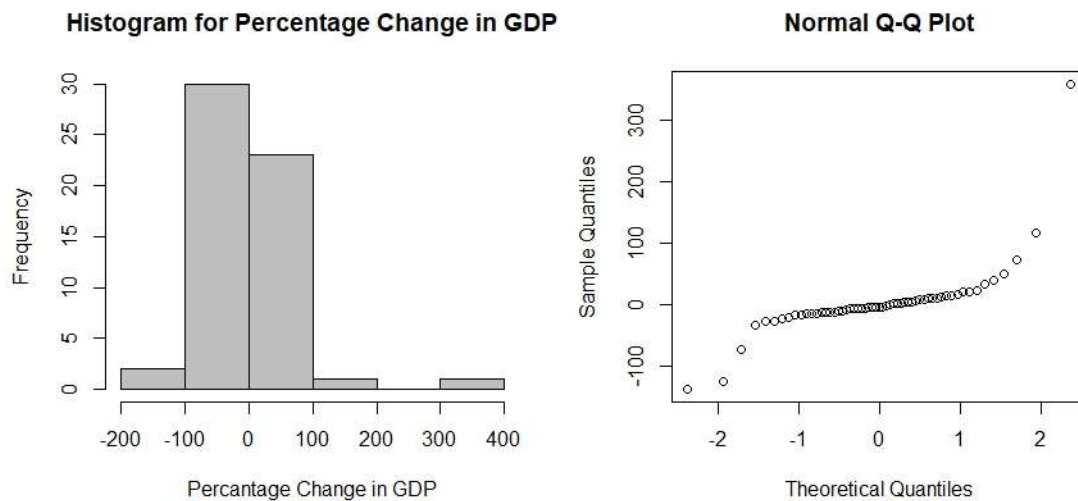
Comments

Quarterly data seems slightly more right skewed and the data has a lot of extreme values showing that between quarters there seem to be a lot of changes in GDP (may be due to seasonal factors)

Distribution for GDP for yearly data

Histogram for GDP

Normal Q-Q Plot
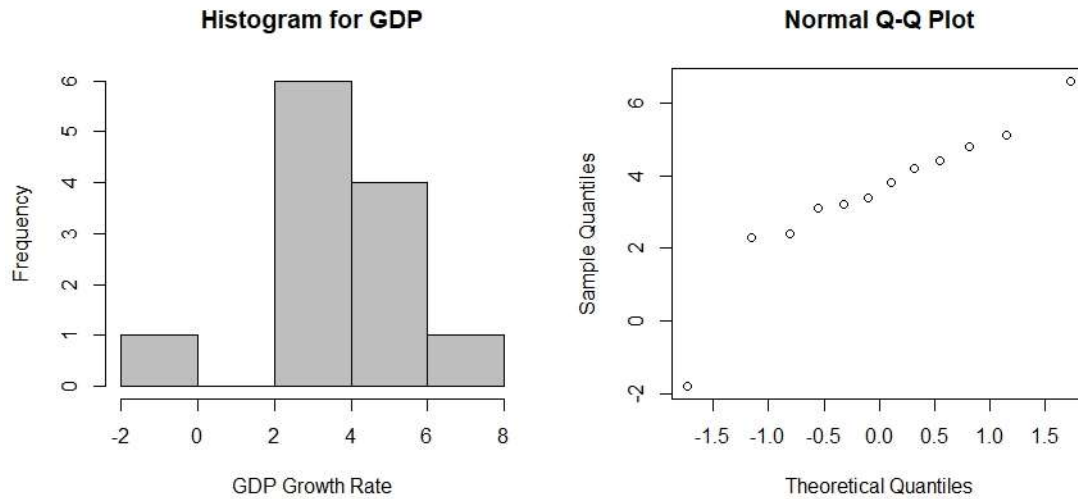
Comments

GDP Growth Rate is concentrated around 2 – 6% which shows that GDP is growing steadily and is consistent with expected values of GDP growth rate

Distribution for GDP for quarterly data

Histogram for GDP

Normal Q-Q Plot
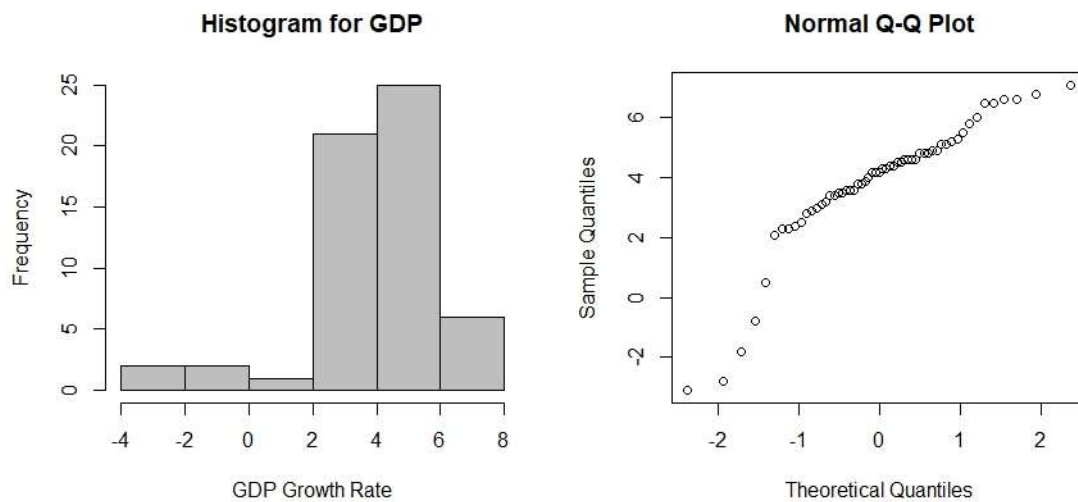
Comments

Same as for yearly data

6.2   Analysis of relationship of predictor variables with movement of Dollar value

Quarterly Data
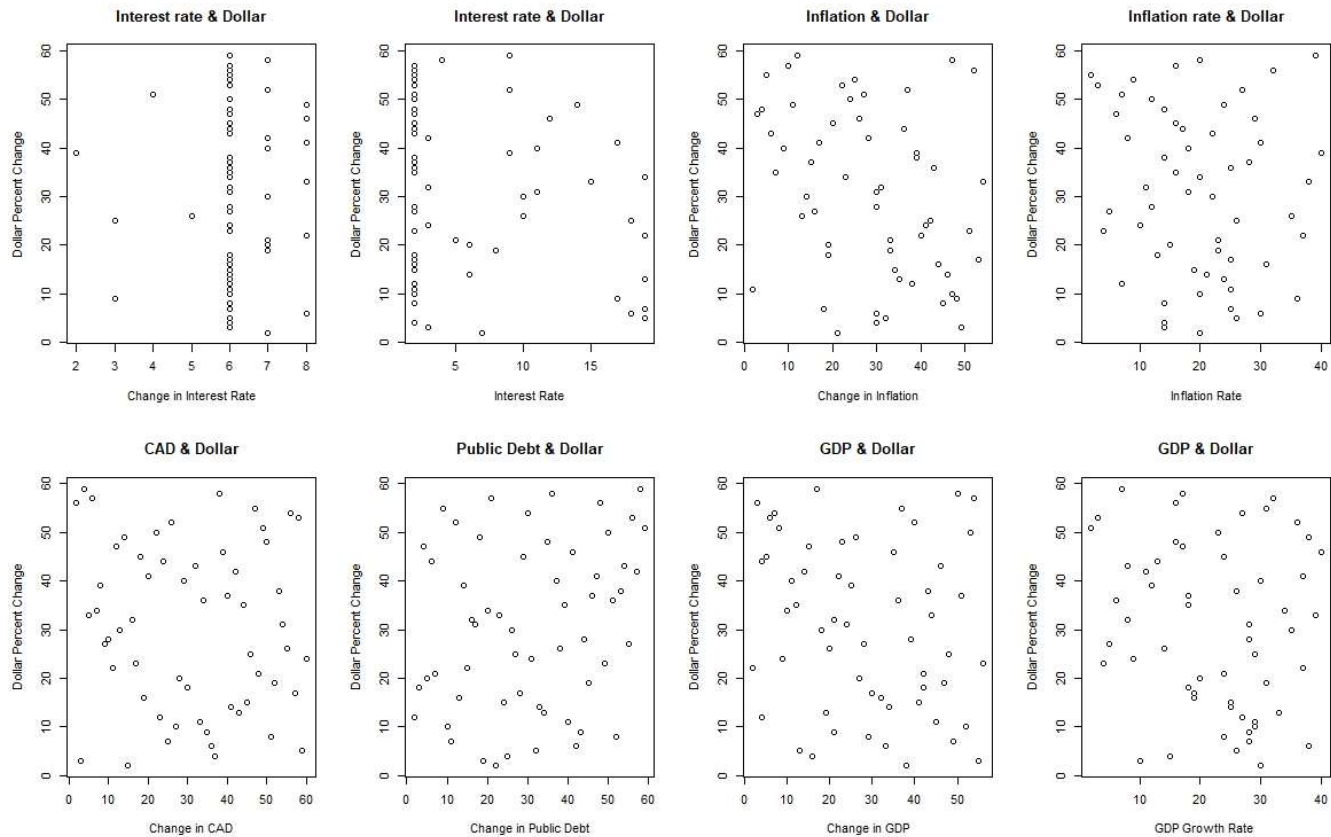
Comments

The scatterplots for quarterly data do not show any significant association or relation. There seems to be complete random distribution between the predictor variables and Dollar Value

Yearly Data

Interest rate & Dollar

Interest rate & Dollar

Inflation & Dollar

Inflation & Dollar

CAD Change & Dollar

Debt Change & Dollar

GDP & Dollar

GDP & Dollar
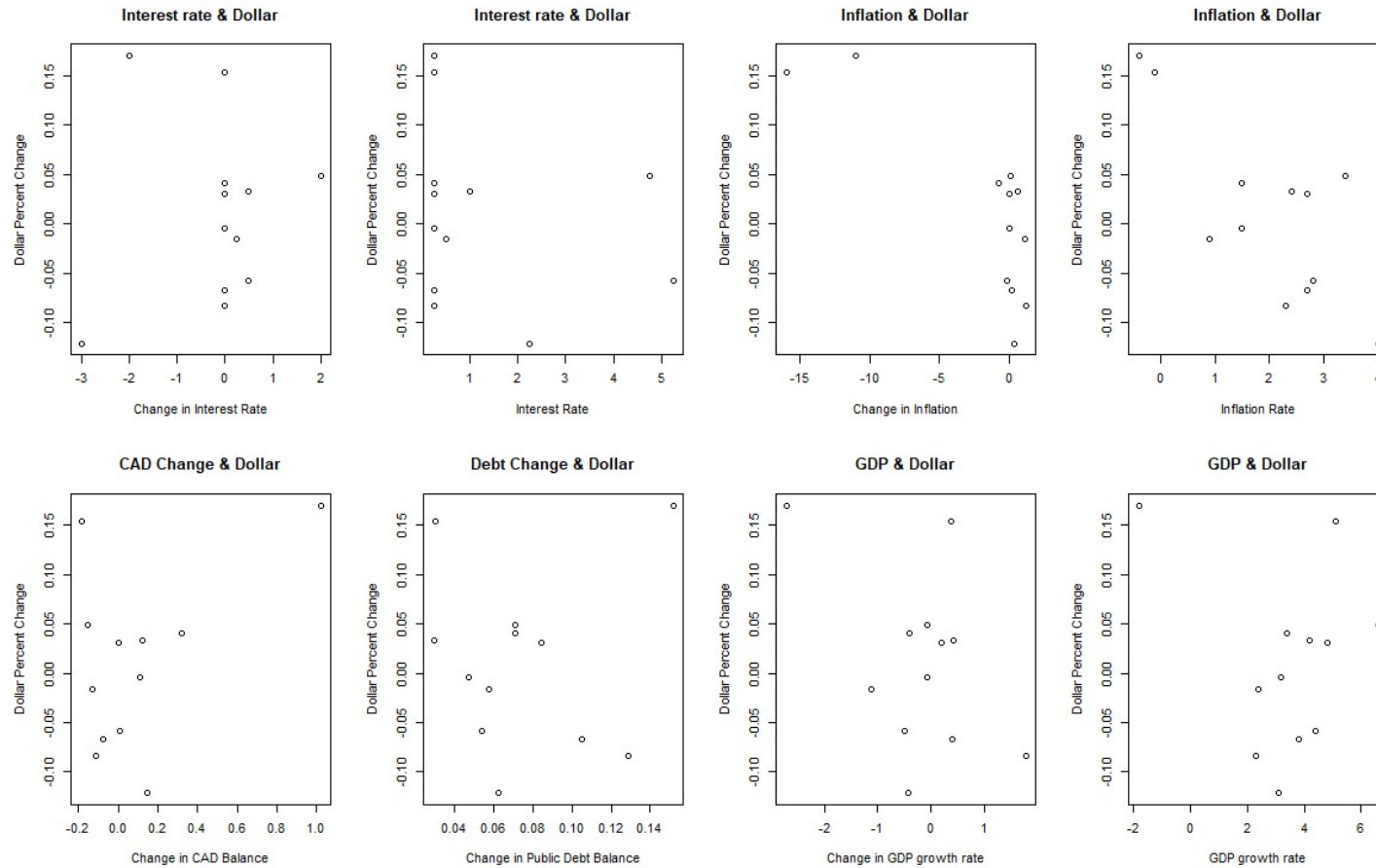
Comments

The scatterplots for yearly data are not randomly scattered like quarterly data but however, they also do not show any strong association or relationship between the predictor variables and Dollar Value.

6.3   Computation of Correlation Coefficient between predictor variables and dollar

Given the very poor results from our graphical analysis of the relationship between the predictor variables and dollar value, we shall compute the correlation coefficients between them to identify if there is any relationship

Yearly Data

	dollar.percent	FDTR.change	FDTR.year	CPI.percent	CPI.year	CAD.percent	debt.percent	GDP.percent	GDP.year
dollar.percent	1	-0.58	-0.04	-0.86	-0.79	0.57	-0.07	-0.61	-0.27
FDTR.change	-0.58	1	0.4	0.53	0.61	-0.87	-0.71	0.73	0.85
FDTR.year	-0.04	0.4	1	0.28	0.22	-0.08	-0.48	0.07	0.17
CPI.percent	-0.86	0.53	0.28	1	0.82	-0.31	-0.04	0.36	0.19
CPI.year	-0.79	0.61	0.22	0.82	1	-0.47	-0.04	0.67	0.51
CAD.percent	0.57	-0.87	-0.08	-0.31	-0.47	1	0.52	-0.77	-0.81
debt.percent	-0.07	-0.71	-0.48	-0.04	-0.04	0.52	1	-0.25	-0.72
GDP.percent	-0.61	0.73	0.07	0.36	0.67	-0.77	-0.25	1	0.7
GDP.year	-0.27	0.85	0.17	0.19	0.51	-0.81	-0.72	0.7	1

Comments
For yearly data, Inflation Rate, Change in Inflation Rate, change in GDP and interest rates show high negative correlation. While, change in current account balance shows positive correlation with dollar price movement

Quarterly Data

	dollar.quart.percent	FDTR.quart.change	FDTR.quart	CPI.quart.percent	CPI.quart	CAD.quart.percent	debt.quart.percent	GDP.quart.percent	GDP.quart
dollar.quart.percent	1	0.11	0.62	-0.1	0.33		-0.11	-0.34	0.5
FDTR.quart.change	0.11	1	-0.1	-0.53	0.21	-0.5	-0.1	0.11	0.25
FDTR.quart	0.62	-0.1	1	-0.44		-0.11	0.34	-0.63	0.63
CPI.quart.percent	-0.1	-0.53	-0.44	1	0.51	0.57		0.71	-0.12
CPI.quart	0.33	0.21		0.51	1		0.09	0.57	0.65
CAD.quart.percent		-0.5	-0.11	0.57		1	0.12	0.35	-0.37
debt.quart.percent	-0.11	-0.1	0.34		0.09	0.12	1	0.08	0.36
GDP.quart.percent	-0.34	0.11	-0.63	0.71	0.57	0.35	0.08	1	
GDP.quart	0.5	0.25	0.63	-0.12	0.65	-0.37	0.36		1

Comments
For quarterly data, only interest rates have strong correlation with dollar price movement

6.4   Full Linear Regression

We shall now use a Multiple Linear Regression model to understand which variables have statistical significance in predicting the movement of dollar and also observe the amount of variability of dollar movement that is explained by these predictor variables.

6.4.1   Creating the Linear Regression Model

Quarterly Data – Full Linear Regression

```
Console   Terminal ×
~/
Call:
lm(formula = dollar.quart.percent ~ ., data = quarterly.data)

Residuals:
    Min     1Q  Median     3Q     Max
-8.9325 -2.3970 -0.1146  2.0710  6.5925

Coefficients:
                     Estimate Std. Error t value Pr(>|t|)
(Intercept)        -3.0910502  1.5572943  -1.985   0.0529 .
FDTR.quart.change   1.0232636  1.2390933   0.826   0.4130
FDTR.quart         -0.7280592  0.3329521  -2.187   0.0337 *
CPI.quart.percent  -0.0106091  0.0055236  -1.921   0.0607 .
CPI.quart           0.4741763  0.4537284   1.045   0.3012
CAD.quart.percent  -0.0063518  0.0233944  -0.272   0.7872
debt.quart.percent  0.7703432  0.3906588   1.972   0.0544 .
GDP.quart.percent  -0.0006305  0.0084462  -0.075   0.9408
GDP.quart           0.5418651  0.3278028   1.653   0.1049
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 3.36 on 48 degrees of freedom
Multiple R-squared:   0.21,    Adjusted R-squared:  0.07834
F-statistic: 1.595 on 8 and 48 DF,  p-value: 0.1513
```

Comments

The full model for quarterly data shows that interest rates are the only significant variable in predicting dollar value. Further, the model gives a very low adjusted R-squared of 7.83%. This shows that these predictors explain only minimum movement in Dollar value

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Yearly Data – Full Linear Regression

```
Console  Terminal ×
~/ ⇗
Call:
lm(formula = dollar.percent ~ ., data = yearly.data)

Residuals:
2017-03-31 2016-03-31 2015-03-31 2014-03-31 2013-03-29 2012-03-30 2011-03-31 2010-03-31
 0.0086229  0.0125656 -0.0004599 -0.0099203 -0.0111694  0.0228636 -0.0467241  0.0149495
2009-03-31 2008-03-31 2007-03-30 2006-03-31
 0.0049557  0.0074617 -0.0207561  0.0176108

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.044567   0.081080  -0.550    0.621
FDTR.change  0.050230   0.038836   1.293    0.286
FDTR.year   -0.019787   0.016760  -1.181    0.323
CPI.percent -0.013700   0.009364  -1.463    0.240
CPI.year     0.019800   0.060669   0.326    0.766
CAD.percent  0.145159   0.083796   1.732    0.182
debt.percent -0.232553  0.732416  -0.318    0.772
GDP.percent -0.025884   0.024693  -1.048    0.372
GDP.year     0.005992   0.034758   0.172    0.874

Residual standard error: 0.03744 on 3 degrees of freedom
Multiple R-squared:  0.9518,   Adjusted R-squared:  0.8233
F-statistic: 7.408 on 8 and 3 DF,  p-value: 0.06359
```

Comments

The model shows that no variables are statistically significant in predicting the dollar rates. Yet, the model gives a high adjusted R-squared of 82.33% which is much better that quarterly data results.

This indicates that these predictor variables may be better predictors of dollar on the long term
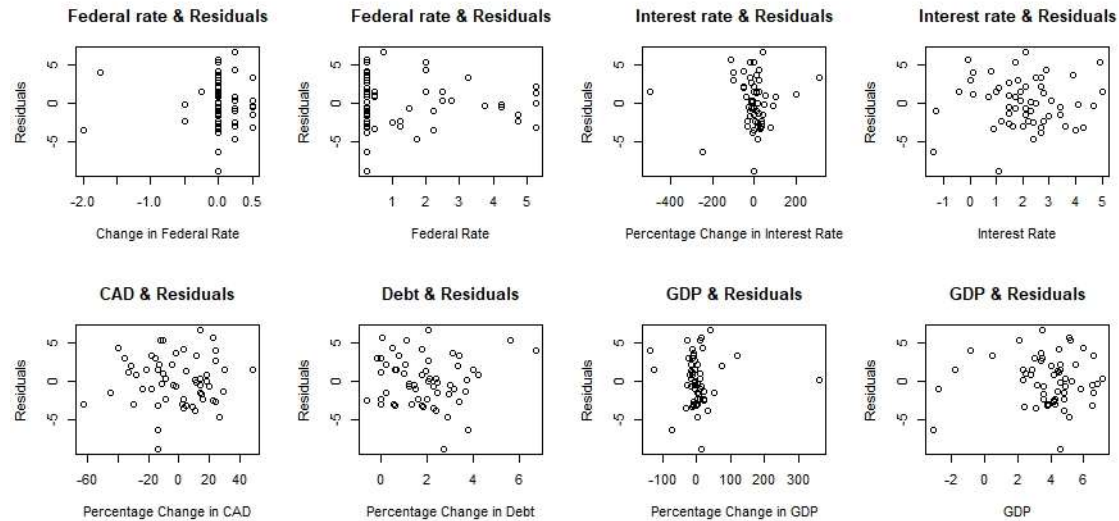
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6.4.2   Checking Model Validity

Prior to analysis of a regression model, we would need to ensure that the model validity is checked,
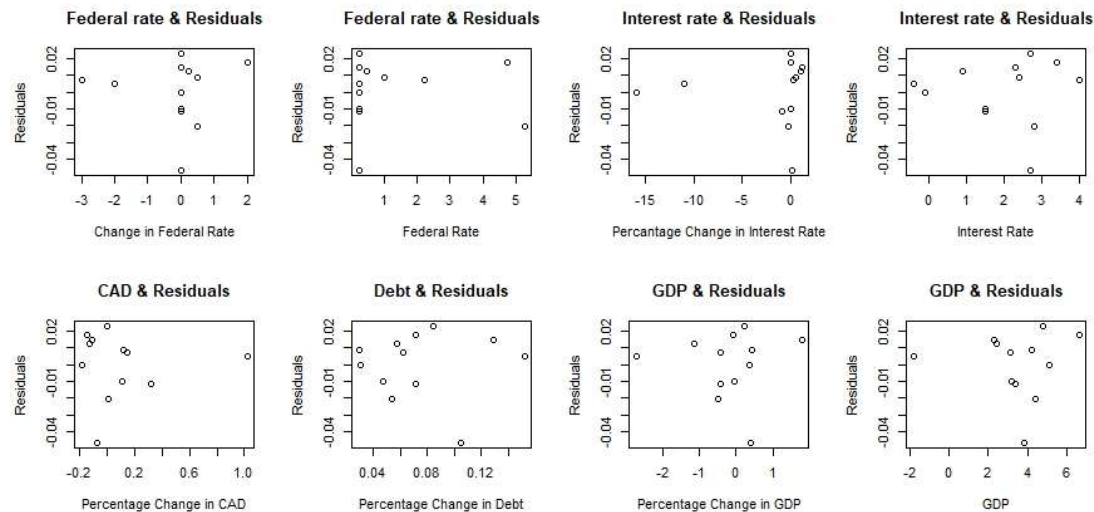
a)   Variance of Residuals

Quarterly Data – Full Model - Variance of residuals

Comments
There is no pattern in the relationship between the predictor variables and the residuals. This variance is a sign that the model satisfies the required conditions
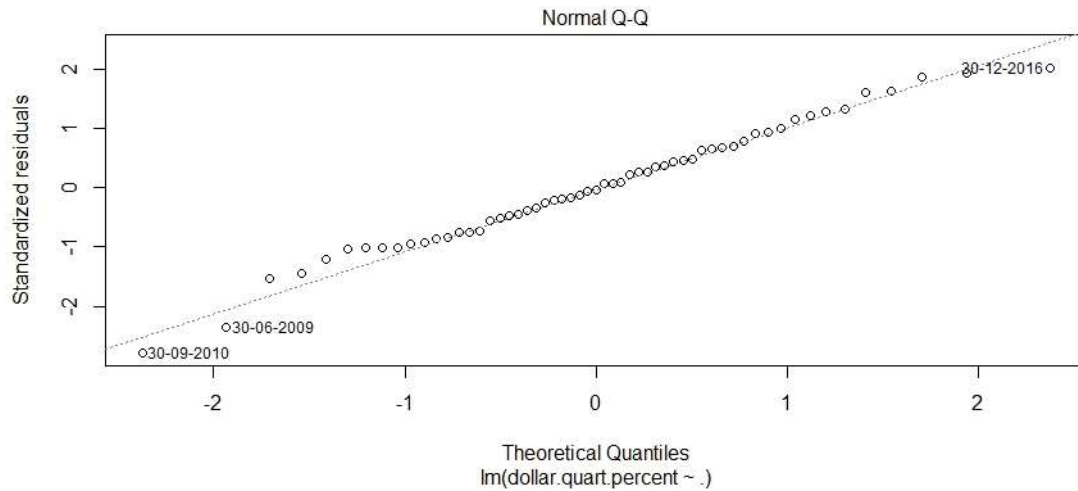
Yearly Data – Full Model - Variance of residuals

Comments
There is no pattern in the relationship between the predictor variables and the residuals. This variance is a sign that the model satisfies the required conditions
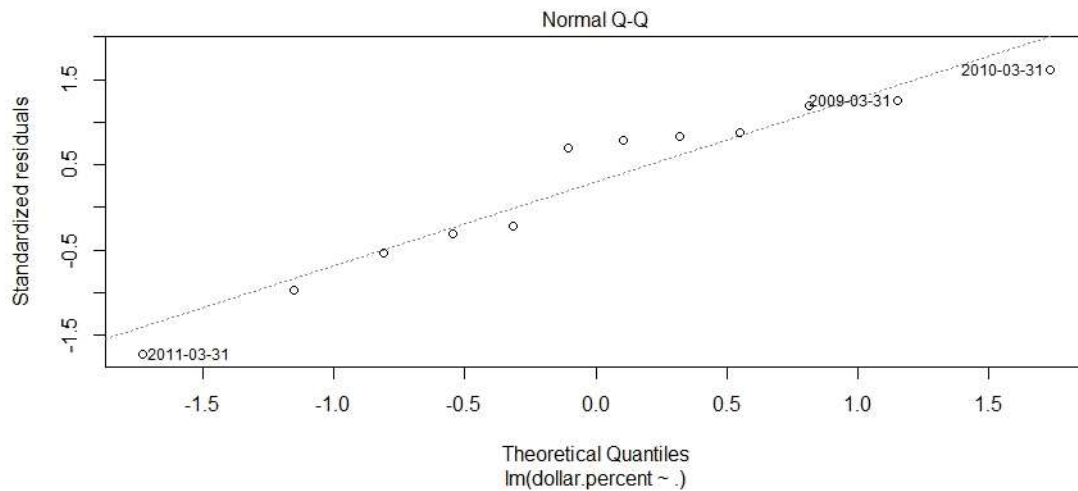
b)   <u>Normality of Residuals</u>

Quarterly Data – Full Model – Normality of Residuals

Normal Q-Q

Comments

The above qq-plot shows that the residuals are normally distributed thus satisfying the normality condition for residuals

Yearly Data – Full Model – Normality of Residuals

Normal Q-Q

Comments

The above qq-plot shows that the residuals are approximately normally distributed thus satisfying the normality condition for residuals

6.5   Stepwise Linear Regression Model

- From the linear regression model in the earlier step we observed that a few predictor variables may be better predictors of dollar value than others. Thus, in order to obtain the best combination of predictor variables we shall use a Stepwise Linear Regression.

- So, we ran a stepwise logistic regression model to identify the predictors that provide an optimum prediction model. A stepwise Logistic Regression Model uses AIC (Akaike information criterion) to determine the optimum model.

- AIC provides a score based on the value of residuals and includes a cost complexity factor which penalizes the model for every additional predictor variable. Thus, unless a predictor variable reduces residuals more than the penalty incurred on addition of the variable it shall not be included in the model.

6.5.1   Creating Stepwise Regression Model

Quarterly Data – Stepwise Linear Regression

```
Console  Terminal ×
~/

Call:
lm(formula = dollar.quart.percent ~ debt.quart.percent, data = quarterly.data)

Residuals:
    Min      1Q  Median      3Q     Max
-7.8017 -2.1635 -0.1472  2.1297  6.7684

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)         -0.5739     0.7488  -0.766    0.447
debt.quart.percent   0.5001     0.3116   1.605    0.114

Residual standard error: 3.452 on 55 degrees of freedom
Multiple R-squared:  0.04474,   Adjusted R-squared:  0.02737
F-statistic: 2.576 on 1 and 55 DF,  p-value: 0.1142
```

Comments

We run a Stepwise Linear Regression model to get the optimum model with lowest AIC. For quarterly data, as we can see from above, the results are very poor.

Percentage change in debt seems to be only variables used in the model and even that is not statistically significant. Furthermore, the model gives a very low adjusted R-squared of 2%.

Yearly Data – Stepwise Linear Regression

```
Console   Terminal ×
~/ ⇗
Call:
lm(formula = dollar.percent ~ CPI.percent + FDTR.change + CAD.percent,
    data = yearly.data)

Residuals:
      Min        1Q    Median        3Q       Max
-0.061077 -0.012502  0.005768  0.013468  0.051717

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.021120   0.011209  -1.884  0.09628 .
CPI.percent -0.012293   0.002082  -5.903  0.00036 ***
FDTR.change  0.041207   0.010471   3.935  0.00432 **
CAD.percent  0.141588   0.041077   3.447  0.00873 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.03568 on 8 degrees of freedom
Multiple R-squared:  0.8833,    Adjusted R-squared:  0.8396
F-statistic: 20.19 on 3 and 8 DF,  p-value: 0.0004344
```

Comments

The stepwise linear regression model gave much better results when used on yearly data. A stepwise model built on the yearly data selected the following variables for building the model with lowest AIC:

- Change in Inflation
- Change in Current Account Balance
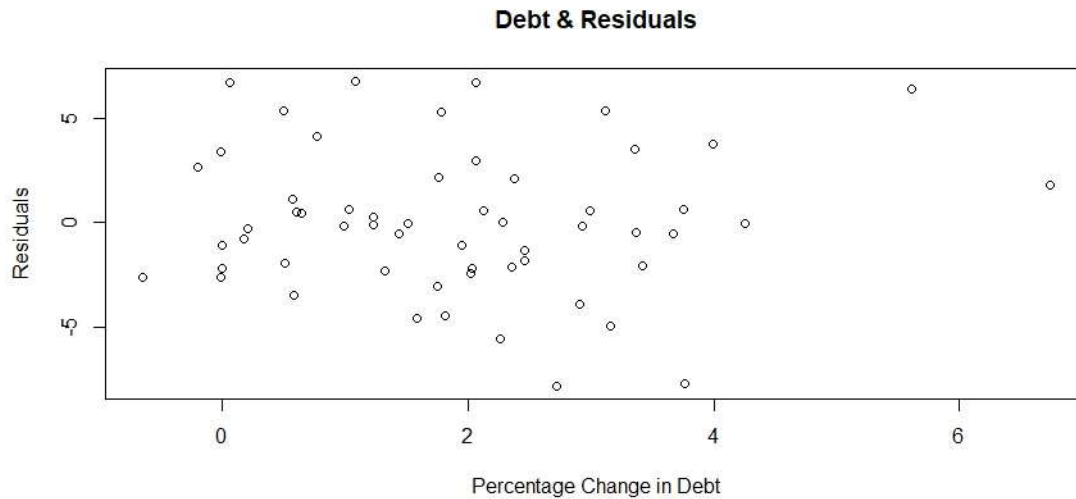- Change in Interest Rate

The model also gave a higher adjusted R-squared value of 83.96% which is higher than the previous model.

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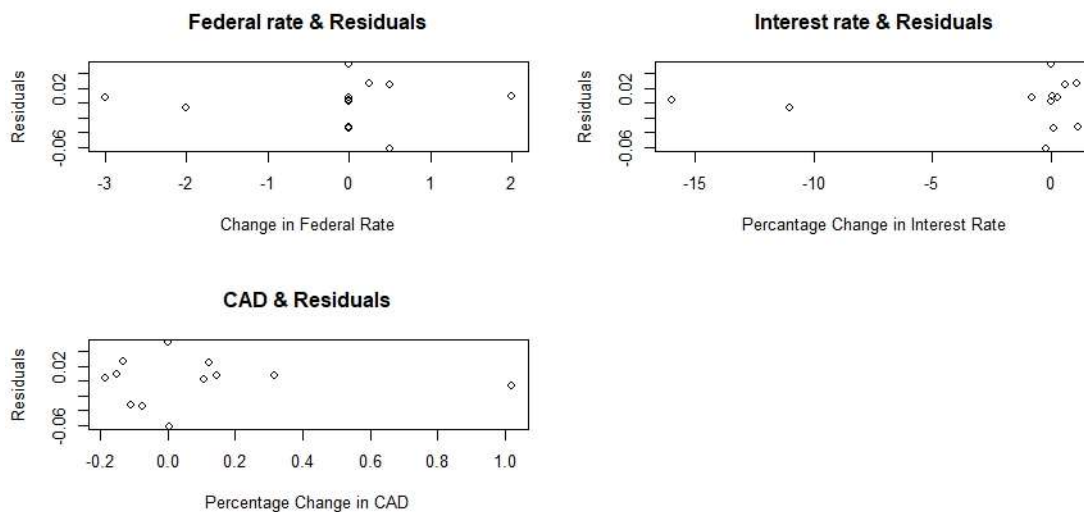## 6.5.2   Checking Model Validity

c)   Variance of Residuals

Quarterly Data – Stepwise Model - Variance of residuals

Debt & Residuals

Comments

There is no pattern in the relationship between the predictor variable i.e. change in debt and the residuals. This variance is a sign that the model satisfies the required conditions

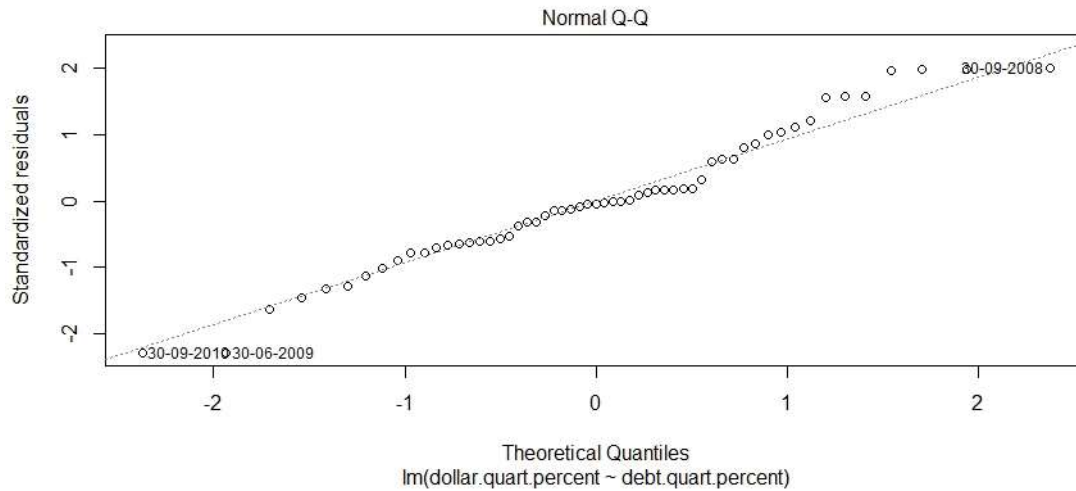### *Yearly Data – Stepwise Model - Variance of residuals*

Comments

There is no pattern in the relationship between the predictor variables selected by the stepwise model and the residuals. This variance is a sign that the model satisfies the required conditions
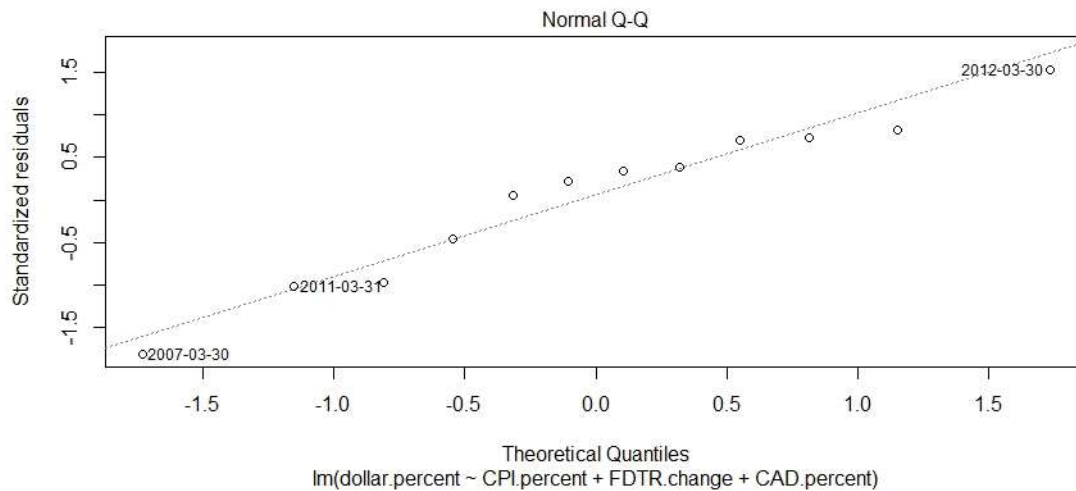
d)   Normality of Residuals

Quarterly Data – Stepwise Model – Normality of Residuals

Normal Q-Q

(y-axis: Standardized residuals, x-axis: Theoretical Quantiles)

lm(dollar.quart.percent ~ debt.quart.percent)

Comments

The above qq-plot shows that the residuals are approximately normally distributed thus satisfying the normality condition for residuals

Yearly Data – Stepwise Model – Normality of Residuals

Normal Q-Q

(y-axis: Standardized residuals, x-axis: Theoretical Quantiles)

lm(dollar.percent ~ CPI.percent + FDTR.change + CAD.percent)

Comments

The above qq-plot shows that the residuals are approximately normally distributed thus satisfying the normality condition for residuals

7. Summary and Conclusions

7.1 Summary of Impact on Macroeconomic Indicators

Particulars	Quarterly Data		Yearly data	
	Full Model	**Stepwise**	**Full Model**	**Stepwise**
Adjusted R Squared	7%	2%	82%	83.6%
Significant Variables	Interest Rate	No variable	No Variable	Change in Inflation, change in Interest Rate and change in CAD
High Correlation*	Only Interest Rate		Change in Interest Rates, Inflation, Change in Inflation, Change in GDP and Interest Rate	

7.2 Summary of Impact on Macroeconomic Indicators

- Change in Inflation Rate looks to be the most significant variable in predicting dollar movement out of the predictors chosen. Change in inflation seems to be negative relationship to change in dollar value.

- In yearly data, interest rates and current account balance also seem to play an important role in predicting movement of dollar value.

- Public Debt and GDP performance do not seem to have a great impact on predicting movement of dollar in the quarterly as well as yearly data.

7.3 Conclusions

- From the previous slides, we can observe that the macroeconomic drivers seem to be have a stronger relationship with dollar movement in the yearly data as compared to short term data. This shows that these macroeconomic indicators act more as a guide to currency movements in the long term rather than impact currency value in short term periods.

- Currency movements in the short-term may be driven more based on demand-supply movements than change in underlying fundamentals barring surprise changes in interest rates or inflation.

7.4 Way Forward

- This analysis gives us an indication of the nature of relationship between macroeconomic indicators and dollar value. However, this is the starting point we would analyze further to understand which of these variables are lagging or leading indicators.

- Another interesting point that may require further analysis is GDP. You may note that GDP growth rate did not play an important factor in predicting currency rate under any of the models. We speculate that GDP growth rate may be more of a lagging indicator for currency movement rather than a current indicator and the same may need to be analyzed in further detail.