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Time Series Analysis of Real Effective Exchange Rate A Case Study of India

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Abstract
This paper analyses the trend and seasonal variation of real effective exchange rate (REER) with an objective of building a model for predicting the exchange rate. Classical decomposition of the time series data of monthly export and trade based REER from January 2011 to August 2015 has been performed. The trend and seasonal components have been studied. The results show that the trend and seasonal effect are attributed only to chance (random) and not by a systematic factor like a trend or a seasonal change.
Keywords: Exchange rate, Trend Analysis, Seasonal variation, Classical Decomposition.

1. Introduction

Globalised business and its expansion together with the modern global economies have resulted in global corporations. These global corporation often have operations across countries exposing themselves to receivables, payables and liabilities denominated in multiplicity of currencies. Such currency exposures add extra risk because of the volatility of the exchange rate between the home and the foreign currency. They are also impacted in the long run because of a more permanent appreciation, depreciation or devaluation of the home and/or the foreign currency. This calls for the global corporations to be prepared with more carefully devised hedging strategies for short and long run. In doing so, while it is essential to understand the long term trends in the exchange rates for making strategic decisions like direct investment and building long term trade relations with certain countries, at the same time it is also necessary to understand if there are any seasonal effects on the exchange rate movement. This research is an attempt toward this end.

The purpose of this study is to analyse the trend and seasonal characteristics of the REER and build a model for predicting the exchange rate.

The outcome of this study will be important for the industry especially the export and imported oriented industries. It will help the exporters and importers to form suitable hedging strategies for covering their currency exposures. It would also serve as an useful input for forming their long term strategies. It is also important for policy makers. It helps them to have an idea about the expected exchange rates against currencies of all trading partners.

The other sections of the paper are organized as below. Section two makes a review of the past literature on the topic, section three presents the objectives of the study, section four details the data and methodology used for the study. Section five presents the analysis, results and discussions. Conclusion is presented in section six.

2. Review of Literature

Researchers have attempted to study factors affecting exchange rates. Numerous studies have also been done to obtain an empirical evidence of the most fundamental theory in the exchange rate- the PPP theory. Most of such studies also had an additional objective of building a model for predicting the exchange rate.

Chia and Bauer in their study of the exchange rate movement of the Singapore Dollar against US dollar have found that it is difficult to forecast exchange rate using ARIMA model as Singapore Dollar is strongly managed. They have therefore concluded that one has to turn to more judgemental methods to 'predict' exchange rate trends.

Martin and Frutos have argued that equilibrium models have not worked well in explaining the actual exchange rate but with seasonally adjusted data there are reasons to expect spurious rejections of the model. They have modeled exchange rate dynamics by means of an equilibrium models that incorporates seasonal preferences. After evaluation of the model to a set of seasonally unadjusted data of five countries model with seasonal preferences can generate monthly time series of the exchange rate without seasonality, even if the variables that theoretically determine the exchange rate show seasonality.

Yu Cai and Howard Qi have conducted a comprehensive computational investigation of exchange rate using time series and econometric analysis. They have performed an empirical time series analysis of the exchange rate movement between US dollar and the British pound. They have tested a few time series models in an ad hoc

fashion aimed at investigating eth time series characteristics of the exchange rate.

Valakevicius and Brazenas in their study have proposed a new approach to investigating the dynamics of hourly exchange rates between Euro and US dollar. They have analysed exchange rate fluctuation by calculating the sum of absolute differences (SAD) of a time series per hour. They have shown empirically that a new time series constructed from SAD values is more suitable for predicting exchange rate volatility if it takes into account only the magnitude of the exchange rate fluctuation and ignores its direction.

Dornbusch has derived a perfect foresight path and has shown that along that path a monetary expansion causes the exchange rate to depreciate.

Santoya and Soutar have analysed movements in the REER is through a simple accounting decomposition of its elements (the NEER, domestic inflation and the foreign level of inflation.

Zhang Xiaopo has, based on new developments in the equilibrium exchange rate theory, developed equilibrium real exchange rate (ERER) and behavioral equilibrium exchange rate (BEER) models for RMB by using cointegration analysis, the Hodrick-Prescott (H-P) filter and other econometrics techniques. His estimation results show that the exchange rate of RMB is close to the equilibrium level in 1999. He also analyses the trajectory of RMB exchange rate misalignment since 1978, and makes an assessment of RMB exchange rates.

Chia and Bauer have analysed the movements in the US$/Ringgit exchange rate with the objective of the forces determining the exchange rates so as to be able to predict these trends. They have analysed the trends in the exchange rates (REER and NEER) and found no strong support for the PPP theory in the case of US$/Ringgit exchange rate.

Sathitwitayakul and Dr. Kriengsin Prasongsukarn have examined the major wave functions that influence the real effective exchange rate of Thai baht. They have used Fourier transform technique to extract the hidden sinusoidal wave function in the main graph. They have built a mathematical model for predicting the future value of exchange rate. Their results show the relativity of economic fundamentals and currency fluctuation, which implies that the basis unit of economic fundamentals exists and its characteristic of time-value (price quantity) function is shown in sinusoidal waveform.

3. Objectives of the Study

The objectives of this study are

- to analyse the trend of REER
- to analyse the seasonal variations in REER
- to develop a forecasting model for REER

4. Data and Methodology

Use of index saves the effort of analysing each of the currencies of major trading partners individually. Hence the following two variants of the exchange rate index are generally published by the monetary authority.

NEER (Nominal Effective Exchange Rate): NEER is the weighted average of bilateral nominal exchange rates of the home currency in terms of foreign currencies. It is not adjusted for inflation

REER (Real Effective Exchange Rate): It is defined as a weighted average of nominal exchange rates adjusted for relative price differential between the domestic and foreign countries. It relates to the purchasing power parity (PPP) hypothesis.

Export Based Weights: Average of India's exports with the countries in the index.

Trade Based Weights: Average of India's bilateral trade (exports plus imports) with the countries in the index.

We consider real effective exchange rate (REER published by RBI) as indicator for the exchange rate. Between the two types of REER, the REER with a 6-currency basket and the REER with a 36-currency basket, the latter is chosen as it would have a better representation of the countries with which trade is made.

Monthly Export and Trade Weighted Real Effective Exchange Rate (REER) data from January 2011 to August 2015 from the data base of Reserve Bank of India (RBI) is used for this study. The base year for the index is 2004-05 and the base year index is 100.

Classical decomposition of the time series of export based REER and trade based REER has been separately done followed by an analysis of seasonality. The trend and seasonal variation has then been tested for significance using the t-test.

5. Analysis, Results and Discussions.

5.1 Trend and Seasonality analysis for REER data

Figure 1 gives the time series plot of export based and trade based weight variables for REER. Inspection of the time series plot indicates trend and seasonality, though either of them does not appear to be large.

Figure 1: Time series plot of export based and trade based weight

5.1.2 Trend and Seasonality Analysis for Export based weight REER

Variability in export based weight variable is decomposed in to trend –cyclical, seasonal and random error terms. Conceptual model of this classical decomposition is given as follows.

$Y_t = (TC)_t S_t R_t$ where Y_t is the original series data for time period t, $(TC)_t$ is the trend cycle part at time t, S_t is the seasonal component at time t and R_t is the random error term at time period t.

Table 1 reports original series, seasonal factors reported as a percentage of trend, seasonally adjusted series (De - seasonalized series), and trend-cycle along with random error term for the entire data from January 2011 to August 2015. February, March, May, July and September months report seasonal indices above trend and other months below trend. Month of March reports highest seasonal index (101.8) reporting 1.8% seasonal effect above the trend in export based REER. June reports the least (98.6%) with 1.4% below the trend. All the 12 months report seasonal indices close to the trend. Figure 2 gives the plot of original series, trend –cycle and seasonally adjusted series. Figure 3 gives the plot of random error term. This plot reports close resemblance to a stationary process supporting evidence for this factor to be random.

[Insert Table 1: Decomposition of Export based weight REER]

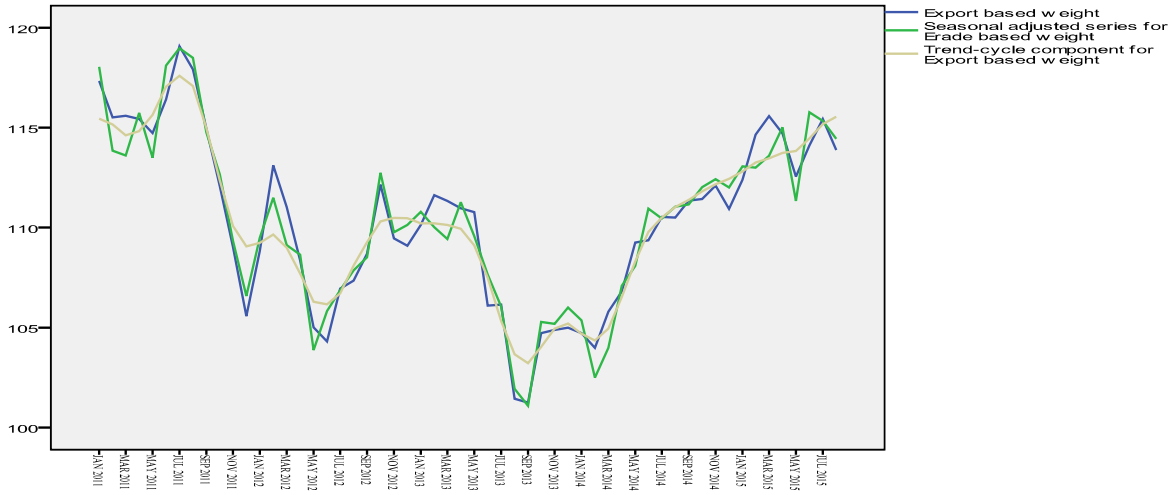

Figure 2: Original series, Trend –Cycle and Seasonally adjusted components of export based weight REER

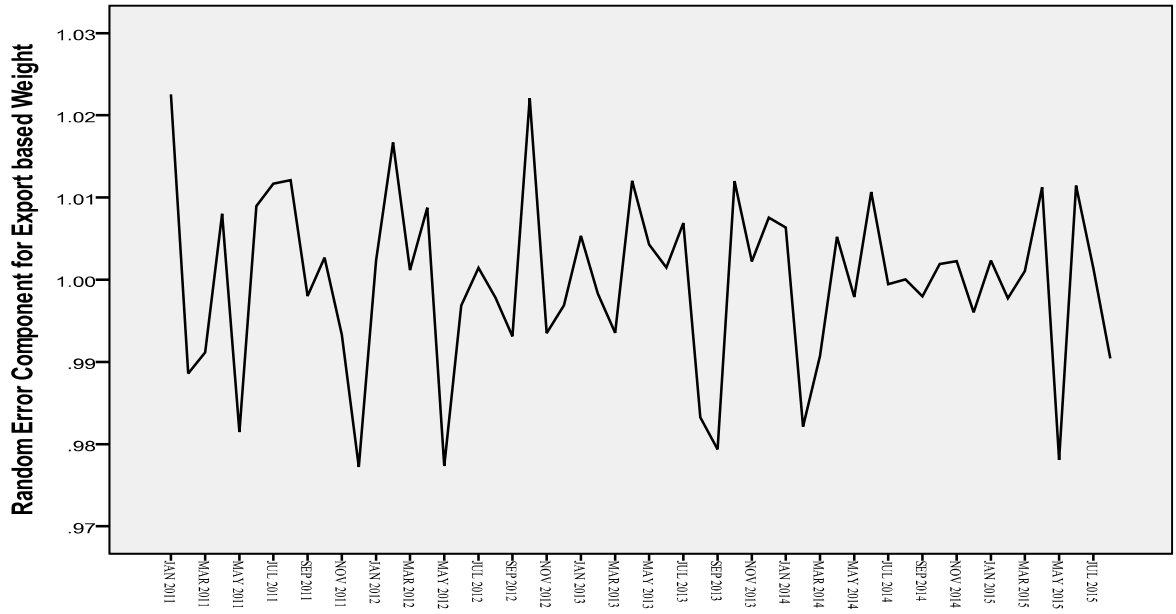

Figure 3:Random error component of export based weight REER

Table 2 reports original series, seasonal factors reported as a percentage of trend, seasonally adjusted series (De - seasonalized series), and trend-cycle along with random error term for trade based weight REER variable. Matching the results of export based weight, February, March, May, July and September months report seasonal indices above trend and other months below trend. Month of March reports highest seasonal index (101.7) reporting 1.7% seasonal effect above the trend in export based REER. June reports the least (98.4%) with 1.6% below the trend. All the 12 months report seasonal indices close to the trend. Figure 4 gives the plot of original series, trend –cycle and seasonally adjusted series. Figure 5 gives the plot of random error term. This plot reports close resemblance to a stationary process supporting evidence for this factor to be random.

[Insert Table 2: Decomposition of Trade based weight REER]

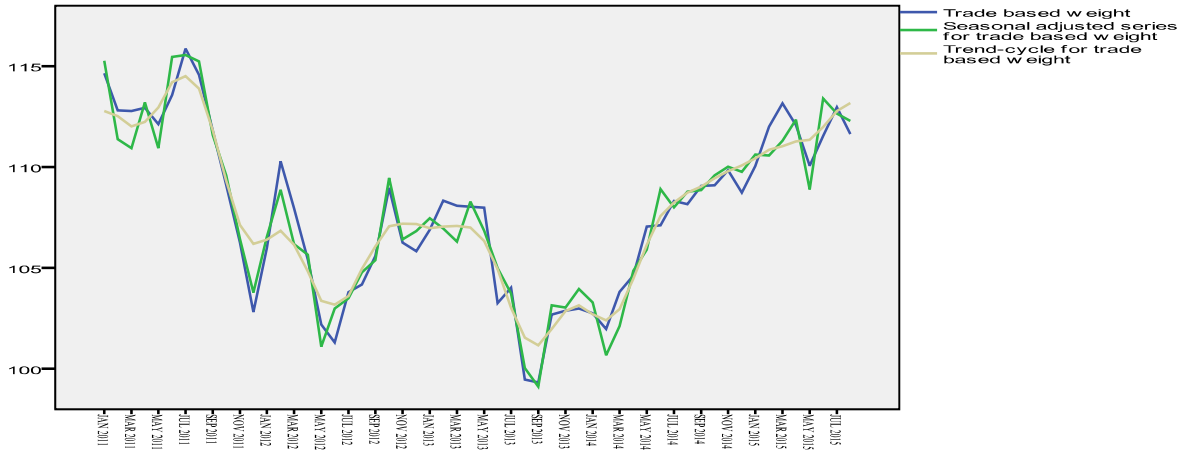

Figure 4: Original series, Trend –Cycle and Seasonally adjusted components of trade based weight REER

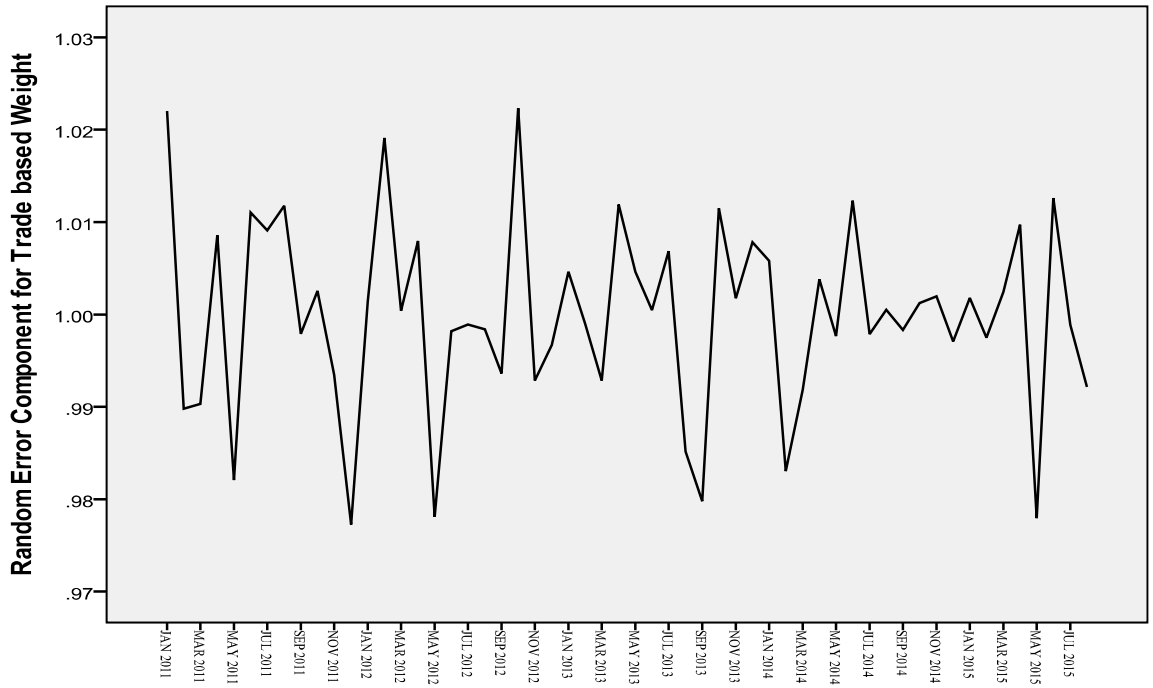

Figure 5:Random error component of export based weight REER

Table 3 and 4 report statistical test performed for testing the significance of seasonal dummy variables along with trend component included in regression model for export and trade based weighs respectively.

The conceptual form of the model fitted and tested is as follows.

$Y_i = \beta_0 + \beta_1 t + \sum \gamma_i D_i + \varepsilon_i$ where D_i's are the dummy variables for different months and "t" is the time index variable used to adjust for the effect of trend in the model.

Table 3: Results of Testing Significance of Trend and Seasonal Dummy Variables for Export based Weight REER.

Month	Estimate (β)	t	P	95.0% CI Lower Bound	Upper Bound
(Constant)	108.819	42.430	.000	103.647	113.991
Jan	2.839	.921	.362	-3.379	9.058
Feb	3.980	1.292	.203	-2.234	10.195
Mar	4.107	1.334	.189	-2.104	10.318
Apr	3.532	1.147	.258	-2.676	9.741
May	2.783	.904	.371	-3.424	8.990
Jun	2.411	.783	.438	-3.796	8.617
Jul	4.020	1.306	.199	-2.187	10.227
Aug	2.645	.859	.395	-3.564	8.853
Sep	1.300	.401	.691	-5.246	7.847
Oct	2.367	.729	.470	-4.177	8.911
Nov	1.186	.366	.716	-5.357	7.729
Trend	-.039	-1.022	.313	-.116	.038

Table 4: Results of Testing Significance of Trend and Seasonal Dummy Variables for Trade based Weight REER.

Month	Estimate (β)	t	P .	95.0% CI for B Lower Bound	Upper Bound
(Constant)	105.797	42.455	.000	100.771	110.822
Jan	2.854	.953	.346	-3.188	8.897
Feb	3.894	1.300	.200	-2.144	9.932
Mar	3.995	1.335	.189	-2.040	10.030
Apr	3.479	1.163	.251	-2.554	9.511
May	2.770	.926	.359	-3.261	8.802
Jun	2.262	.756	.454	-3.769	8.293
Jul	3.924	1.312	.196	-2.108	9.955
Aug	2.559	.856	.397	-3.473	8.592
Sep	1.287	.408	.685	-5.074	7.648
Oct	2.330	.739	.464	-4.028	8.689
Nov	1.194	.379	.707	-5.163	7.551
Trend	-.024	-.634	.529	-.098	.051

Results of the fitted regression model does not report overall model significance (F (12, 43) = 0.404, .954). This means that trend and none of the other seasonal dummy variables are significant predictors of variability in export based REER. This is confirmed by results of t test performed for testing the significance of each predictor variables. P value associated with each predictor variable is comfortably more than .05. These results, report that classical decomposition reports small seasonal effects over and below the trend. But none of months report statistical significance indicating that the seasonal effect reports is attributed only to chance (random) and not by a systematic factor like a Seasonal change. Same result is reported for trade based weight REER variable also. Therefore, it is concluded that export and trade based REER variables does not report significant trend or seasonal effects.

6. Conclusion

The results of this analysis show that neither the trend nor the seasonal variation is significant for the REER data over the selected time frame using the classical decomposition method. Hence a forecasting model cannot be fitted.

However it could be possible to fit a forecasting model using more advanced econometric methods. This serves as a scope for further research on this issue.

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Table 1: Decomposition of Export based weight REER

Month	Series	Seasonal Factor (%)	Seasonally Adjusted	Trend-Cycle Series	Error Component
Jan 2011	117.340	99.4	118.050	115.447	1.023
Feb 2011	115.520	101.5	113.856	115.172	.989
Mar 2011	115.600	101.8	113.609	114.620	.991
Apr 2011	115.440	99.7	115.747	114.824	1.008
May 2011	114.740	101.1	113.499	115.643	.981
Jun 2011	116.410	98.6	118.107	117.057	1.009
Jul 2011	119.070	100.1	118.974	117.600	1.012
Aug 2011	117.920	99.5	118.500	117.084	1.012
Sep 2011	114.960	100.2	114.765	114.995	.998
Oct 2011	112.070	99.5	112.669	112.369	1.003
Nov 2011	109.040	99.7	109.350	110.090	.993
Dec 2011	105.570	99.1	106.582	109.065	.977
Jan 2012	108.830	99.4	109.489	109.232	1.002
Feb 2012	113.120	101.5	111.490	109.658	1.017
Mar 2012	111.040	101.8	109.127	109.000	1.001
Apr 2012	108.350	99.7	108.638	107.693	1.009
May 2012	105.010	101.1	103.874	106.284	.977
Jun 2012	104.310	98.6	105.830	106.164	.997
Jul 2012	106.950	100.1	106.864	106.709	1.001
Aug 2012	107.340	99.5	107.868	108.105	.998
Sep 2012	108.700	100.2	108.516	109.269	.993
Oct 2012	112.150	99.5	112.750	110.314	1.022
Nov 2012	109.460	99.7	109.772	110.489	.994
Dec 2012	109.090	99.1	110.135	110.479	.997
Jan 2013	110.130	99.4	110.797	110.211	1.005
Feb 2013	111.630	101.5	110.022	110.212	.998
Mar 2013	111.340	101.8	109.422	110.136	.994
Apr 2013	110.970	99.7	111.265	109.941	1.012
May 2013	110.780	101.1	109.582	109.116	1.004
Jun 2013	106.100	98.6	107.647	107.490	1.001
Jul 2013	106.140	100.1	106.055	105.331	1.007
Aug 2013	101.430	99.5	101.929	103.664	.983
Sep 2013	101.250	100.2	101.078	103.210	.979
Oct 2013	104.720	99.5	105.280	104.031	1.012
Nov 2013	104.880	99.7	105.179	104.947	1.002
Dec 2013	104.990	99.1	105.996	105.203	1.008
Jan 2014	104.720	99.4	105.354	104.688	1.006
Feb 2014	103.990	101.5	102.492	104.359	.982
Mar 2014	105.800	101.8	103.978	104.949	.991
Apr 2014	106.810	99.7	107.094	106.538	1.005
May 2014	109.260	101.1	108.078	108.307	.998
Jun 2014	109.360	98.6	110.954	109.784	1.011
Jul 2014	110.540	100.1	110.451	110.510	.999
Aug 2014	110.500	99.5	111.043	111.037	1.000
Sep 2014	111.350	100.2	111.161	111.389	.998
Oct 2014	111.430	99.5	112.026	111.812	1.002
Nov 2014	112.110	99.7	112.429	112.175	1.002
Dec 2014	110.940	99.1	112.003	112.449	.996
Jan 2015	112.390	99.4	113.070	112.806	1.002
Feb 2015	114.660	101.5	113.008	113.264	.998
Mar 2015	115.580	101.8	113.589	113.472	1.001
Apr 2015	114.720	99.7	115.025	113.747	1.011
May 2015	112.560	101.1	111.343	113.840	.978
Jun 2015	114.110	98.6	115.773	114.463	1.011
Jul 2015	115.440	100.1	115.347	115.187	1.001
Aug 2015	113.880	99.5	114.440	115.549	.990

Table 2: Decomposition of Trade based weight REER

Month	Series	Seasonal Factor (%)	Seasonally Adjusted Series	Trend-Cycle Series	Error
Jan 2011	114.650	99.5	115.260	112.775	1.022
Feb 2011	112.810	101.3	111.373	112.522	.990
Mar 2011	112.780	101.7	110.933	112.016	.990
Apr 2011	112.940	99.8	113.205	112.242	1.009
May 2011	112.130	101.1	110.932	112.955	.982
Jun 2011	113.560	98.4	115.456	114.196	1.011
Jul 2011	115.870	100.3	115.546	114.504	1.009
Aug 2011	114.570	99.4	115.232	113.891	1.012
Sep 2011	111.810	100.2	111.589	111.821	.998
Oct 2011	109.110	99.6	109.593	109.314	1.003
Nov 2011	106.260	99.8	106.429	107.129	.993
Dec 2011	102.810	99.1	103.779	106.195	.977
Jan 2012	105.980	99.5	106.544	106.395	1.001
Feb 2012	110.280	101.3	108.876	106.835	1.019
Mar 2012	107.950	101.7	106.182	106.139	1.000
Apr 2012	105.410	99.8	105.658	104.822	1.008
May 2012	102.190	101.1	101.098	103.364	.978
Jun 2012	101.300	98.4	102.992	103.179	.998
Jul 2012	103.790	100.3	103.500	103.614	.999
Aug 2012	104.180	99.4	104.782	104.950	.998
Sep 2012	105.590	100.2	105.381	106.059	.994
Oct 2012	108.970	99.6	109.453	107.063	1.022
Nov 2012	106.250	99.8	106.419	107.184	.993
Dec 2012	105.830	99.1	106.828	107.182	.997
Jan 2013	106.890	99.5	107.458	106.962	1.005
Feb 2013	108.330	101.3	106.950	107.055	.999
Mar 2013	108.080	101.7	106.310	107.077	.993
Apr 2013	108.030	99.8	108.284	107.009	1.012
May 2013	107.990	101.1	106.836	106.343	1.005
Jun 2013	103.260	98.4	104.984	104.935	1.000
Jul 2013	104.020	100.3	103.729	103.023	1.007
Aug 2013	99.470	99.4	100.045	101.552	.985
Sep 2013	99.320	100.2	99.123	101.169	.980
Oct 2013	102.690	99.6	103.145	101.975	1.011
Nov 2013	102.880	99.8	103.043	102.862	1.002
Dec 2013	102.990	99.1	103.961	103.153	1.008
Jan 2014	102.750	99.5	103.296	102.702	1.006
Feb 2014	101.970	101.3	100.671	102.408	.983
Mar 2014	103.820	101.7	102.119	102.959	.992
Apr 2014	104.620	99.8	104.866	104.469	1.004
May 2014	107.050	101.1	105.906	106.153	.998
Jun 2014	107.110	98.4	108.899	107.575	1.012
Jul 2014	108.310	100.3	108.007	108.239	.998
Aug 2014	108.160	99.4	108.785	108.729	1.001
Sep 2014	109.070	100.2	108.854	109.036	.998
Oct 2014	109.100	99.6	109.583	109.447	1.001
Nov 2014	109.840	99.8	110.014	109.800	1.002
Dec 2014	108.730	99.1	109.755	110.078	.997
Jan 2015	110.040	99.5	110.625	110.427	1.002
Feb 2015	112.000	101.3	110.574	110.851	.997
Mar 2015	113.150	101.7	111.297	111.026	1.002
Apr 2015	112.080	99.8	112.343	111.262	1.010
May 2015	110.060	101.1	108.884	111.341	.978
Jun 2015	111.530	98.4	113.392	111.984	1.013
Jul 2015	112.960	100.3	112.644	112.771	.999
Aug 2015	111.630	99.4	112.275	113.164	.992