EXCHANGE RATE ANALYSIS

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Abstract

A shiny application that provides time series, decomposition and volatility analysis of emerging economies' exchange rate.

Link to the App: - https://dataandanalysis.shinyapps.io/ExchangeRateAnalysisApp/

Background

The exchange of currencies is at the centre of globalization. Without globalization the modern world would probably not be possible. It is therefore necessary for us to be able to understand the dynamics of how exchange rates behave, and what we can do to better mitigate exchange rate risk. With this shiny application I hope to be able to provide a tool that can help us better understand the dynamics of exchange rates.

Autoregressive Conditional Heteroscedasticity (ARCH) models, are very important in understanding the volatility and/ or fluctuations in time series data. Engle (1982) highlighted that a major limitations of conventional econometric models is that they assume constant volatility. He argued that this is a significant oversimplification considering the dynamic and complex nature of financial markets. ARCH models allow for variance to be modelled as a part of past volatility rather than being considered constant. By incorporating past data, we can use ARCH models to capture the complex volatility provide in exchange rates. This allows for a more accurate analysis of exchange rate data.

Baillie and Bollerslev (1989) explored the relationship the behaviour of exchange rates on a daily basis. They used a conditional variance model, specifically the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model. They identified a unit root in the exchange rate data, this points to the fact that exchange rate data is unpredictable and is in line with the random walk hypothesis. They observed leptokurtosis and time dependent heteroscedasticity in the data. Using the GARCH model they were able to quantify the volatility/heteroscedasticity. This ability to quantify the volatility is important for analysing all kinds of financial time series data, including the exchange rates. Due to the random walk forecast, predicting exchange rates has been proven to be a difficult task. Kilian and Taylor (2013) proposed a model considering the diversity of opinions and levels of influence in the foreign exchange market, and in doing so they incorporated heterogeneous agents. With incorporating heterogeneous agents, they were able to demonstrate a deeper analysis of both real and nominal exchange rate analysis. Their empirical analysis presented a strong case for long horizon predictability in exchange rates. However, they also noted in using this predictability for out-of-sample forecasts. Although by employing time series graphs, decomposition, and GARCH volatility modelling, we can addresses the nuanced behaviours of exchange rates highlighted by (Kilian & Taylor, 2013). They provide a practical tool for analysing exchange rate data and potentially even predicting exchange rate movements. Engle and Manganelli (2004) developed the Conditional Autoregressive Value at Risk (CAViaR) model. They focused on modelling the quantile of future portfolio values, or Value at Risk (VaR). The CAViaR model used an autoregressive process to determine VaR evolution over time, and used regression quantiles to estimate parameters. Moreover, they emphasized the importance for advanced volatility modelling techniques like GARCH. A GARCH model along with CAViaR will be useful for analysing the volatility in financial data such as; exchange rate.

The challenge of predicting exchange rates and the extensive efforts made to improve forecast accuracy is addressed by (Rossi, 2013). Their research analyses various exchange rate prediction models and methods such as; interest rate differentials, inflation, and productivity. The author analysed the effectiveness of these predictors and models in capturing the dynamics of exchange

rates. They highlighted the challenges of outperforming benchmarks like the random walk hypothesis in exchange rate forecasting. Rossi (2013) suggested that although some models show some promising results in forecasting, but due to the complex nature of financial markets that affect the exchange rate, the overall forecasting accuracy is still very limited. The author emphasized the importance of using a variety of tools, including time series analysis, decomposition, and GARCH for a better understanding of exchange rates. The necessity of having various visualization and analytical tools for econometric analysis is also reiterated by (Taylor, 1993). The study examines the application of econometric research on monetary policy and identifies how effective policy rules generally adjust interest rates as a result of inflation and income changes. Taylor (1993) suggests that the nuances and complexity of financial markets is the same as exchange rate volatility. The research highlighted the importance of using econometric models such as GARCH with time series analysis to more effectively analyse exchange rates.

The importance of GARCH model is also reiterated by (Poon & Granger, 2010). They conducted a comprehensive review of volatility forecasting in financial markets, elaborating on various models and their applications. Their research represents how significant it is to forecast volatility due to its essential role in investment decision-making, risk management, and monetary policy. They extensively cover methodologies ranging from traditional time series models to ARCH/GARCH models, and stochastic volatility models. With each method, highlighting their strengths and limitations in capturing the dynamic nature of financial market. Keeping in mind the dynamic nature of financial markets, they recommended using GARCH model along with time series graphs and decomposition.

Data Description

The dataset is gathered from Yahoo finance API and spans from 2004 to 2022. It includes the currency exchange rate of various countries against a base currency (USD). The data includes a total of 31 currencies. Each row representing a day, with the first column for date (formatted as MM-DD-YY), and subsequent columns representing the exchange rates of the listed currencies.

Due to the incorporation of a wide set of currencies, the dataset provides a wide ranging analysis on global financial markets. This can be used to examine how socio-economic factors may influence exchange rates differently across regions. This aids in comparative analysis between currencies from various regions of the world. This dataset allows for a comprehensive analysis of exchange rate over time, such as; time series analysis. Time series analysis helps analyse patterns and trends in the exchange rates. The GARCH model can be used to analyse, quantify and predict the volatility of the currencies over time. Furthermore, the dataset can be used for time series decomposition analysis. This will involve breaking down the data into trend, seasonal, and remainder components. This decomposition will assist in understanding the underlying trend of currency over time, any seasonal patterns and the residual fluctuations that cannot be attributed to trend or seasonality.

In conclusion, this dataset can be a very useful tool for conducting a comprehensive analysis of exchange rates. Through time series analysis, GARCH modelling, and decomposition, the dataset

supports a detailed evaluation of the dynamics in the global financial markets, which can offer valuable insights for economic and exchange rate analysis.

Excerpt of the Exchange Rate Data:

Date	Chinese Yuan	Iranian Rial	Thai Bhat	Syrian Pound	Euros
01-02-04	8.27	8236.2	39.53	47.23	0.79
01-05-04	8.27	8731.5	39.26	47.25	0.79
01-06-04	8.27	8724.7	39.03	47.21	0.79
01-07-04	8.27	8728.7	38.97	47.22	0.79
01-08-04	8.27	8217.8	38.98	47.14	0.78
01-09-04	8.27	8236.9	38.98	47.26	0.78
01-12-04	8.27	8221.9	39.02	49.75	0.78
01-13-04	8.27	8222.9	38.72	49.99	0.78
01-14-04	8.27	8238	39.11	49.97	0.79
01-15-04	8.27	8239	38.95	49.97	0.79
01-16-04	8.27	8253.2	39.09	50.05	0.81
01-19-04	8.27	8244.9	38.99	49.91	0.81
01-20-04	8.27	8238.3	39.03	47.76	0.79
01-21-04	8.27	8245.1	38.84	46.88	0.79
01-22-04	8.27	8254.4	38.96	50	0.79

Method

In the Shiny web application designed for analysing exchange rate data, the methodology integrates the use of time series graph, decomposition graphs, and the GARCH model to provide a comprehensive analysis of exchange rate fluctuations. The users of the application view the **time series graph** and the corresponding statistical summaries to get an idea of the trend and fluctuation of the selected currency and the time frame selected. For a more in-depth analysis this can be broken down into a **time series decomposition plot.** This plot breaks the data into trend, seasonal, and residual elements. This plot aids in understanding the underlying long-term movement, seasonal patterns linked to specific events or periods, and the irregularities and/or remainder that cannot be explained by either trend or seasonality. For an analysis into the volatility the **GARCH** model is used, which on quantifies and forecasts the volatility. This is particularly useful in understanding where and when the currency fluctuates. By incorporating all of the analytical techniques, the user can gain insights regarding the past performance of the currency and potentially make predictions regarding the future.

Instructions

User Interface:

Navigation Panel: On the left side, you'll find the navigation panel, which has the user inputs.

- **Select Currency:** Use the dropdown menu labeled “Select Currency” to choose the currency for which you wish to analyze the exchange rate.
- **Select Date Range:** Below the currency selection, there is a “Select Date Range”. This feature allows you to specify the time frame for your analysis, enabling an evaluation of exchange rate trends and volatility within the period of interest.

Conducting Exchange Rate Analysis:

- **Visualizing Exchange Rates over Time:** With the selections made, the main panel to the right will display a time series graph depicting the exchange rate movements of the chosen currency throughout the selected dates. This visualization provides a snapshot of the currency's performance, presenting any significant trends or fluctuations.
- **Time Series Decomposition:** This breaks down the data time series into its core components: trend, seasonality, and remainder. This plot can be viewed in the main panel. It isolates the smooth long-term trend, any recurring seasonal effects, and the irregular or and/or remainder components not explained by the trend or seasonality.
- **GARCH Model:** The application's tool for volatility assessment is the GARCH model. The app presents a volatility plot, which visualizes the estimated volatility trends over time, crucial for identifying periods of high risk or stability.

Customizing and Iterating Analysis:

- The application is designed for customizable exploration. Change your currency selection or the analysis period at any time, and the application will update the visualizations to reflect your new criteria.
- If the selected time period lacks sufficient data points, the application will display a message indicating the inadequacy of data points for analysis.

Statistical Summaries:

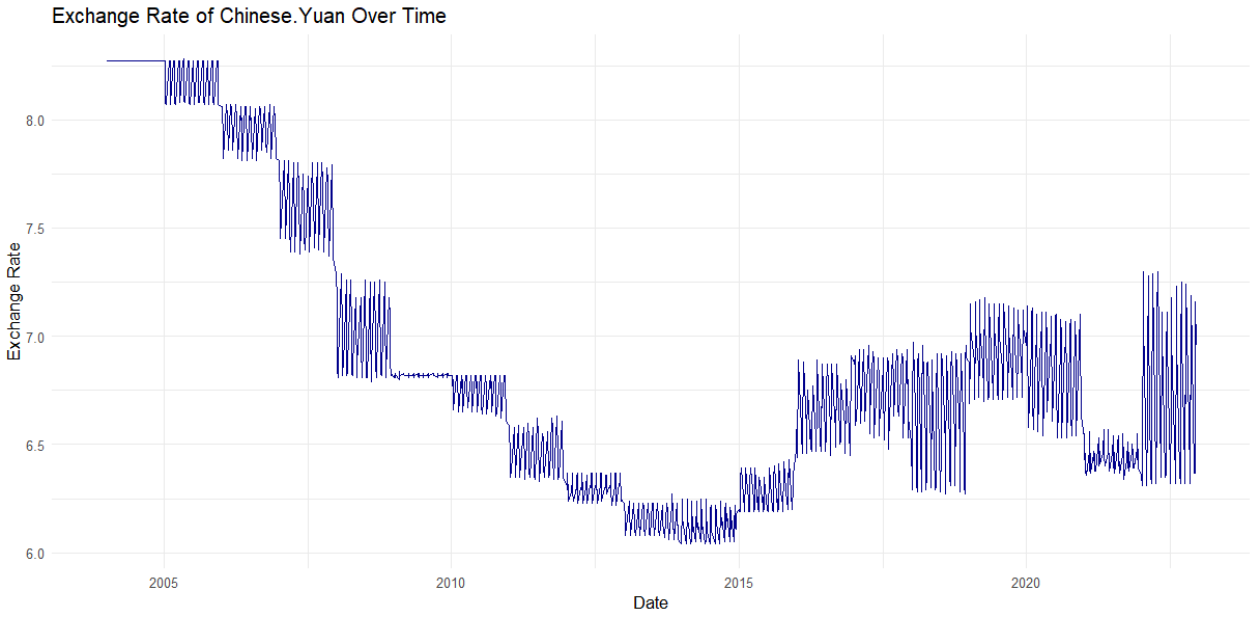
- **Summary Insights:** Below the plots, summary outputs provide a highlight of the analyses. Exchange rate summary complements the time series plot. Trend, seasonality and remainder summary complement the decomposition plot, and volatility summary complements the GARCH volatility plot.
- **Exchange Rate Summary**: This reflects the central tendencies of the exchange rates. The mean provides the average rate over the period analysed, offering a general sense of overall exchange rate levels. The median shows the middle value when the rates are listed in order, giving us an idea of the typical rate, unaffected by extreme values. The standard deviation indicates the extent of rate fluctuations around the mean.

- **Trend Summary:** This captures the long-term direction in which the exchange rate is moving. The Long-term Trend Mean provides the average rate, accounting for upward or downward movements over time. The Overall Trend Change quantifies the total increase or decrease in the exchange rate.
- **Seasonality Summary:** This focuses on the repetitive and predictable movements observed throughout the year. The Max Seasonal Effect is the highest point of seasonal influence, while the Min Seasonal Effect is the lowest. This highlights the extent to which seasonality effects the exchange rates.
- **Remainder Summary:** This presents the irregularities in the exchange rate that cannot be explained by trend and seasonality. The Remainder Standard Deviation measures the unpredictability not explained by the model. The Number of Outliers indicates the values that significantly deviate from the pattern, which could signal anomalies impacting the rates.
- **Volatility Summary:** It outlines the degree of exchange rate variability. The Average Volatility gives a sense of the usual fluctuation level, while Max Volatility and Min Volatility denote the extreme values, informing about potential risk scenarios and stability periods.

Graphical Interpretation

Example for interpreting time series graph:

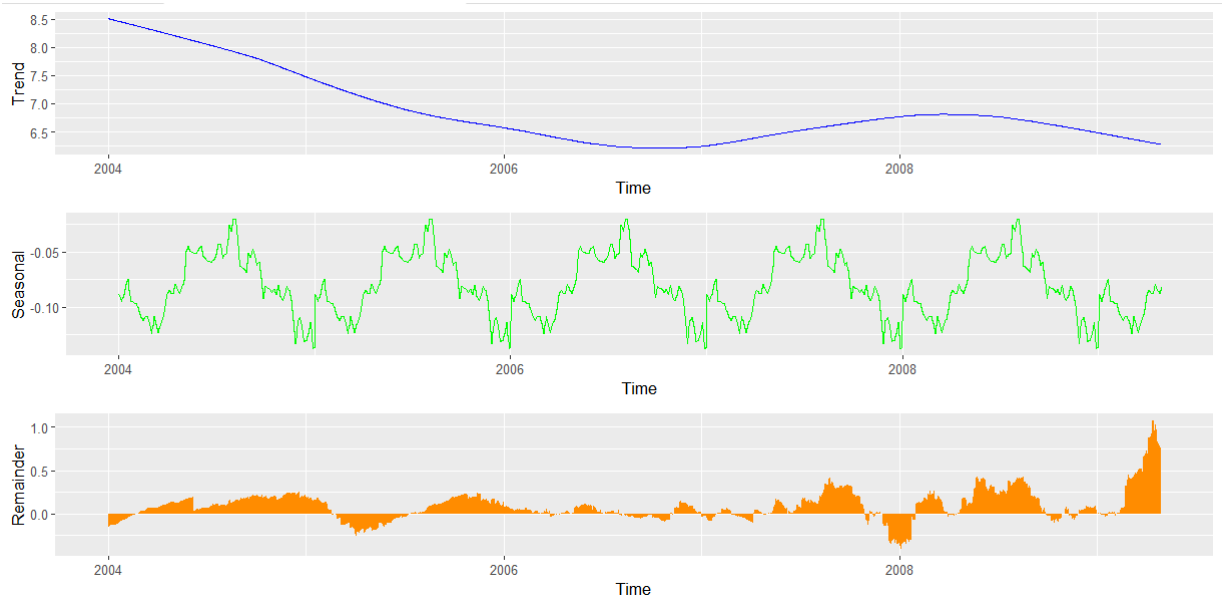
The below graph depicts the exchange rate of the Chinese Yuan over time and serves as an example of how to interpret such time series data. To understand this graph, observe the y-axis which reflects the value of the Yuan relative to the base currency, and the x-axis which indicates the time period.



A downward trend in the plot, as seen from around 2005 to 2014, suggests a strengthening of the Yuan. Conversely, upward spikes indicate weakening of the Yuan. Periods of relative flatness suggest stability in the exchange rate. Post-2014, the frequent and sharp rises and falls denote increased volatility, signalling economic events or market reactions that impacted the Yuan's value.

Example for interpreting time series decomposition graph:

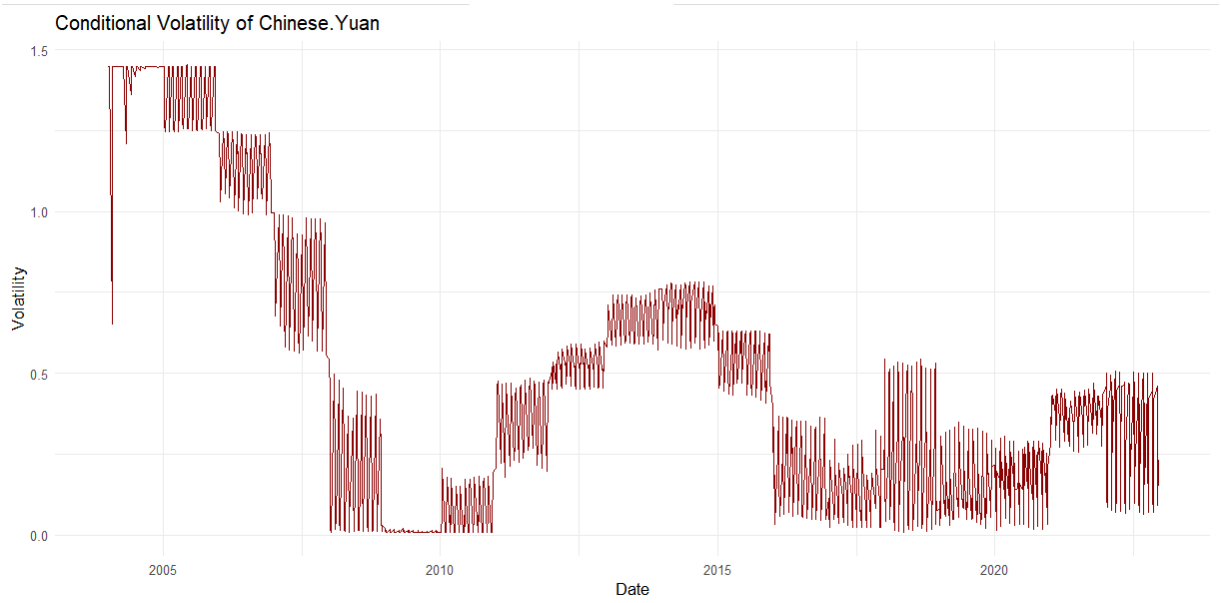
The graph presents a decomposition of a time series of the Chinese Yuan into three components: trend, seasonal, and remainder (sometimes referred to as the irregular or residual component).



- **Trend Component (Top Panel):** This shows the long-term movement of the exchange rate. It reveals a downward trend from 2004 to approximately the middle of 2007, indicating a period of strengthening for the Yuan, followed by a levelling off towards the end of the observed period.
- **Seasonal Component (Middle Panel):** The seasonal fluctuations represents patterns occurring at specific intervals within the data. In this graph, there appears to be a regular pattern that repeats over time, which could be due to fiscal policies, business cycles, or other economic fluctuations.
- **Remainder Component (Bottom Panel):** This captures the irregular movements in the exchange rate that are not explained by the trend or seasonal components. These are often unpredictable and can result from random factors. The plot shows varying activity, with the irregular component becoming larger towards the end of the period, suggesting an increase in unexpected fluctuations.

Example for interpreting GARCH conditional volatility graph:

The conditional volatility plot of the Chinese Yuan provides a visual representation of the currency's exchange rate volatility over time.



High spikes suggest periods of significant market uncertainty, where the Yuan's value changed unpredictably. Periods of low volatility reflect more stability in the currency's exchange rate, indicating less fluctuation and greater predictability. The plot reveals a phase of declining volatility from 2005 to around 2010, suggesting a stabilization in market conditions. However, post-2015, the volatility increases, indicating a return to uncertain market conditions. This plot is crucial for understanding the risk patterns associated with the currency, which can inform investment strategies and economic policy decisions.

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