Daily USD/JPY exchange rates are influenced by a host of factors ranging from macroeconomic trends, expectation of monetary policies and speculative investor action based on past price actions. A deep neural network trained on current and historical information is shown to be able to predict the next-day USD/JPY open rate.

Despite being a complex and nonlinear problem, the set of determining factors for USD/JPY rate seems to be reasonably finite, this suggests that a well-trained neural network could be effective in predicting price movements.

## Data Processing

**Input variables** including macroeconomic, financial, trade and monetary policies indicators are used:
- Spot daily rates of other major currencies: EUR/USD, GBP/USD, USD/CNY, NZD/USD and USD/CHF
- Consumer price inflation rates of US and Japan
- Close price of stock indices in US and Japan: S&P 500 Index and Nikkei 225
- Export and import price indices in US and Japan
- Cross-border trading volumes between US and Japan
- CBOT volatility index (VIX)

These variables dated from 1995-03-31 to 2017-06-11 were extracted manually from FRED, Quandl, Yahoo Finance, Bloomberg and Bureau of Labor Statistics and transformed into daily frequencies. Observations on the first 5000 days, next 1200 days and last 1200 days of the above-mentioned period were placed into the training, dev and test sets (70;15;15) respectively.

**Autoregressive factor of 1** is chosen based on time-series analysis. Consistent with Weak Efficient Market Hypothesis ("Markov property").

![Autocorrelation Function](image1.png)

![Partial Autocorrelation Function](image2.png)

## References


## Model

Deep Neural Network with inclusion of previous day close price was sufficient in providing robust prediction since price contains all past relevant information. Other "memory" models like Recurrent Neural Networks (RNNs), Time-Delay Neural Networks and Long Short-Term Memory (LSTMs) were all found to perform worse during preliminary testing, probably due to inclusion of additional noise.

**Mean Squared Error** is used as loss function.

**Hyperparameter tuning** was conducted in 3 phases based on RMSE of dev set, starting with 20+10+5 configuration with no regularization.

### Results

**Test results of tuned model** demonstrates low error rate. Test RMSE of 0.235 and test MAE of 0.222 significantly outperforms devRMSE of other models.

- Rel.Lv(20) = Rel.Lv(50) = Rel.Lv(5)
- No dropout regularization
- Epochs=2000
- Loss: MSE
- Adam Optimizer

## Portfolio Simulation

Investment Portfolios were generated using the test set based on 3 differing strategies:

![Portfolio Returns](image3.png)

With 10x leverage and mean absolute error of dev set as margin for investment, investor would have gained $14,853 on a $10,000 portfolio over 1000 days. That is an annualized return of 54.2% and Sharpe ratio of 0.834.