Causal Inference Case Study

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Case Study

Brexit - Withdrawal of the United Kingdom (UK) from the European Union (EU)

Objective - Impact of Brexit on Exchange Rates between British Pound(£) and US Dollar($)

Case Study by Google in 2021.

Dataset Preprocessing

Collection

From FRED
(Federal Reserve Economic Data)

Using URL of ‘fred.stlouisfed.org’.
Values of exchange rates on a daily basis are stored in the dataframe.

DATE	DEXUSEU	DEXUSUK
2012-01-03	1.3061	1.5655
2012-01-04	1.2930	1.5638
2012-01-05	1.2783	1.5480
2012-01-06	1.2723	1.5431
2012-01-09	1.2745	1.5436

Preprocessing

- Pre-period
  - From 2012 to 2016 June
- Post-period
  - After Brexit
  - 4 weeks after 2016 June
  - From 24th June to 22nd July. 2016

Causal Effect with Time Series Analysis

1. Pre-model training

Prophet model learns patterns (trends, seasonality) from the historical data (pre-period)

2. Projection into Post-Period

Based on the learned patterns, it forecasts expected values for the post-period.

3. Comparison with Observed Data

Predicted values act as the baseline (counterfactual). Observed values are compared to determine if there is a significant difference. i.e. ATE = Actual.mean( ) - Predicted.mean( )

Prophet Model by Meta

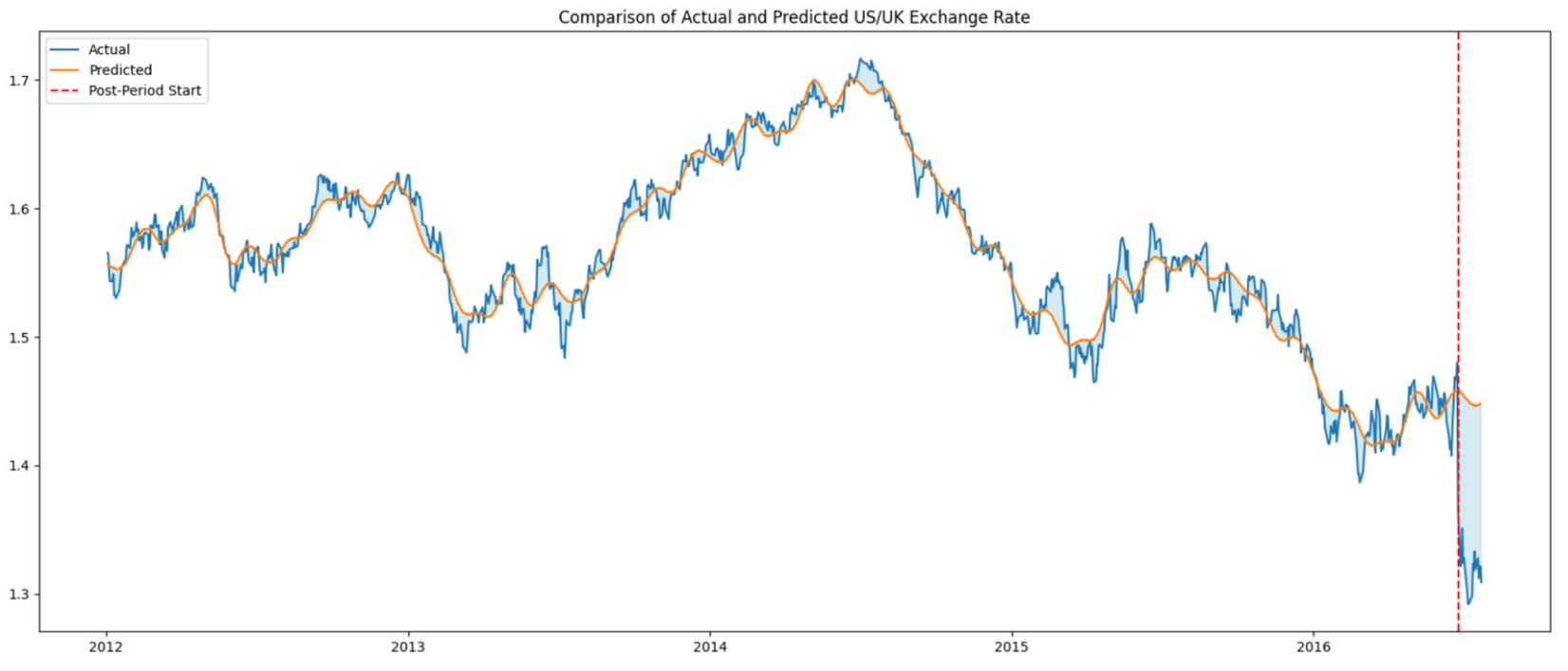
Result (without Regressor)

Exchange Rate

Blue Line : Actual data
Orange Line : Predicted data by time series model
Shaded region: Represents the decrement in the value in exchange rate

Exchange Rate decreased by 0.12, i.e. 8.58% than if Brexit had not occurred.

```
Actual US/UK exchange rate:    1.319
Predicted US/UK exchange rate: 1.451
Average treatment effect:     -0.124
Relative treatment effect:    -8.58%
```



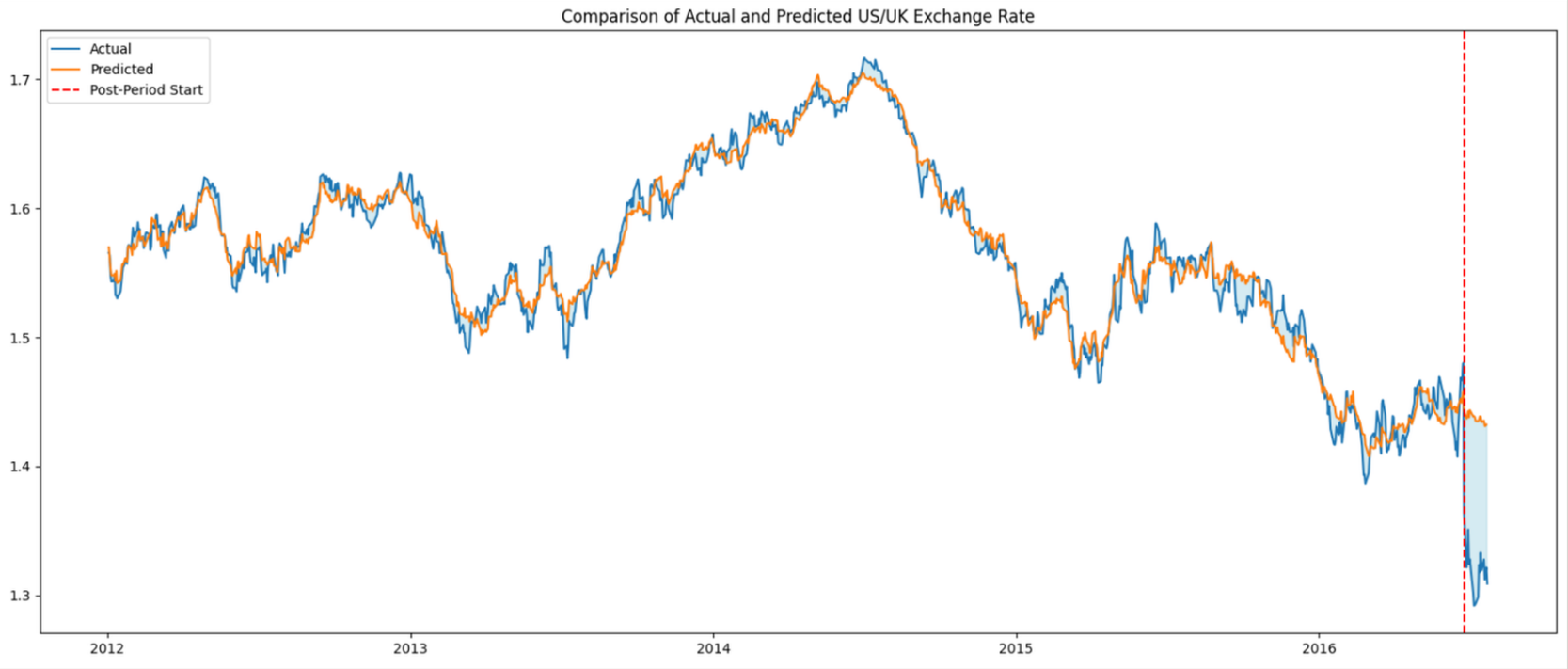
Result (with Regressor)

Exchange Rate

Blue Line : Actual data
Orange Line : Predicted data by time series model
Shaded region: Represents the decrement in the value in exchange rate

Exchange Rate decreased by 0.112, i.e. 7.77% than if Brexit had not occurred.

```
Actual US/UK exchange rate:    1.319
Predicted US/UK exchange rate: 1.437
Average treatment effect:     -0.112
Relative treatment effect:    -7.773%
```



USD, GBP, Euro

The Euro:USD and GBP:USD exchange rates usually move together because both are influenced by similar market factors.

Using Euro:USD, we can estimate what GBP:USD might have been without Brexit.

Causal Variables

Treatment

Brexit vote that might have caused the Pound to drop.

Outcome

GBP:USD exchange rate, which dropped sharply after the vote.

Control

Euro:USD exchange rate, as a benchmark.

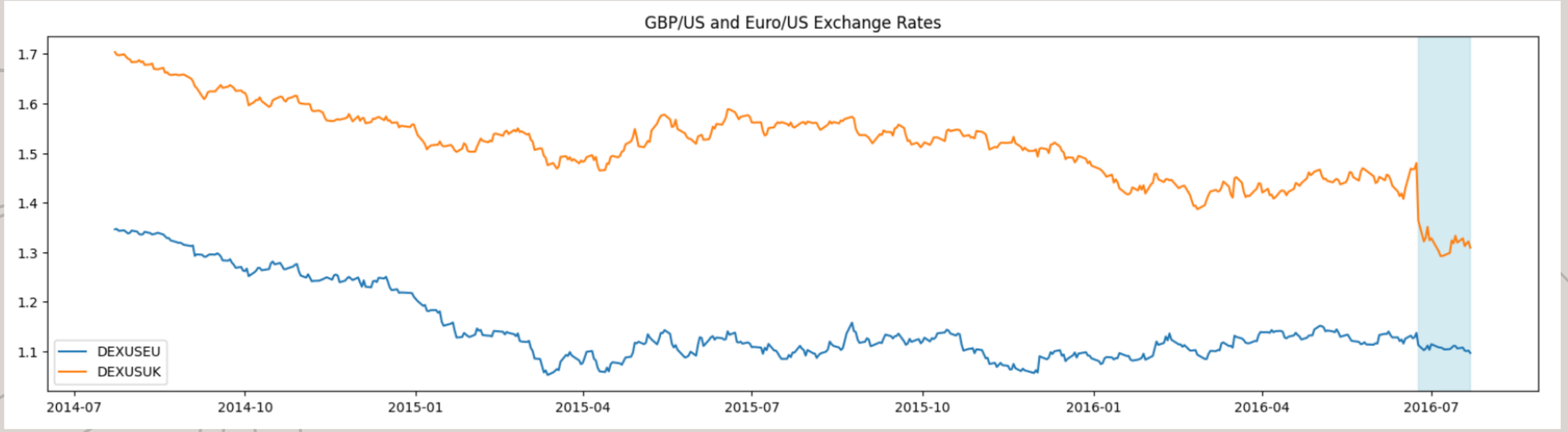
Why Euro:USD as Control?

Before treatment

Pearson Correlation between two exchange rates was 0.76.
So, they were quite similar in how they behaved.

After treatment

Only GBP:USD rate dropped, not Euro:USD! Thus, can be used as counterfactual.



CausalImpact Library

1. Pre-model training

Algorithm learns relation between DEXUSUK and DEXUSEU

2. Counterfactual Prediction

Using learned relationship, model predicts what the target variable would have been in post-period.

3. Causal Effect Estimation

Actual observed values in the post-period are compared to the predicted counterfactual values to estimate causal effect

Result

Relative Effect

Exchange rate post-Brexit was 9.7% lower than what would have been if Brexit hadn't occurred.

p-value

Observed p-value of 0% means o% of occurring due to random chance. So, very significant results.

Prob. of Causal Effect

Fully confident that Brexit had an impact on the exchange rate.

	Average	Cumulative
Actual	1	26
Predicted	1	29
95% CI	[1, 1]	[28, 29]
Absolute Effect	0	-2
95% CI	[0, 0]	[-2, -3]
Relative Effect	-9.7%	-9.7%
95% CI	[-7.2%, -12.2%]	[-7.2%, -12.2%]
P-value	0.0%	
Prob. of Causal Effect	100.0%	

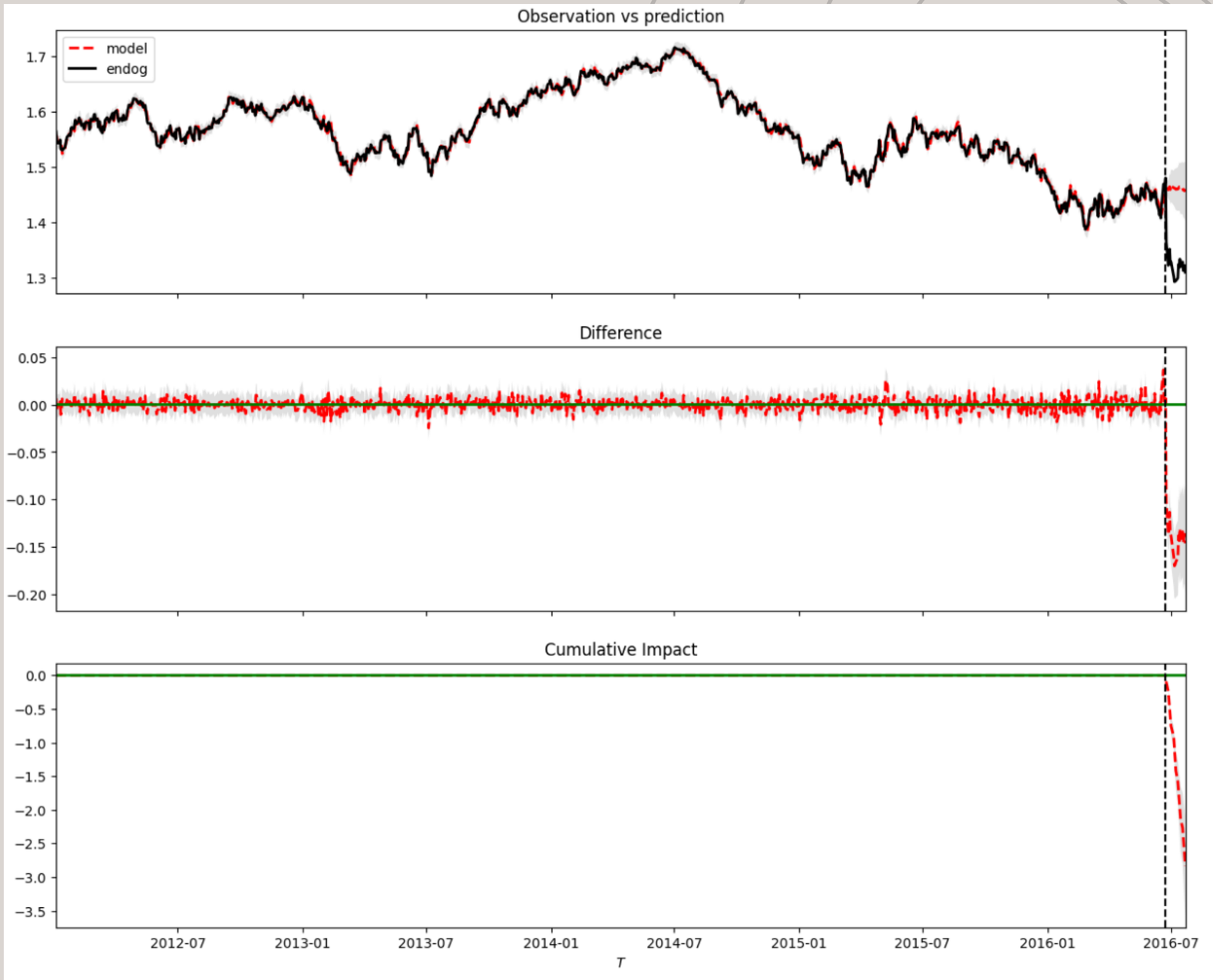
Average Treatment Effect during the post-treatment period is a drop of about 9%.

Result

Exchange Rate

Black Line: Observed data
Red line: Actual data
Shaded region: Represents uncertainty in the model's estimates

The difference between actual and predicted exchange rate of USD:GBP lowered to negative values.



Thank You