HS2101

Evaluating the Long-Run Validity of Purchasing Power Parity Between India and the United States

Evidence from August,2015 to February,2025

Real Exchange Rate

Consumer Performance Index

Purchasing Power Parity

Our Plan Of Action

In this project, We aim to evaluate the long run validity of Purchasing Power Parity (PPP) between India and the United States over the period August 2015 to December 2024.

- Checked stationarity of the real exchange rate (RER) for 2015–2024.
- If We found the full sample to be non stationary.
- Performed structural break analysis.
- Split data into sub-periods based on breaks.
- Tested stationarity within each sub-period.
- Verified partial validity of PPP across these periods.

Understanding Real Exchange Rate

The Real Exchange Rate (RER) measures the relative price of goods between two countries, taking into account both the nominal exchange rate and the price levels in each country. It tells us how expensive domestic goods are compared to foreign goods in terms of a common currency.

$$\text{RER} = S \times \frac{P^*}{P}$$

Where:

- S = nominal exchange rate (domestic currency per unit of foreign cur rency)
- P*= foreign price level (e.g., US CPI)
- P =domestic price level (e.g., Indian CPI)

Understanding Purchasing Power Parity and Its Puzzle

Purchasing Power Parity (PPP) is the idea that identical goods should have the same price across countries once their prices are converted using the exchange rate, meaning the real exchange rate should eventually return to 1. However, in practice, real exchange rates often deviate from this theoretical level for long periods, showing slow or incomplete adjustment. This persistent gap between theory and real-world behavior is known as the PPP puzzle.

Data and Methods Used

The data for this study has been collected from Federal Reserve Economic Data (FRED), a reliable source for historical economic time series.

Here are some helpful links:

- **Nominal Exchange Rate (DEXINUS)**
- **India CPI (INDCPIALLMINMEI)**
- **US CPI (CPIAUCSL)**

Methods:- Augmented Dickey Fuller (ADF) test to examine the **stationarity** of ln(RER)

Testing Validity of PPP using time series ln_RER

$$\ln(RER) = \ln(S) + \ln(P^*) - \ln(P)$$

1. **Step-1 : Stationarity (ADF Test)**

   ln(RER) is stationary (p < 0.05) → satisfies the key condition for long-run PPP.

2. **Step-2 : Mean Reversion (Half-Life)**

   ln(RER) deviations revert to equilibrium:

   - Half-life < 3 years → Strong PPP
   - Half-life 3–5 years → Moderate PPP

3. **Step-3: Mean Test (t-Test for μ = 0)**

   - p < 0.05 → Absolute PPP (mean ln(RER) ≈ 0)
   - p > 0.05 → Relative PPP (mean ≠ 0 but stable)

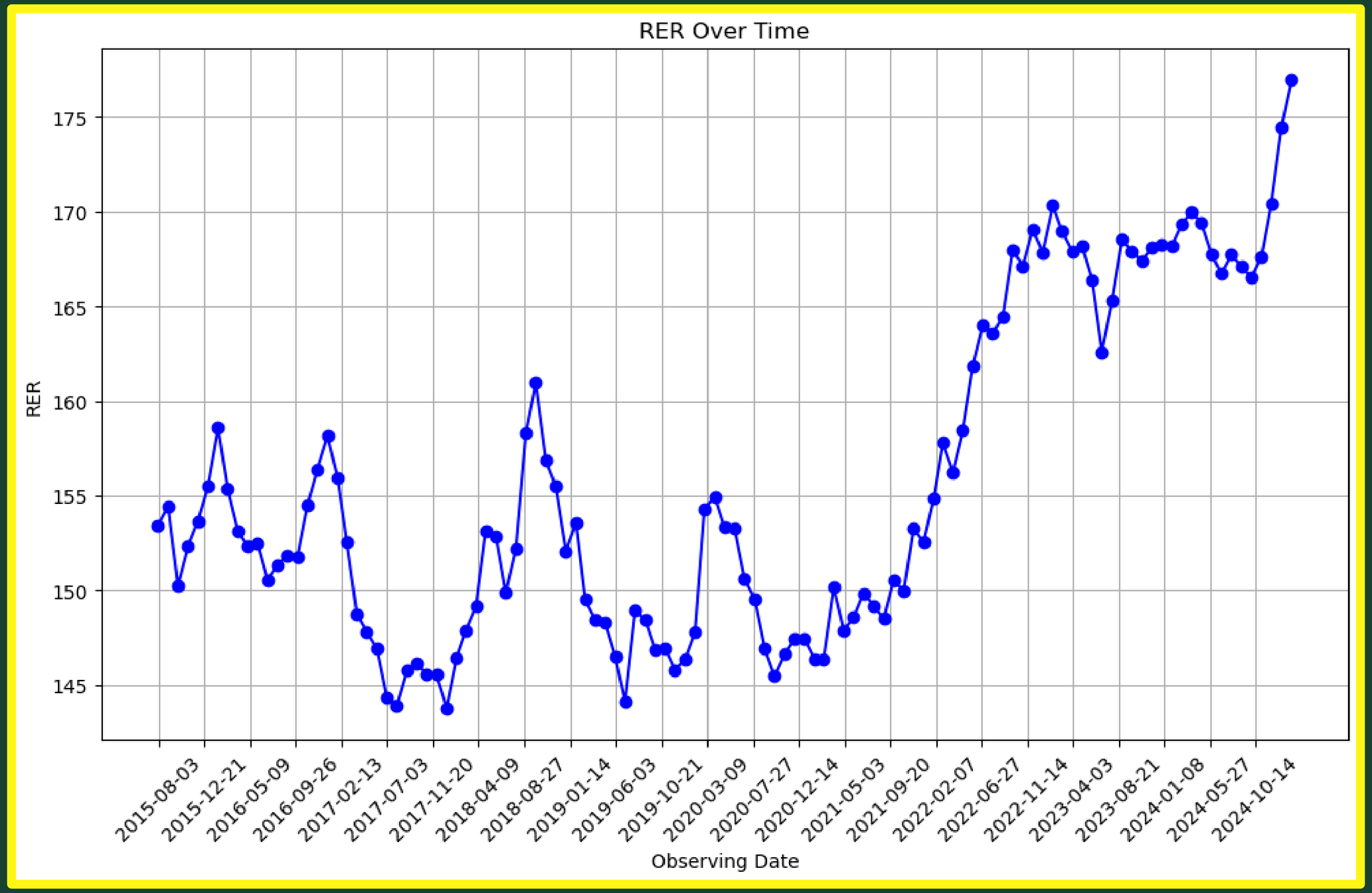
The Analytical Utility of the Log-Transformed RER (ln(RER))

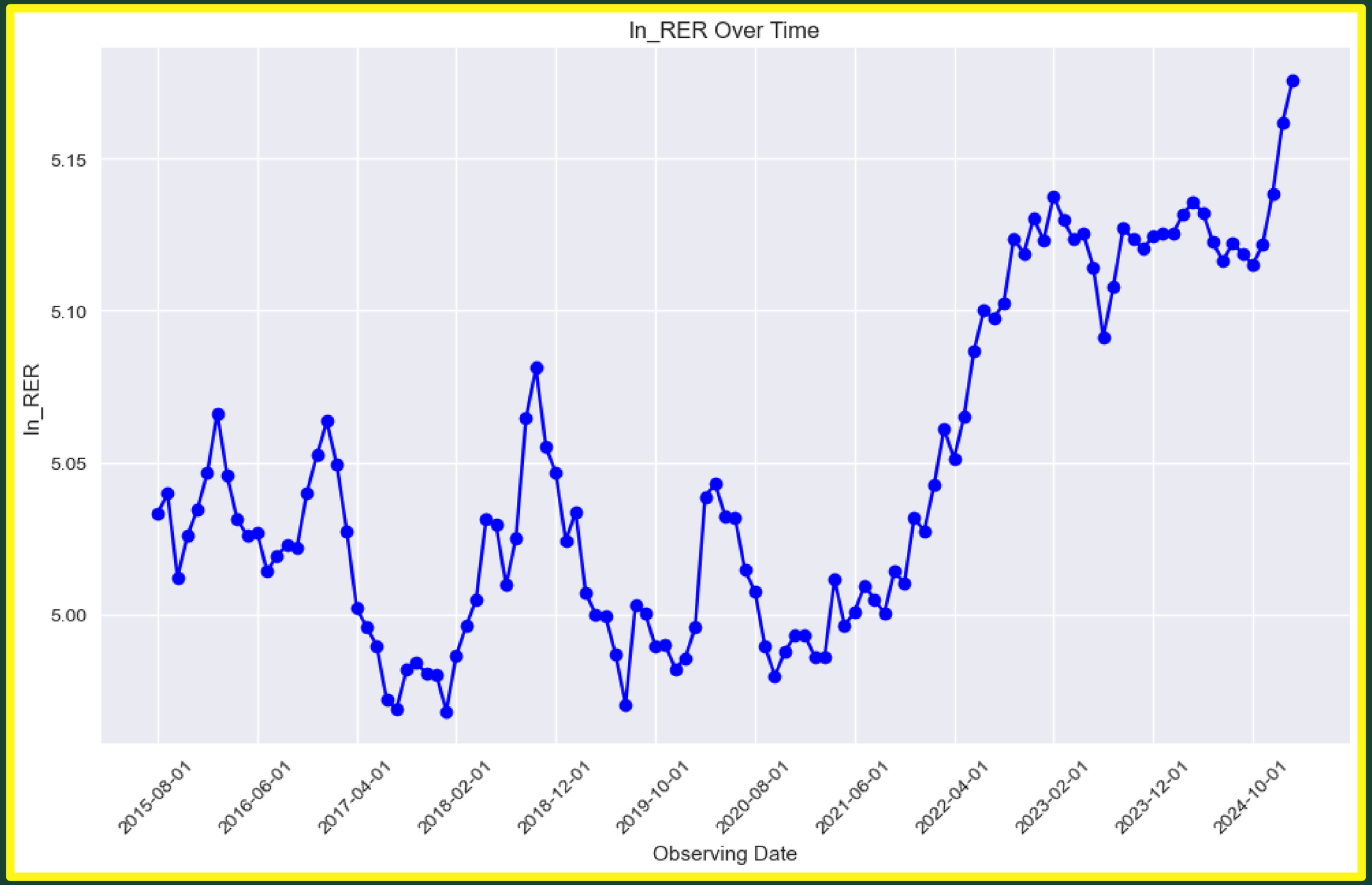
Before beginning the analysis, We perform a standard data transformation. We converted the RER equation into its natural logarithm (ln) form 1:

$$\ln(RER) = \ln(S) + \ln(P^*) - \ln(P)$$

The log transformation is applied for “convenience” and to allow results to be interpreted as proportional changes. But also there are deeper econometric reasons why this transformation is essential to the analysis.

- **Linearizing Growth:** Economic and financial variables, such as prices and exchange rates, typically follow multiplicative (exponential) growth patterns rather than additive ones. Taking natural logarithms converts this exponential behavior into a linear form.
- **Stabilizing Variance:** Log transformations often stabilize the variance of a time series. Many statistical procedures, including those used in the paper, can perform poorly or even become invalid when the underlying data exhibit changing variance (heteroscedasticity).
- **Model Compatibility:** The AR(1), DF, and ADF frameworks are all linear regression models. To meaningfully apply these linear models to data that grow multiplicatively, the data must first be converted into an additive structure—which the log transformation accomplishes.

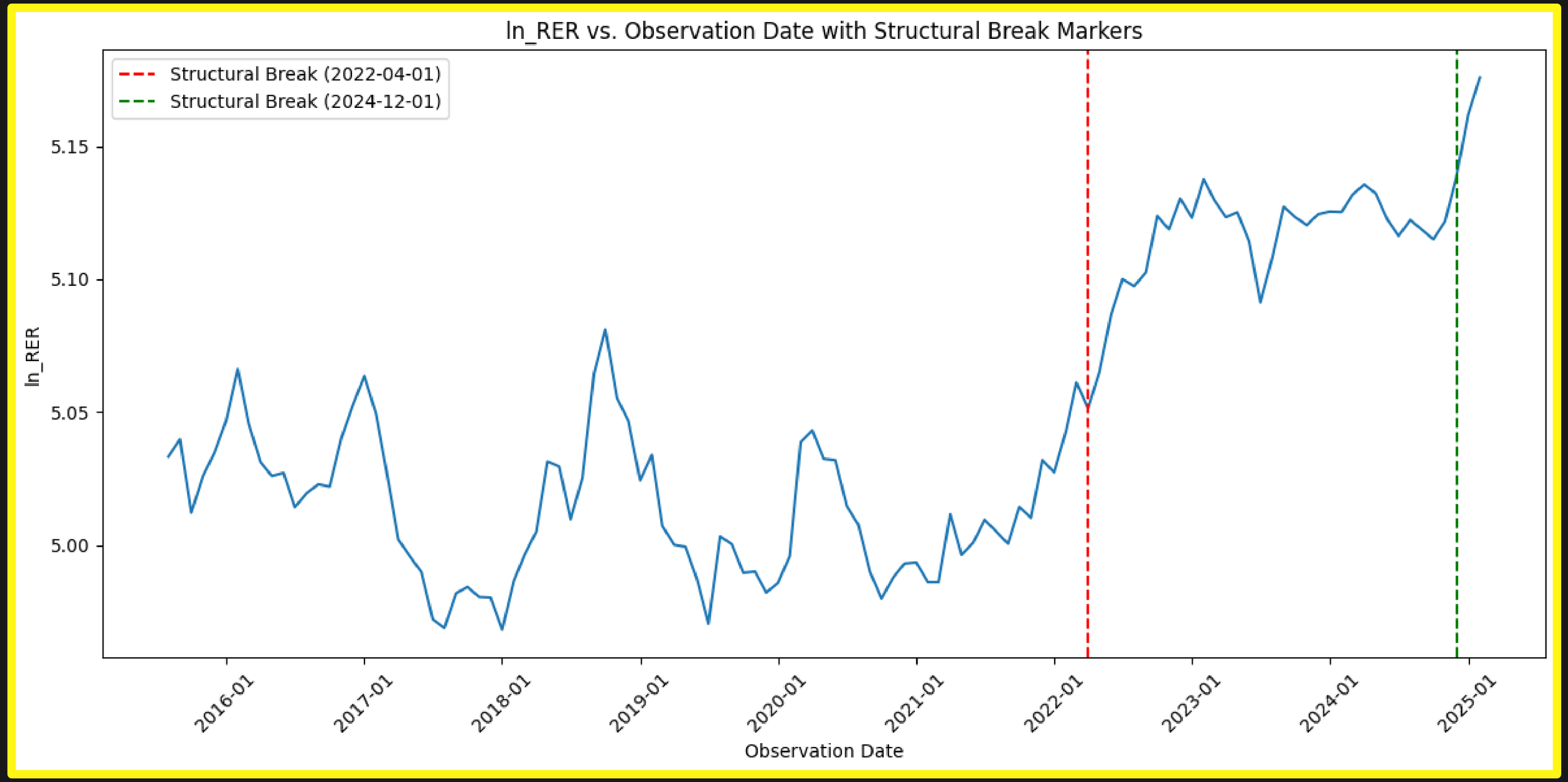

RER Over Time
RER
175
170
165
160
155
150
145
2015-08-03
2015-12-21
2016-05-09
2016-09-26
2017-02-13
2017-07-03
2017-11-20
2018-04-09
2018-08-27
2019-01-14
2019-06-03
2019-10-21
2020-03-09
2020-07-27
2020-12-14
2021-05-03
2021-09-20
2022-02-07
2022-06-27
2022-11-14
2023-04-03
2023-08-21
2024-01-08
2024-05-27
2024-10-14
Observing Date


ln_RER Over Time
ln_RER
5.15
5.10
5.05
5.00
2015-08-01
2016-06-01
2017-04-01
2018-02-01
2018-12-01
2019-10-01
2020-08-01
2021-06-01
2022-04-01
2023-02-01
2023-12-01
2024-10-01
Observing Date

Checking validity of PPP on the Full Sample (August 2015 to February 2025.)

```
ADF Test Result
ADF Statistic: -0.6358964881158041
p-value: 0.8626628772089138
Number of lags used: 1
Number of observations used: 113
```

Conclusion (Full Sample: Aug 2015 – Feb 2025):
The ADF test shows a very high p-value (0.86 > 0.05), indicating that ln(RER) is non-stationary in the full sample, and therefore PPP does not hold over the entire period.


ln_RER vs. Observation Date with Structural Break Markers
Structural Break (2022-04-01)
Structural Break (2024-12-01)
5.15
5.10
5.05
5.00
ln_RER
2016-01
2017-01
2018-01
2019-01
2020-01
2021-01
2022-01
2023-01
2024-01
2025-01
Observation Date

Checking Validity of PPP : August 2015 to April 2022

```
ADF Test Result
ADF Statistic: -3.044266641736 96
p-value: 0.0309621871089128 4
Number of lags used: 1
Number of observations used: 79
```

```
Mean Test (t-Test for μ = 0)
t-statistic: 1706.6507453868778
p-value: 3.166603724535652e-184
```

```
Half Life in Year = 0.3424116606992349
Half Life in Month = 4.108939928390819
speed of adjustment(%)= 34.24116606992349
```

Conclusion (Aug 2015 – Apr 2022):

ln(RER) is stationary (ADF p = 0.03 < 0.05), mean reverts rapidly with a very short half-life (~4 months), and the mean is highly significant (t-test), indicating strong and fast mean reversion but only relative PPP since μ ≠ 0.

Checking Validity of PPP from May 2022 to December 2024

```
ADF Test Result
ADF Statistic: -3.0422384492235737
p-value: 0.03113374200710614 8
Number of lags used: 3
Number of observations used: 28
```

```
Mean Test (t-Test for μ = 0)
t-statistic: 1819.6383373584533
p-value: 1.6190682658755322e-79
```

```
Half Life in Year = 0.11490396880641152
Half Life in Month = 1.3788476256769382
speed of adjustment(%)= 11.490396880641152
```

Conclusion (May 2022 – Dec 2024):

ln(RER) is stationary (ADF p = 0.03 < 0.05), shows very fast mean reversion with a half-life of about 1.4 months (strong PPP), and the mean is statistically different from zero (t-test p ≈ 0), indicating strong mean reversion but only relative PPP during this period.

Final Conclusion :
(Aug 2015 – Feb 2025)

- Full sample (Aug 2015 – Feb 2025) does not support PPP
  - ln(RER) is non-stationary (ADF p = 0.86 > 0.05) → PPP does not hold overall.
- Two Regimes Identified
  - Regime 1: Aug 2015 – Apr 2022
  - Regime 2: May 2022 – Dec 2024
- PPP holds within each regime (stationarity restored)
  - ln(RER) is stationary in both regimes (ADF p ≈ 0.03 < 0.05).
- Very fast mean reversion in both regimes
  - Half-life ≈ 4 months (Regime 1)
  - Half-life ≈ 1.4 months (Regime 2)

  → Strong PPP with quick adjustment.
- Relative PPP, not absolute PPP
  - Mean ln(RER) ≠ 0 in both regimes (t-test p ≈ 0) → Relative PPP holds regime-wise.

Thank You

Under The Guidance Of

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