Forecasting Consumer Price Index using Vector Error Correction Model

ECO619: Time Series Analysis and Forecasting

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Outline

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3. Data & Methodology
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Even though the past does indeed matter, we deny our own power and the power of development and change if we allow ourselves to be defined by the past, to be trapped in perceptions that use past patterns to limit present and future possibilities.

- Dudley Weeks, Author of The Eight Essential Steps to Conflict Resolution

Motivation

Do stock markets have any predictive power for inflation? SP500 is used as Composite index to derive its relationship with inflation.

The Fed Reserve lowers inflation by raising interest rates. Is the Fed Funds rate useful for prediction?

In this project, we have tried to answer all these questions.

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Literature Review

- Stock and Watson. (1988) observation that cointegrated variables share common stochastic trends provides a very useful way to understand cointegration relationships. The theory of the term structure implies that yields on similar assets of different maturities will be cointegrated. They applied these tests to postwar U.S. data on the federal funds rate and the three and twelve month treasury bill rates and provided support for their prediction.

- Mukherjee, T.K. and Naka, A. (1995) examines the short run impact of livestock export on economic growth in Somalia using annual time series data for the period 1990 − 2015 by applying cointegration analysis and vector error correction model (VECM).

- Ramin Cooper Maysami, Tiong Sim Koh (2000) study the long-term equilibrium relationships between the Singapore stock index and selected macroeconomic variables, as well as among stock indices of Singapore, Japan, and the United States. Using **vector error correction models (VECM)** they find that industrial production and trade, are not integrated of the same order as changes in Singapore's stock market levels.

VECM Models

Cointegration

We say two time series processes x_t and y_t are cointegrated if

- x_t and y_t are non stationary.
- x_t and y_t, being at $I(d)$, $\forall d \geq 1$, becomes stationary.
- $\exists_\beta : y_t - \beta x_t$, becomes stationary.

Cointegration is like a rubber band between the two time series with a stick of length β attached at endpoints.

If we have two time series processes y_t and x_t as cointegrated, then we can do something more powerful than any time series model.

VECM Models

Error Correction Model

So if two time series processes y_t and x_t are cointegrated, and are stationary at $I(1)$. then, there exists a long run linear relation, $\exists_{\alpha,\beta} : y_t^e = \alpha + \beta x_t^e$, . Now,

$$y_t = c_0 + c_1 x_t + c_2 x_{t-1} + c_3 y_{t-1} + u_t$$

problem!

$$y_t - \mathbf{y_{t-1}} = c_0^{\cdot} + c_1 x_t - \mathbf{c_1 x_{t-1}} + \mathbf{c_1 x_{t-1}} + c_2 x_{t-1} + c_3 y_{t-1} - \mathbf{y_{t-1}} + u_t$$

$$\Delta y_t = c_0^{\cdot} + c_1 \Delta x_t + \lambda(y_{t-1} - \alpha - \beta x_{t-1}) + u_t$$

where $\lambda = c_3 - 1$, $\beta = \dfrac{c_1 + c_2}{1 - c_3}$, and $\alpha = \dfrac{c_0^{\cdot} - c_0}{c_3 - 1}$.

Here, Δy_t and Δx_t are stationary at $I(0)$.
Also the term $(y_{t-1} - \alpha - \beta x_{t-1})$ will be cointegrated, so it has to $I(0)$.

VECM Models

Vector Error Correction Model
Then the general form for two conintegrated variable x_t and y_t, at $I(1)$ is given by

$$\Delta y_t = \dot{c_0} + \underbrace{\sum_{i=0}^{k} c_i \Delta x_{t-i} + \sum_{i=0}^{k} d_i \Delta y_{t-i}}_{\text{Short Run Dynamics}} + \underbrace{\lambda(y_{t-1} - \alpha - \beta x_{t-1})}_{\text{Long Run Dynamics}} + u_t$$

where we can use estimates of α and β using OLS regression (Engel-Granger Test).

Here, λ represents the speed of adjustment, which measures the speed at which, y_t returns to long-run equilibrium after a change in x_t

It is called an error correction model because of the fact that the last period deviation from the long-run equilibrium(the error) influences the short-term dynamics of the variable, just like a rubber band.

VECM Models

Since we are dealing with a linear combination of multiple variables, the first approach that comes to mind is **Vector Auto Regressive Model** . But if we have cointegrated variables then its more strong to use **Vector Error Correction Model**. Why?

- VAR is unable to deal with non-stationary variables.
- With VAR, even if we change the variables to stationary, it is likely that the impulse response function may not decay.
- Interestingly, VECM can interpret long-term and short-term dynamics.

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Data & Methodology

Dataset of following US economic indicators for the period 1959 - 2022 constructed by economists, Michael McCracken and Serena Ng:

1. Consumer Price Index (CPI)
2. Real Personal Income (RPI)
3. Unemployment rate (UNRATE)
4. Fed Funds rate (FEDFUNDS)
5. Stock Price Index (S&P 500)

Source: https://research.stlouisfed.org/econ/mccracken/fred-databases

Data & Methodology

O v e r v i e w

01 Stationarity tests- ADF, KPSS, PP, ZA

02 Cointegration test- Johnasen Test

03 Vector Error Correction Model

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Model Framework: Plots

Figure: Macroeconomic Variables
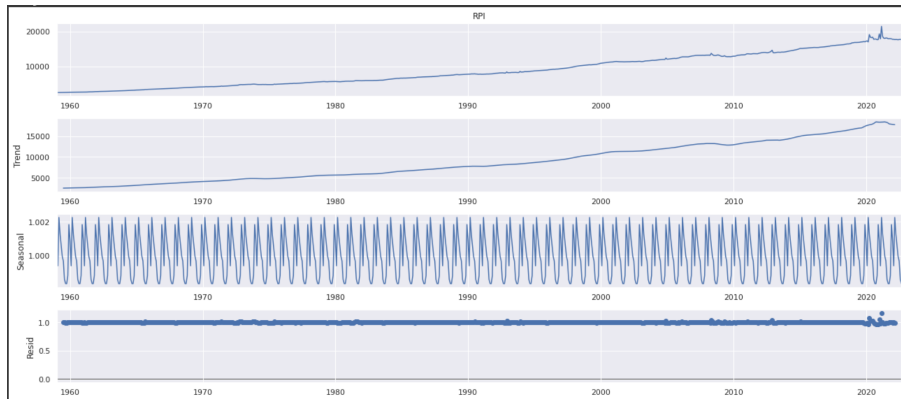
Model Framework: Plots

Figure: Decomposition of RPI (Real Personal Income) time series data set
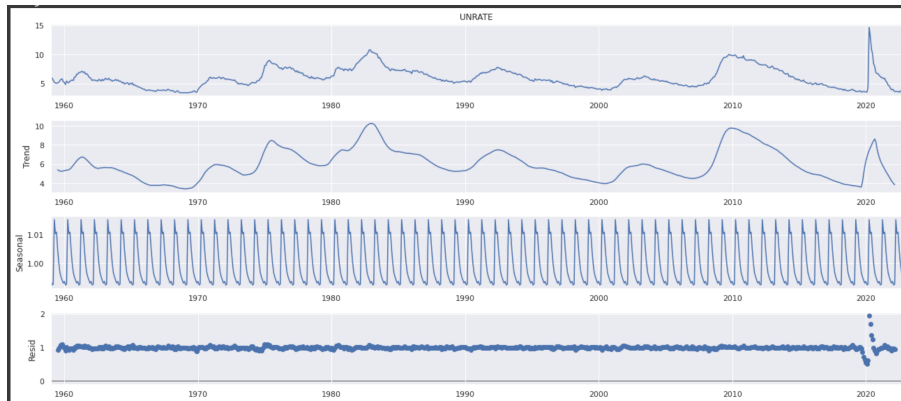
Model Framework: Plots

Figure: Decomposition of UNRATE (unemployment rate) time series data set
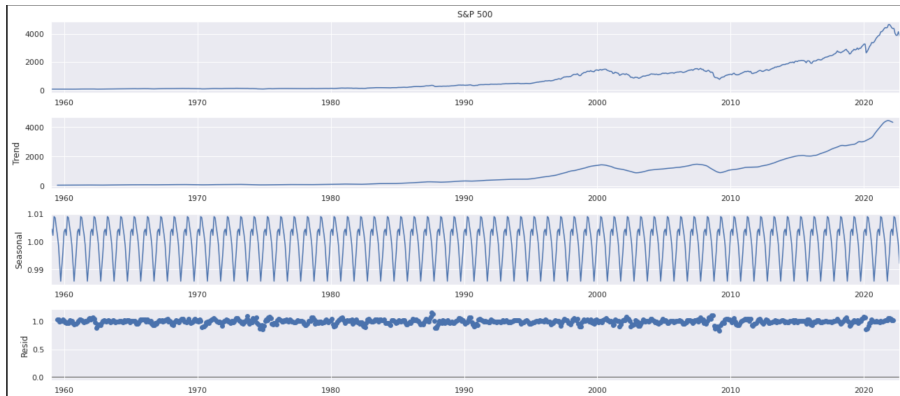
Model Framework: Plots

Figure: Decomposition of S&P 500 (Stock Price Index) time series data set
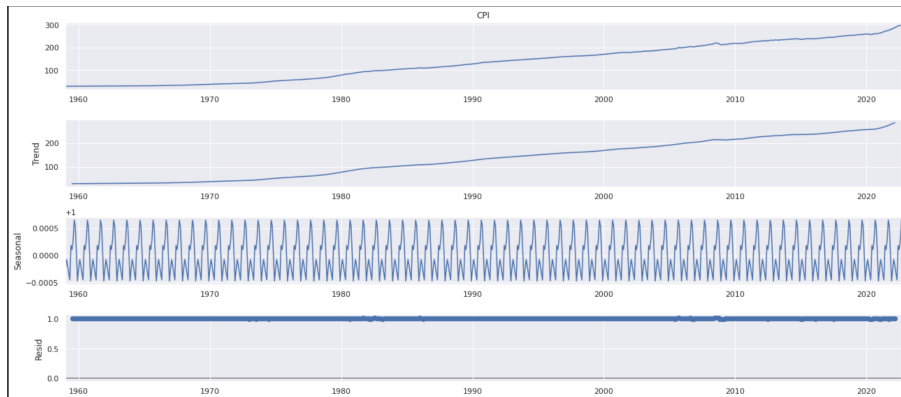
Model Framework: Plots

Figure: Decomposition of CPI (Consumer Price Index) time series data set
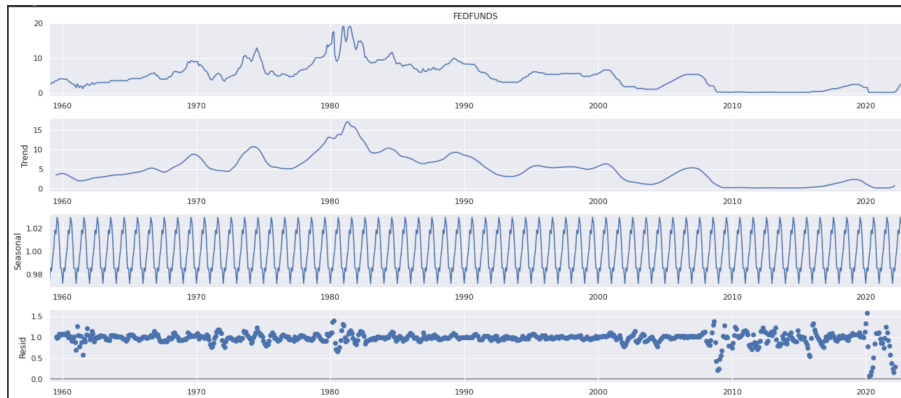
Model Framework: Plots

Figure: Decomposition of FEDFUNDS (Fed Funds rate) time series data set

Model Framework: Stationarity Tests

Variables	ADF	KPSS	PP	ZA
Real Personal Income	Non-stationary	Non-stationary	Non-stationary	Non-stationary
Unemployment Rate	Stationary	Stationary	Stationary	Non-stationary
Fed Funds Rate	Non-stationary	Non-stationary	Non-stationary	Stationary
Consumer Price Index	Non-stationary	Non-stationary	Non-stationary	Non-stationary
Stock Price Index	Non-stationary	Non-stationary	Non-stationary	Non-stationary

Table: 1. Stationarity Tests

Model Framework: Johansen Cointegration Test

Variables	RPI	UNRATE	S&P 500	CPI	FEDFUNDS
RPI	0	No Cointegration	No Cointegration	No Cointegration	No Cointegration
UNRATE	No Cointegration	0	Cointegration exists	Cointegration exists	Cointegration exists
S&P 500	No Cointegration	Cointegration exists	0	Cointegration exists	No Cointegration
CPI	Cointegration exists	Cointegration exists	Cointegration exists	0	Cointegration exists
FEDFUNDS	No Cointegration	Cointegration exists	No Cointegration	Cointegration exists	0

Table: 2. Cointegration Test
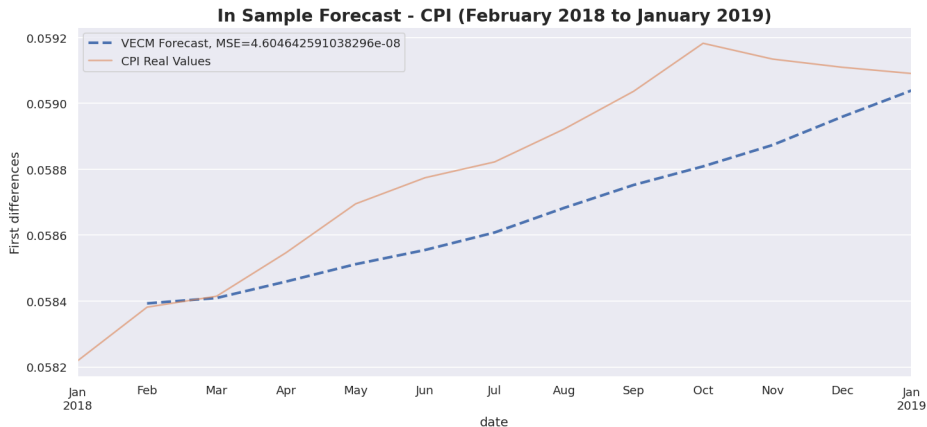
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Empirical Results

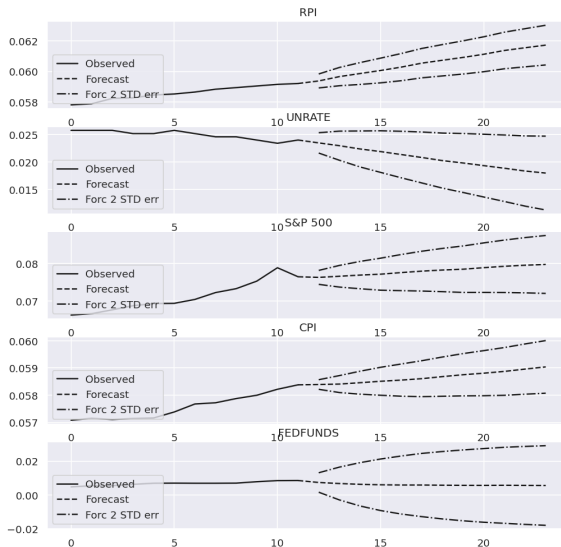Figure: VECM-In Sample Forecast of Consumer Price Index for 12 months

Empirical Results

Figure: VECM In Sample Forecast of Macroeconomic Variables for 12 months

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Scope of Further Studies

- In terms of policy implications, there is still value in looking to economic theory (such as the Phillips Curve) to assist in forecasting.
- The variables used in the model are significantly correlated and the results are quite pleasing, however this also signifies that there must exist more cointegrated variables.

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References

- Time-series Analysis with VAR & VECM: Statistical approach
- Error correction model
- Cointegration Slides, Dr. Biswajit Patra, IISER Bhopal
- A Guide to Conducting Cointegration Tests
- Bryan, M. F., Cecchetti, S. G. (1993). The consumer price index as a measure of inflation.
- Alchian, A. A., Klein, B. (1973). On a correct measure of inflation. Journal of Money, Credit and Banking, 5(1), 173-191.

Thank You