Time Series | Project

India's Month-over-Month Inflation Rates

A case study - Part 1 & 2

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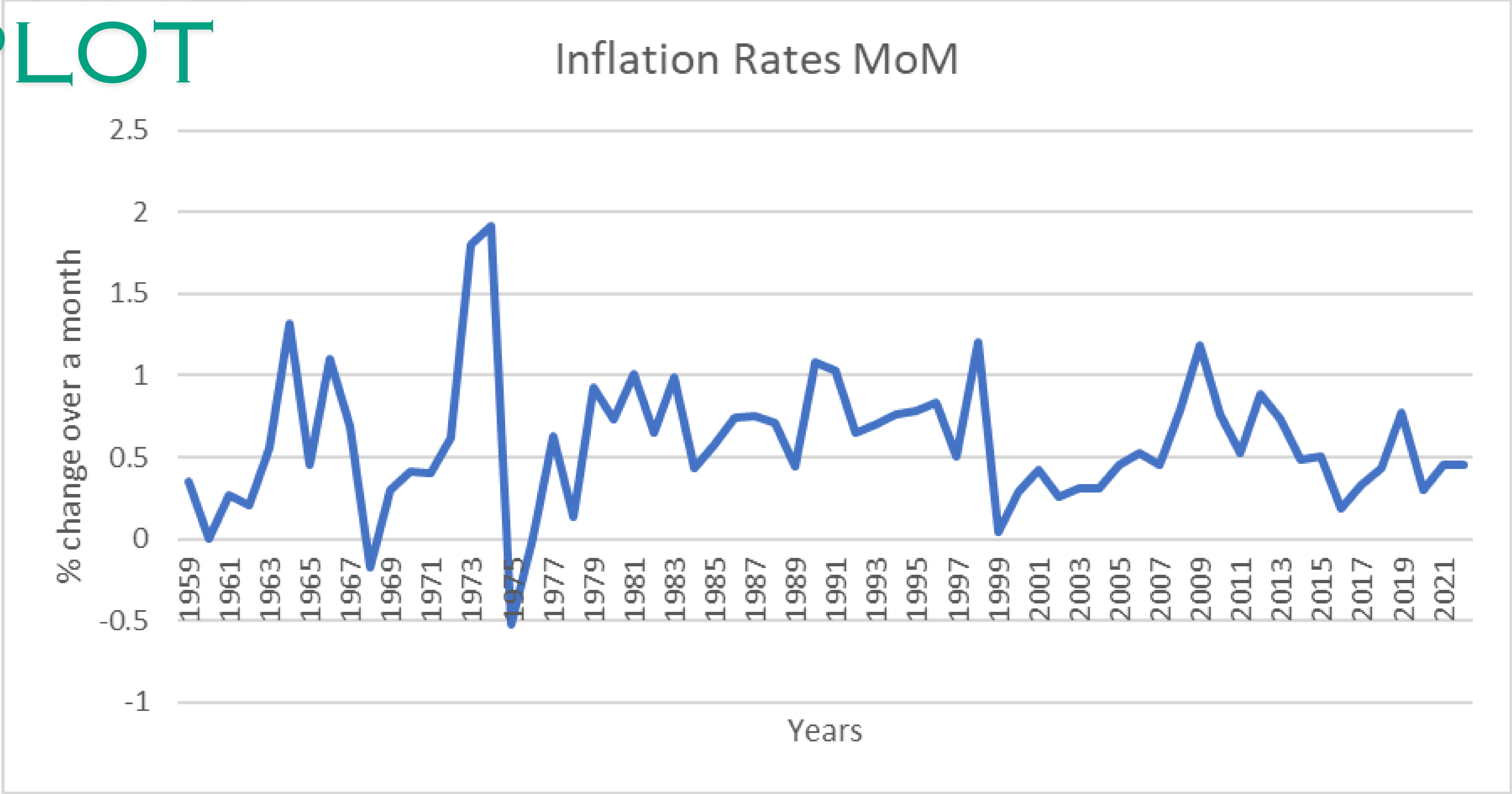
MoM Inflation Rates (1959-2022)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1959	-1.56	0.91	-0.9	0	1.58	1.78	2.41	0.85	-0.85	1.71	0	-1.68
1960	-1.5	0	-0.87	0.88	0.65	0.86	1.71	0	-0.84	0	-0.85	0
1961	-0.85	0	0.86	0	0	0.85	1.69	0.62	0	0	0	0
1962	-0.62	0	0	0.62	0.83	0.82	1.43	0.8	0	0.8	-0.79	-1.39
1963	-0.81	-0.81	0.82	0.81	0.61	1.61	0.79	0.78	0.58	0.77	0	1.54
1964	0	1.32	0.75	0.74	2.02	1.98	2.83	1.2	1.87	2.67	0	0.49
1965	0.65	-1.77	-1.96	0.67	0.66	1.32	2.92	1.26	1.25	0	0.46	0
1966	0	0.61	0	0.61	3.33	2.34	1.57	0.99	0.56	0.55	1.1	1.5
1967	0	0.54	0.94	1.06	1.97	2.44	0.88	1	-0.49	1.36	-0.37	-0.98
1968	2.85	-1.44	-1.83	0.5	-0.87	0.87	-0.5	2.24	0.61	0.48	-2.17	-2.83
1969	-0.63	-0.51	0.51	0.64	1.14	2.88	0.61	0	0	-0.6	-0.49	0
1970	0	0	1.1	1.09	1.08	1.18	0.47	0.58	0.46	0.58	0	-1.6
1971	-1.05	0	0	0	0	1.65	1.62	2.05	1	0	0.55	-0.99
1972	-0.55	-0.56	0.56	0.56	0.44	2.54	2.05	0.95	0.52	0.42	0.52	0
1973	0	1.44	1.42	2.3	3.13	2.18	4.28	1.69	0.44	2.36	1.96	0.42
1974	1.5	1.15	3	2.91	3.9	2.36	3.38	3.2	4.05	0.26	-1.16	-1.5
1975	0	-0.33	-1.2	0.61	1.21	0.33	-1.19	-0.94	-0.61	-0.95	-0.34	-2.89
1976	-2.55	-2.69	-1.42	1.06	0.37	0.3	2.08	0.36	1.31	0.65	0.64	0
1977	0.35	0.99	0.63	0.35	1.59	0.61	1.56	0.6	1.26	-0.33	0	0
1978	-1.51	-1.53	0.34	0.27	0.34	1.21	0.93	0.33	1.5	1.22	0	-1.53
1979	-0.84	-0.91	0.92	1.5	0.58	1.79	2.32	1.96	0.84	0.54	0.83	1.65
1980	-0.81	-0.58	1.12	0.52	1.91	1.02	2.08	0.77	1.25	0.97	1.23	-0.68
1981	0.69	1.74	0.47	1.65	1.42	1.4	1.82	1.55	0.43	0.9	0.42	-0.42
1982	-0.24	-0.19	-0.24	0.43	0.66	1.73	1.7	2.08	0.22	0.4	1.01	0.22
1983	-0.44	1.05	0.39	1.21	2.56	2.28	1.5	1.48	0.91	0.7	0.54	-0.35
1984	0.74	-0.38	-0.54	0.19	0.54	2.12	1.92	0.19	0.52	0.51	0.48	-1.16
1985	0	-0.52	0.19	1.37	0.98	1.01	1.5	0.49	0.14	0.98	0.8	0
1986	-0.17	0.65	0.79	0.78	1.25	1.06	1.55	0.58	0.61	1.31	1.01	-0.56
1987	0	-0.28	0	0.73	1.72	1.72	1.24	1.67	1.21	0.67	0.66	-0.37
1988	0.12	-0.52	0.52	1.32	1.05	1.43	1.66	0.63	0.76	2.12	0.6	-1.19
1989	-0.6	0	0.61	0.6	1.2	0.59	1.18	1.16	1.15	0	0	-0.57
1990	-0.57	0.57	1.14	1.69	1.11	1.65	2.16	0.53	0.53	2.09	1.54	0.51
1991	1.51	0	-0.5	0.5	0.99	2.45	2.39	1.4	1.84	0.91	0.9	0
1992	1.33	0.44	0	0.87	1.3	0.85	2.54	0	0.41	0.41	0	-0.41
1993	-0.82	0	0.83	0.82	0.41	1.63	1.2	1.19	1.17	1.16	1.15	-0.38
1994	-0.38	0.76	0.75	0.75	1.12	1.84	1.44	1.07	1.41	0.35	0.69	-0.69
1995	0	0.69	0.69	0.68	1.69	2	2.29	0.64	0.63	0.63	0.63	-1.25
1996	-0.63	0.32	0.95	1.57	1.23	1.52	1.8	1.18	0.29	0.58	0.87	0.29
1997	0	0	0.29	0.85	-0.56	0.85	0.85	0.28	0.56	1.11	0.27	1.64
1998	3.23	-0.52	-0.52	0.79	1.57	2.57	3.01	0.49	1.69	3.1	1.15	-2.05
1999	-2.1	-1.19	-0.24	0.24	0.96	0.24	0.95	0.47	0.7	1.86	0.23	-1.6
2000	0	-0.23	0.93	0.92	0.46	0.45	0.68	-0.45	0.23	1.13	0.22	-0.89
2001	-0.22	-0.45	0.45	0.67	0.67	1.33	1.31	0.65	-0.21	0.65	0.85	-0.64
2002	-0.43	-0.21	0.43	0.21	0.64	0.85	1.05	0.62	0.21	0.41	0.41	-1.02
2003	-0.21	0.21	0.62	1.23	0.2	0.61	0.8	-0.4	0	0.8	0.2	-0.4
2004	0.4	0	0	0	0.79	0.79	0.98	0.97	0.19	0.57	-0.19	-0.76
2005	0.96	-0.19	0	0.76	-0.38	0.38	1.7	0.37	0.37	1.11	0.91	-0.54
2006	-0.18	0	0	0.84	0.83	1.65	0.81	0	0.81	1.6	0	0
2007	0	0.79	-0.78	0.79	0.78	0.78	1.54	0.76	0	0.75	0	0
2008	0	0.75	1.48	0.73	0.72	0.72	2.14	1.4	0.69	1.37	0	-0.68
2009	0.68	0	0	1.35	0.67	1.32	4.58	1.25	0.62	1.23	1.82	0.6
2010	1.78	-1.16	0	0	1.18	1.16	2.3	0	0.56	1.12	0.55	1.65
2011	1.62	-1.6	0	0.54	0.54	1.07	2.12	0.52	1.55	0.51	0.51	-1.01
2012	0.51	0.51	1.01	1.99	0.49	0.97	1.92	0.94	0.47	0.93	0.46	0.46
2013	0.91	0.9	0.45	0.89	0.88	1.32	1.73	0.85	0.42	1.26	0.83	-1.65
2014	-0.84	0.42	0.42	1.26	0.83	0.82	2.44	0.4	0	0	0	0
2015	0.4	-0.39	0.4	0.79	0.78	1.16	0.77	0.38	0.76	1.13	0.37	-0.37
2016	0	-0.74	0.37	1.12	1.48	0.73	1.08	-0.71	-0.36	0.36	-0.36	-0.72
2017	-0.36	0	0.36	0.73	0.36	0.72	1.79	0	0	0.7	0.35	-0.69
2018	0.7	-0.35	0	0.35	0.35	0.69	3.44	0	0	0.33	0	-0.33
2019	1.99	0	0.65	0.97	0.64	0.64	0.95	0.31	0.63	0.93	0.92	0.61
2020	0	-0.61	-0.61	0.92	0.3	0.61	1.2	0.6	0.64	1.19	0.33	-0.92
2021	-0.51	0.68	0.5	0.42	0.42	0.91	0.9	0.16	0.24	1.3	0.64	-0.24
2022	-0.24	-0.08	0.8	1.35	1.02	0.16	0.54	0.23	0.84	0.91	0	-0.15

TIME PLOT



Inflation Rates MoM
2.5
2
1.5
1
0.5
0
-0.5
-1
% change over a month
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
Years

DATA EXPLORATION

Three major extremums in the inflation plot can be seen:

1) Peak 1960s:
From 1964-67, prices rose at double-digit rates due to the wars fought in Year 1962 and 1964. By the end of the decade, inflation cooled down and was even negative in 1969 aided by a bumper crop and Green revolution initiatives.

2) High rise 1970s:
The 70s were the most tumultuous period in terms of inflationary uncertainty. International crude oil prices were up by over 250 per cent in 1974 amidst the first oil shock of 1973. Heavy dependence on oil imports resulted in higher domestic fuel prices with its effects on other consumer products. Thus, higher fuel prices and agricultural commodity prices got reflected in overall inflation in 1976 . Also due to national Emergency in 1975, it faced the lowest inflation.

3) 1991-1999 (LPG policy)
Inflation spiked again in the 90s as India devalued and went through a payment crisis. The liberalization of the early 90s helped keep inflation low as supply pressures eased, and productivity increased..
Inflation continued to be high for a few years – from 1992-1996 . Later it came down sharply over the next decade (1996-2005) as structural reforms started bearing fruit.

DATA EXPLORATION(contd)

4) 2008 -2009 (Effect of oil price and elections)
Oil price rise saw inflation temporarily go into double digits (not reflected in annual numbers) and interest rates went all the way to 9%.As the elections removed the LEFT from power in 2009, the subsequent recovery then took inflation back up vigorously, and it has been above the 8% mark since.

5) 2014 -2016 (Effect of Demonetization and GST Measures)
In 2014-15, the major crude oil price crash resulted in inflation falling to below the 0.51%.However, since 2016, inflation levels were down with the economic slowdown and as demonetization and GST measures got implemented.

6) 2019-2021 (Effect of COVID 19)
The Covid crisis in 2020 took the rupee to a USDINR rate of 75, and with supply shocks all over the world, inflation moved up to 6% again, before cooling down to below 5% in the subsequent year.

TIME SERIES MODEL

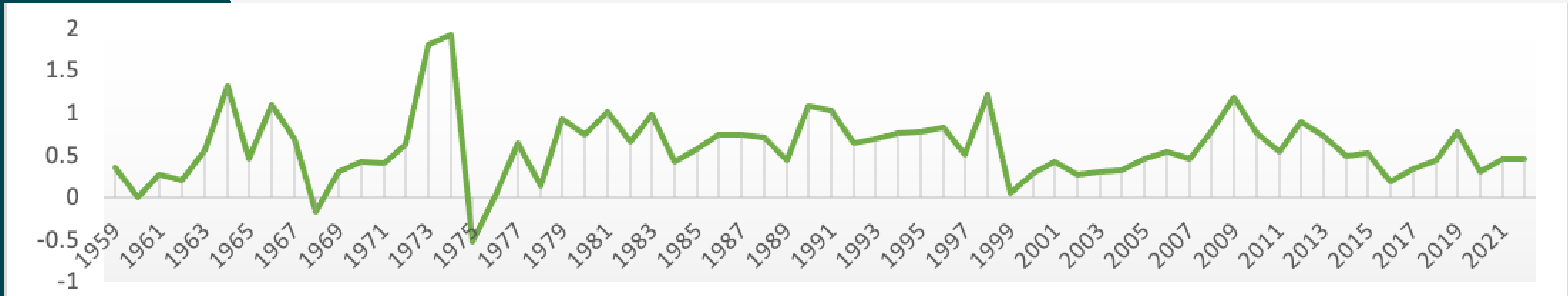
If y_t represents the inflation rate at time t, then the multiplicative model is

$$y_t = T_t S_t C_t R_t$$

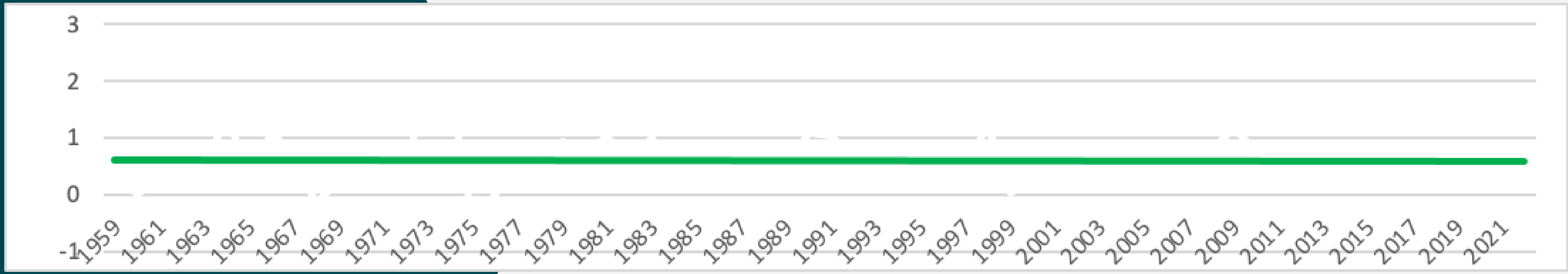
where T_t, S_t, C_t and R_t represent Trend, Seasonal, Cyclical and Random Components respectively. The Multiplicative model is used here such that in the phenomenon of Inflation rates, all the significant components are known to be interdependent on each other.

TIME SERIES DECOMPOSITION

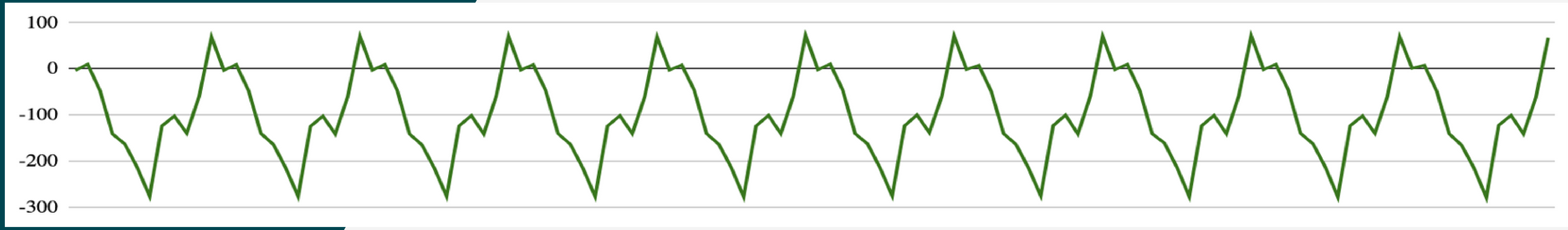
DATA



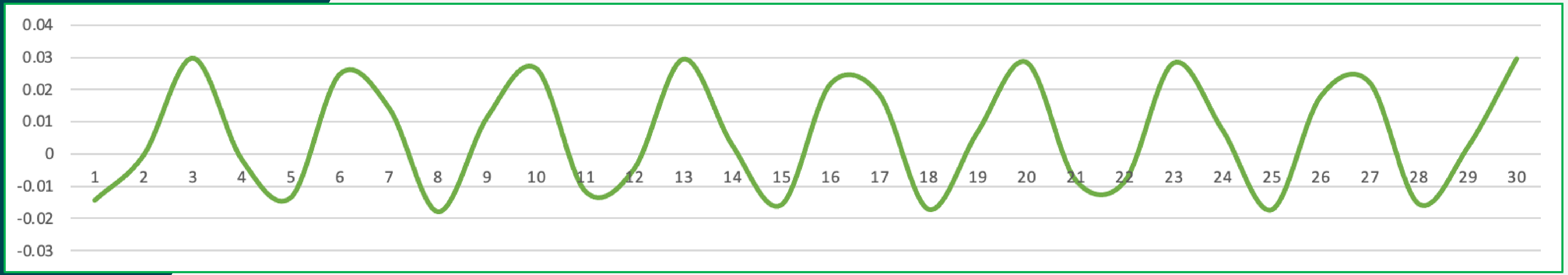
TREND



SEASONAL



CYCLICAL



DEFENSE FOR THE ABSENCE OF A PROMINENT TREND

Variate Difference Method

n	64	63	62
k	0	1	2
sum sq	32.81622	16.86465	44.46045
2kCk	1	2	6
$\mu 2$	0.512754	0.267693	0.717104
H(k,64)	7.934	16.095	21.8645
σ	0.512754	0.133846	0.119517
Rk	5.862951	1.723068	
5% l.o.s	1.96	1.96	

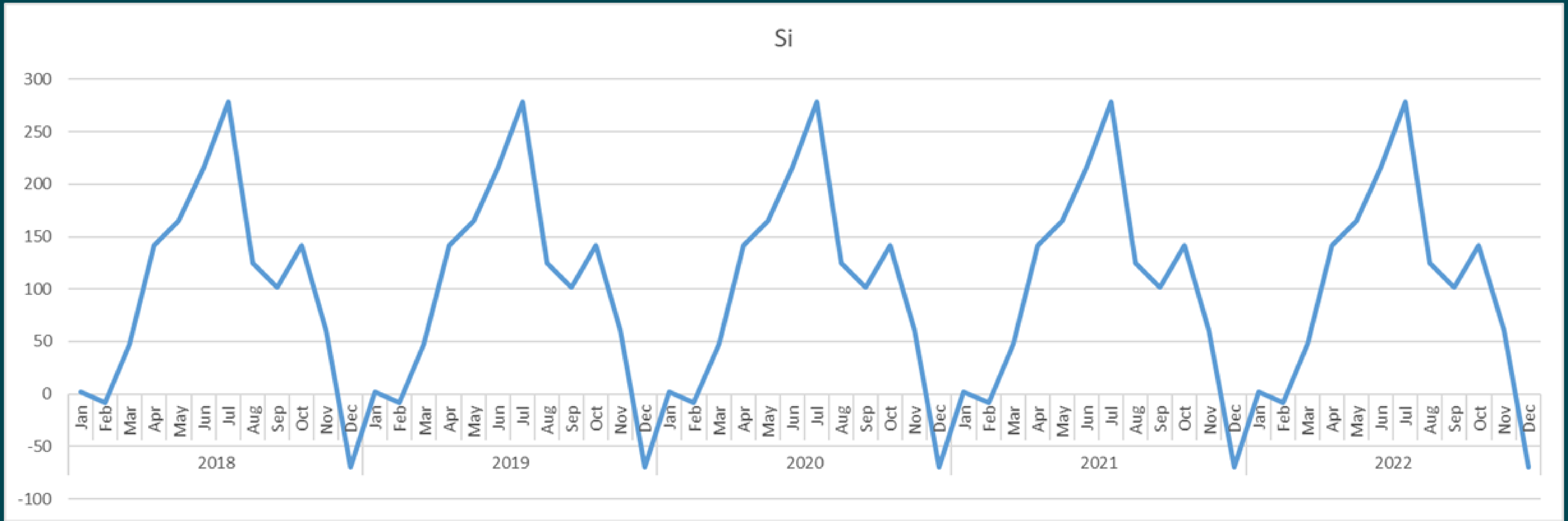
Corresponding to k = 1, we fail to reject the null hypothesis, implying that (k-1)th degree polynomial can be fitted to represent the systematic part.

Negligible to No Trend

Corresponding to $k = 1$, the required degree of the polynomial is coming out to be 0.
It can thus be interpreted that the given data has no statistical trend that can be plotted.

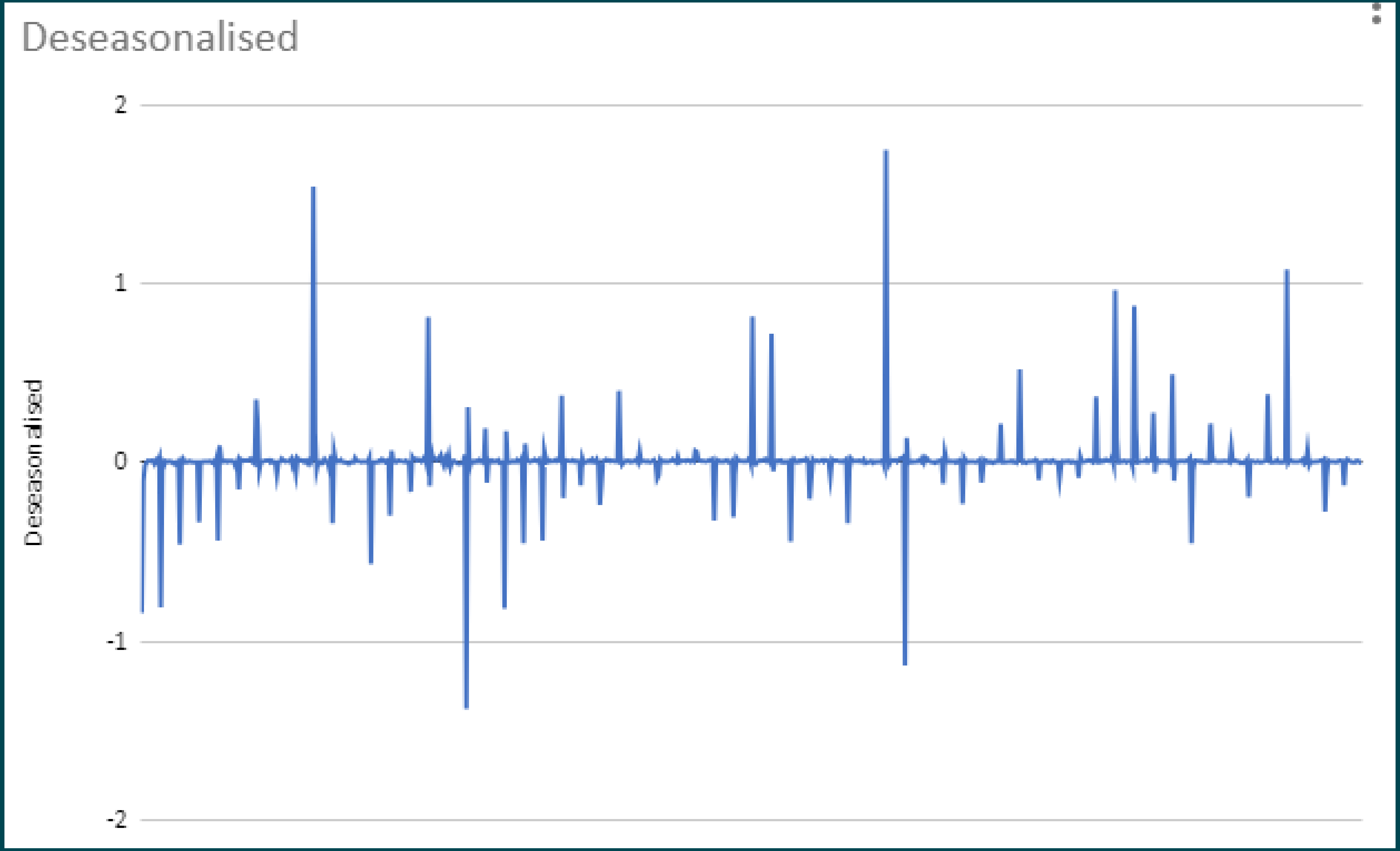
Seasonal Component

Months	Seasonal Indices
Jan	1.850505585
Feb	-8.723812042
Mar	47.18789241
Apr	141.6165488
May	164.7478686
Jun	215.9804375
Jul	278.6068337
Aug	124.8298196
Sep	101.9099861
Oct	141.5372414
Nov	60.51153262
Dec	-70.05485427



Devising the method of Simple Averages, seasonal indices were computed and listed.

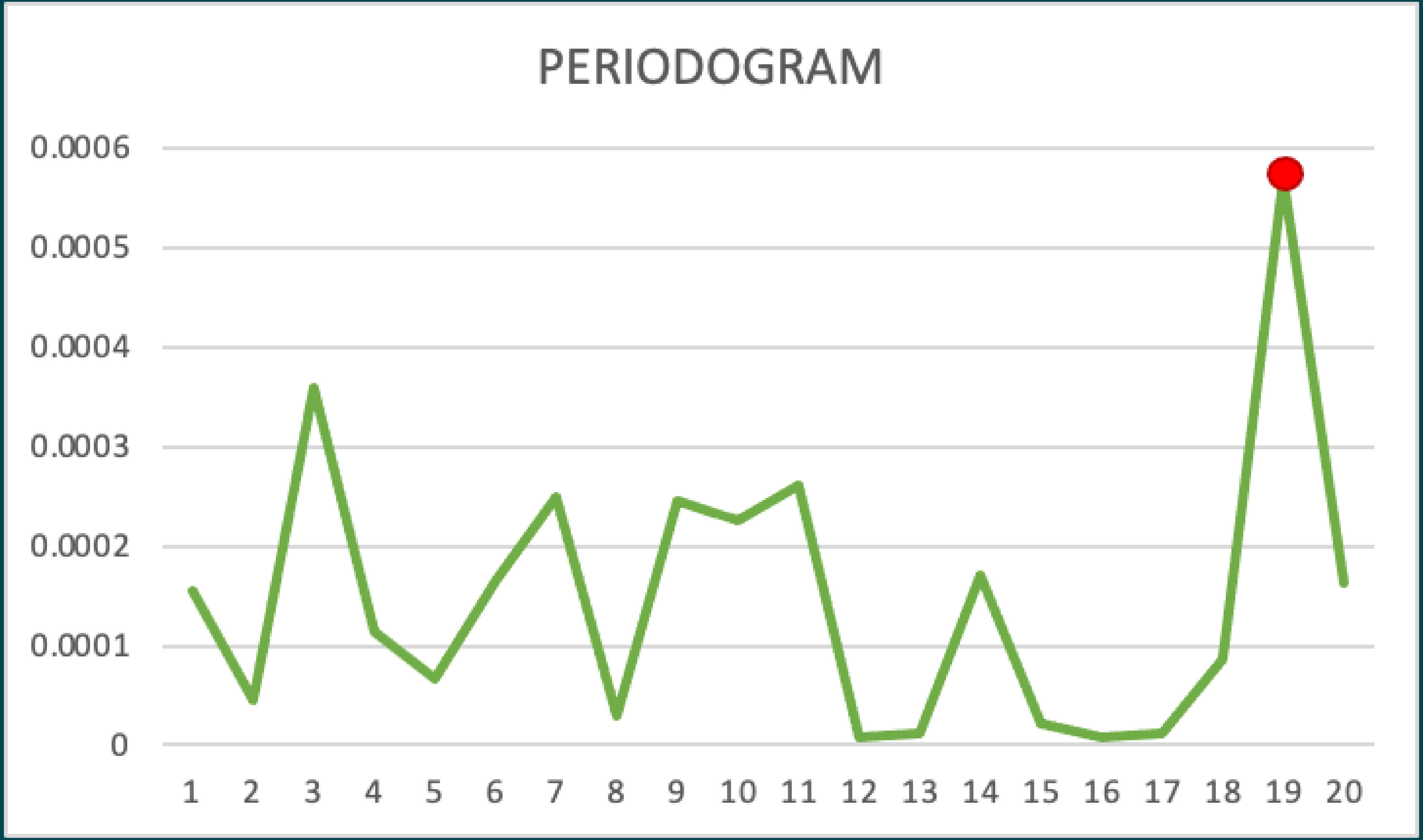
Deseasonalised Series



Cyclical Component can be seen here. As seasonal upswings (or downswings) can be mistaken for the periods of prosperity (or depression).

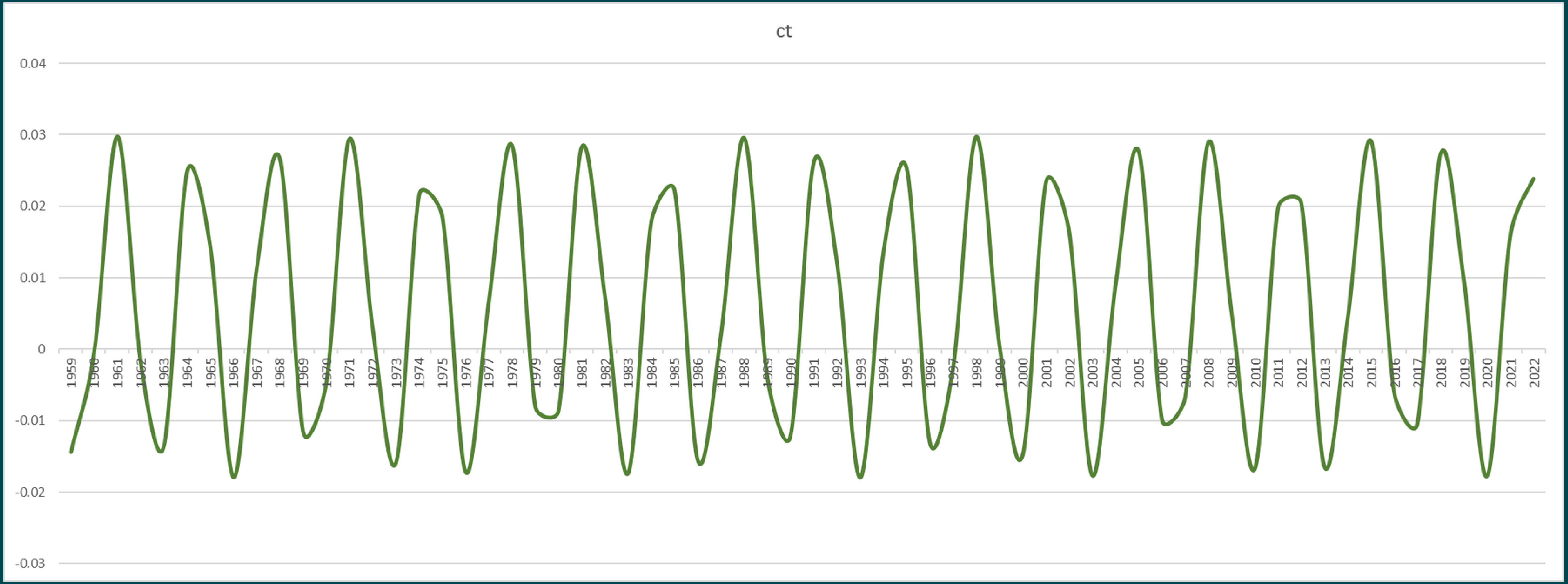
Cyclical Component

For the computation of cyclical component, harmonic analysis is a well proven medium to procure indices. With the assumptions of cyclic component, we have detrended and deseasonalised the data. Taking 20 trial periods, we have obtained the periodogram and constructed an ANOVA table. We have noticed that only one significant trial period exists i.e., lambda corresponding to the 19th trial, which can be chosen as lambda that is periodicity.

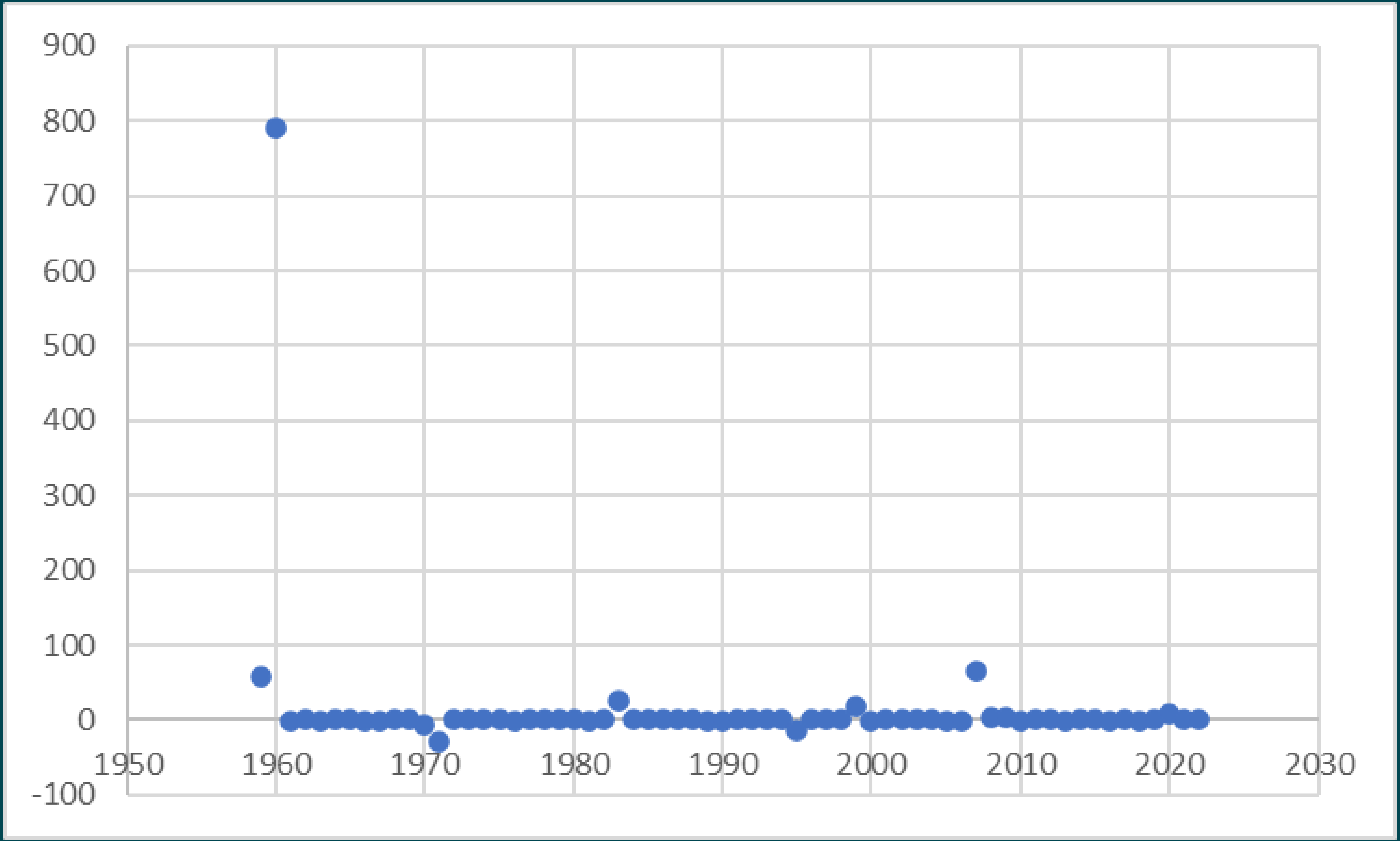


Cyclical Component

The cyclical component is estimated and plotted corresponding to the significant period corresponding to the 19th trial. The plot below shows the estimated oscillatory movements present in our data.



Random Component



Residual of a time series, left unaccounted for after all other components(systematic) are determined and eliminated.

TESTING STATIONARITY

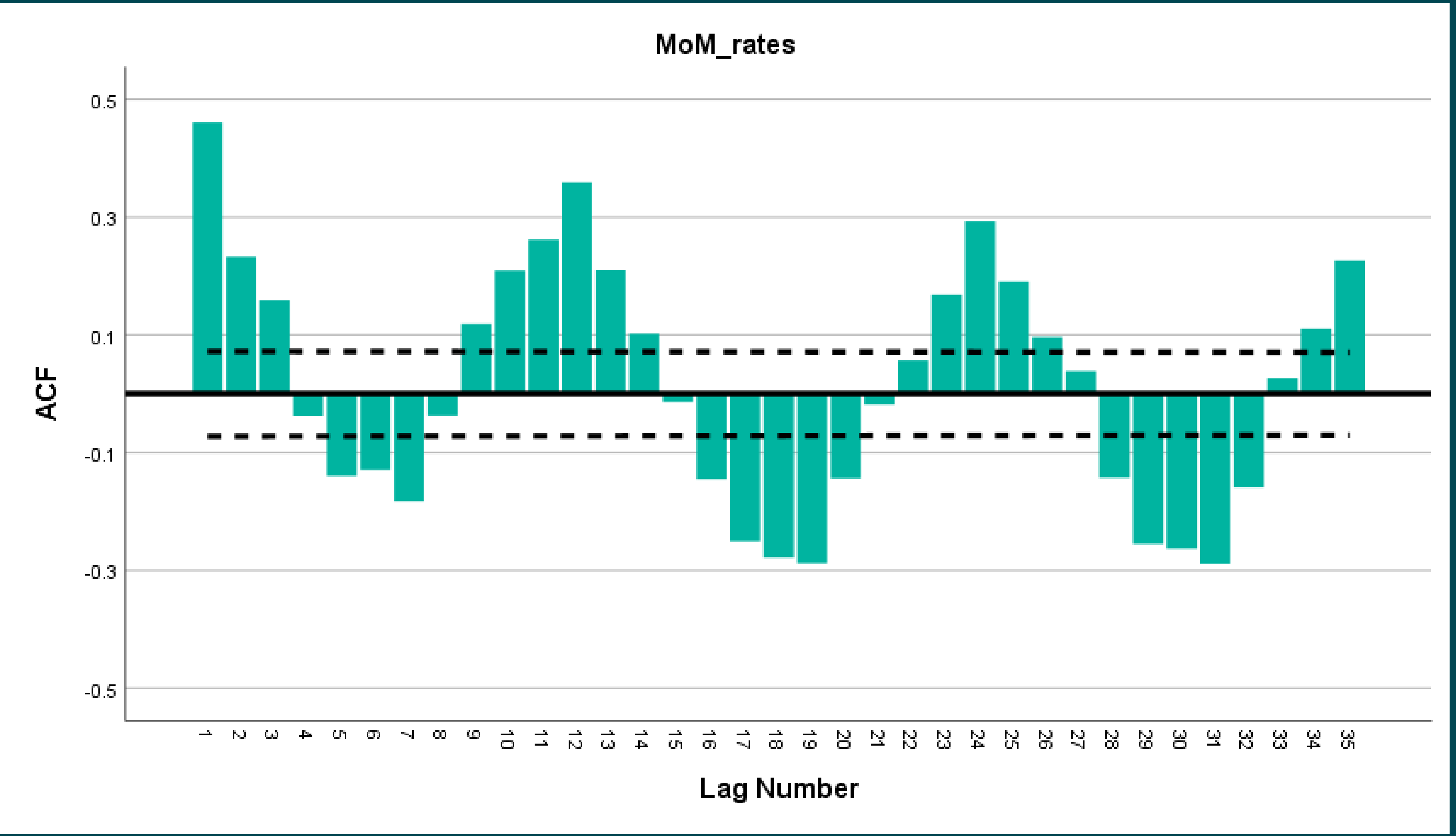
```
Augmented Dickey-Fuller Test

data:  df_numeric
Dickey-Fuller = -68.865, Lag order = 9,
p-value = 0.01
alternative hypothesis: stationary
```

H0: Data has a unit root; the time series is non-stationary.
H1: Data does not have a unit root; the time series is stationary.

Since the p-value(0.01) is less than 0.05. The null hypothesis is rejected and hence we say that the time series data has no unit root in it i.e No presence of unpredictable systematic pattern and hence the data is stationary.

AUTO-CORRELATIONS

Peaks above the confidence limit in the ACF suggest positive autocorrelation i.e past values influence the future values Conversly, troughs below the CL suggest the negative autocorrelation.



MODEL FITTING

SIMPLE SEASONAL

SARIMA (0,0,2)(1,0,1)[12]

ARIMA (3,0,4)

ARIMA (2,0,1)

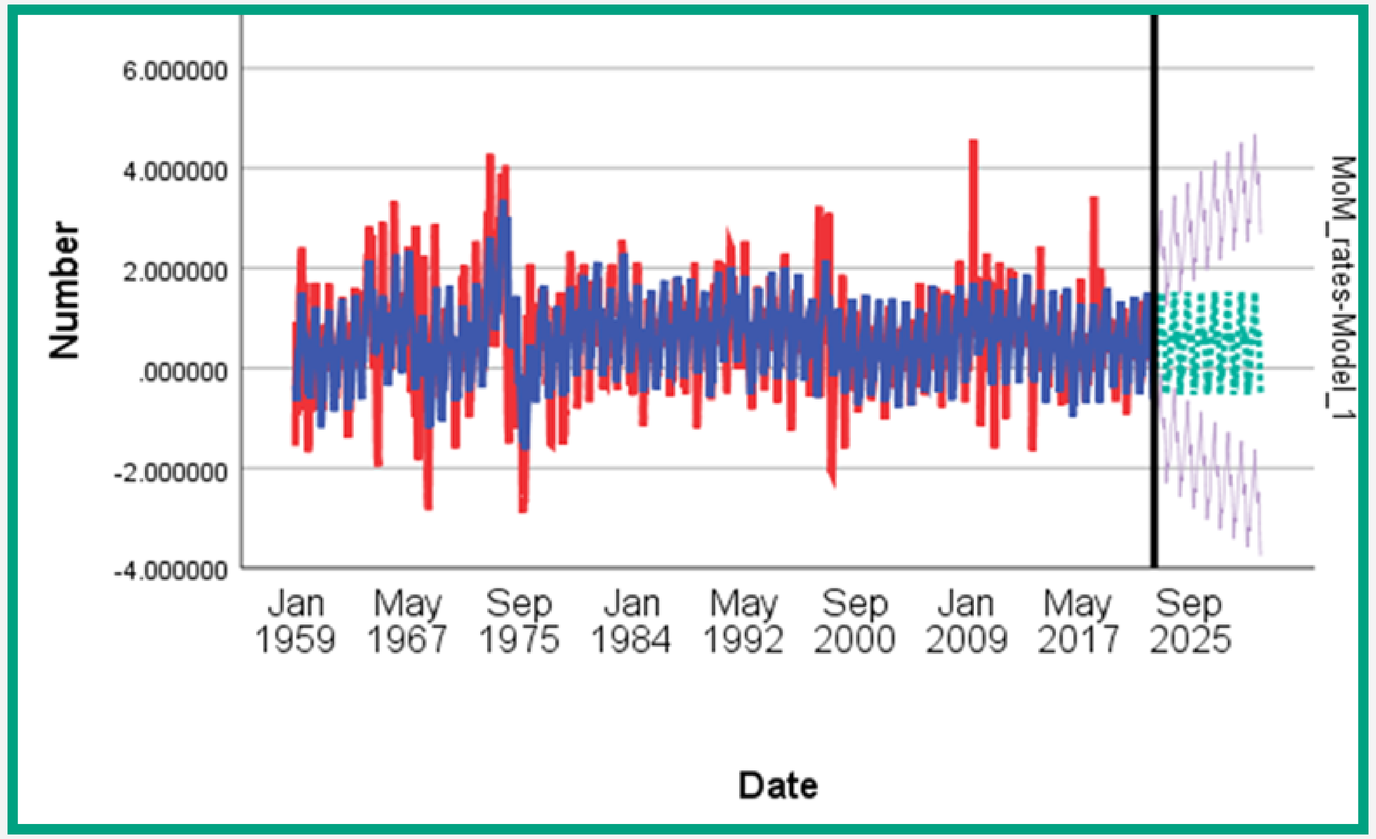
COMPARING THE FITTED MODELS

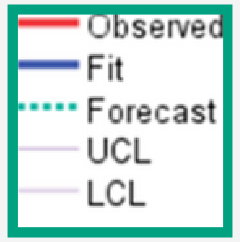
COMPARITIVE TABLE						
MODEL	Stationary R-squared	R-squared	RMSE	MAE	Normalized BIC	Predicted Interval Width
Simple Seasonal	0.641	0.405	0.749	0.554	-0.562	2.939
SARIMA(0,0,2)(1,0,1)	0.378	0.378	0.767	0.560	-0.488	3.650
ARIMA(3,0,4)	0.337	0.337	0.793	0.586	-0.394	3.767
ARIMA(2,0,1)	0.215	0.215	0.861	0.650	-0.265	3.808

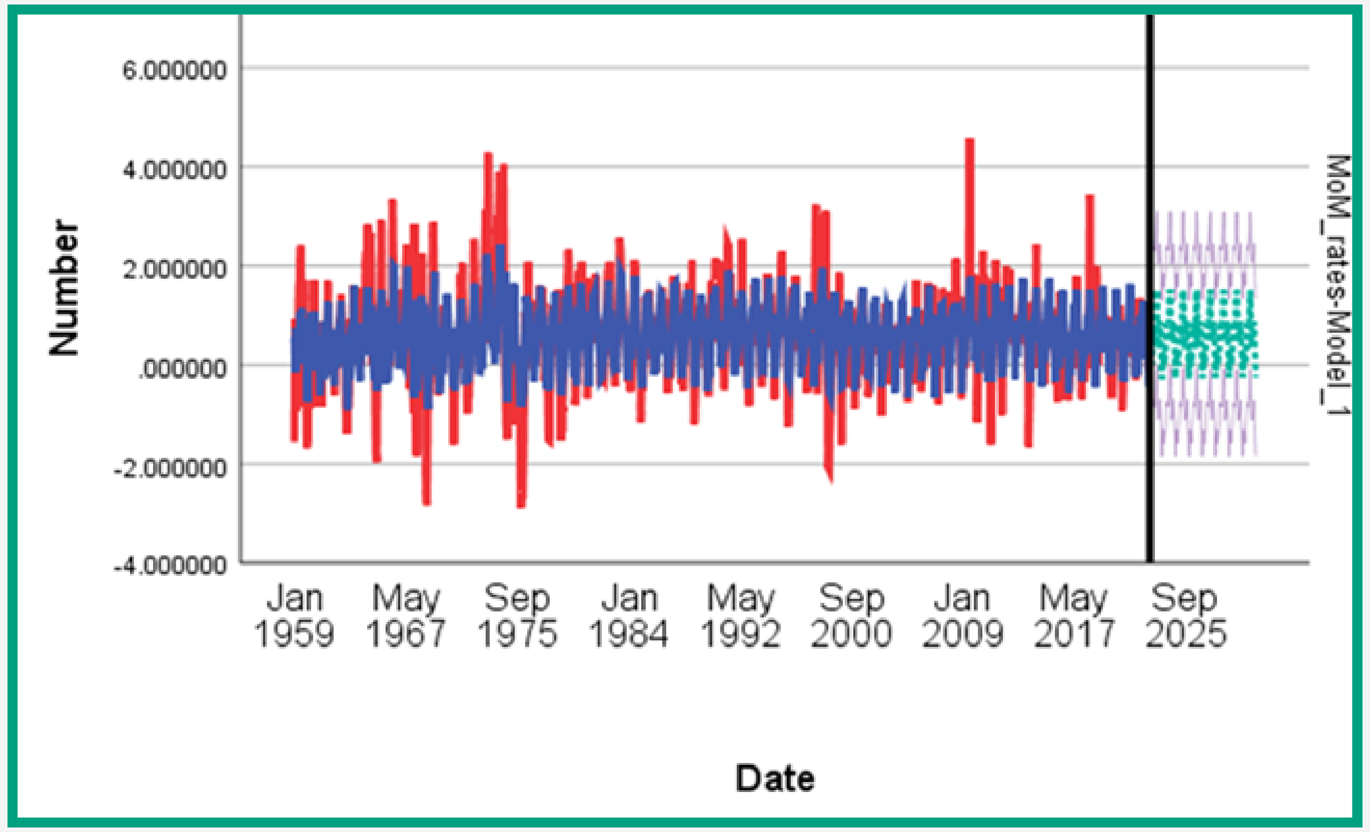
THE BEST FIT

- **Simple Seasonal** has the highest R-Sq(0.405) and Stationary R-Sq(0.641). It has the lowest RMSE(0.749) and MAE(0.554). Also the predicted interval width(2.939) is the smallest. The model thus turns out to be the best of the four fitted models.

- **SARIMA(0,0,2)(1,0,1)[12]** is the second best fit model with R-Sq(0.378),Stationary R-Sq(0.378), RMSE(0.767), MAE(0.560) and predicted interval width(3.650).

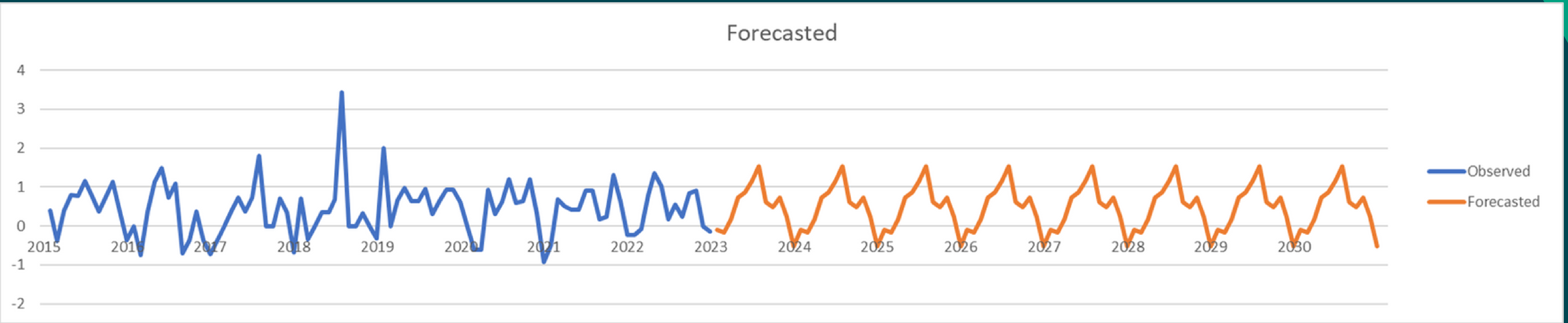




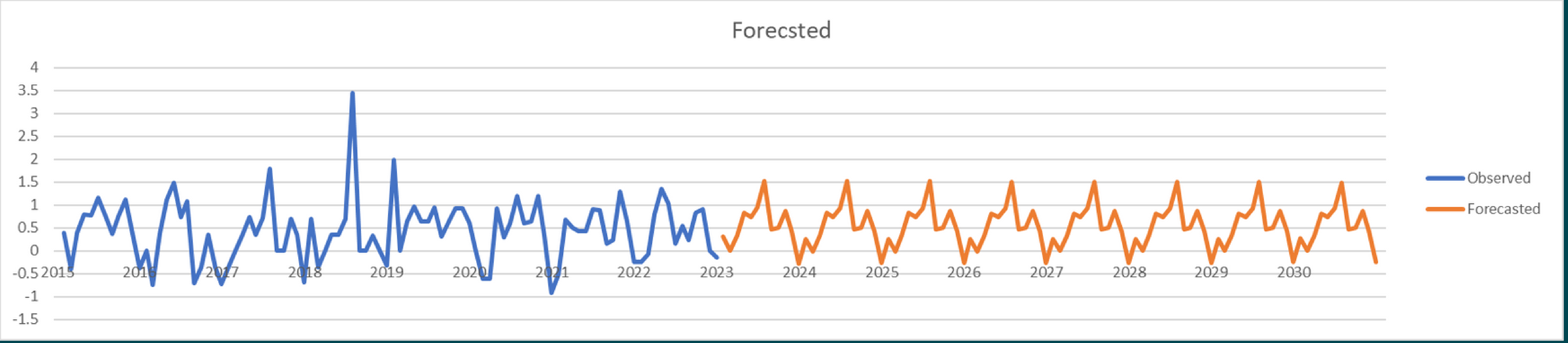


FORECASTING

SIMPLE SEASONAL



SARIMA(0,0,2)(1,0,1)[12]



CONCLUSION

- The time series data for the inflation rate has been shown stationary through the Augmented Dickey-Fuller Test.
- Through the Auto Correlation Function, we can see that the time series data attains peaks at the interval of 1 and 12. This suggests the yearly seasonality in the data.
- Next using Box Jenkins Method of forecasting, Simple Seasonal has found out to be the best model to predict the future outcomes. R squared (0.405) being the highest of all the four models fitted for the time series.
- The second best model is found out to be is the SARIMA(0,0,2)(1,0,1)[12] with R-Squared(0.378).

Sources

DATA SOURCE:

https://www.inflationtool.com/rates/india/historical

OTHER SOURCES:

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https://scripbox.com/blog/history-of-inflation-in-india-and-what-to-expect-going-forward/

Thank You