

# Title: Analyzing the Economic Impact of COVID-19 on Various Sectors in India

## 1. Introduction

**Objective:** To analyze the economic impact of COVID-19 on various sectors in India by comparing key economic indicators before and after the pandemic.

**Scope:** This study focuses on indicators such as GDP Growth Rate, Contribution to GDP, Employment Rate, Inflation Rate, FDI, Exchange Rate, Industrial Production Index, Agricultural Production Index, Services Production Index, Government Expenditure, Consumer Confidence Index, and Business Confidence Index.

**Methodology:** The analysis includes data preprocessing, exploratory data analysis, statistical analysis, data visualization, and time series decomposition.

## 2. Loading the Data

Import necessary libraries

**Explanation:** This step involves loading the dataset into a Pandas DataFrame and displaying the first few rows to get an initial understanding of the data structure.

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

file_path = 'India_Economic_Data_Large.xlsx'
df = pd.read_excel(file_path)
```

df

	Year	Month	Sector	Sub-sector	GDP Growth Rate (%)
0	2019	Jan	Agriculture	Crop Production	9.65
1	2019	Jan	Agriculture	Crop Production	8.12
2	2019	Jan	Agriculture	Crop Production	6.63
3	2019	Jan	Agriculture	Crop Production	3.54
4	2019	Jan	Agriculture	Crop Production	3.00
...	...	...	...	...	...

13495	2023	Dec	Services	Hospitality	9.58
13496	2023	Dec	Services	Hospitality	5.92
13497	2023	Dec	Services	Hospitality	5.50
13498	2023	Dec	Services	Hospitality	4.15
13499	2023	Dec	Services	Hospitality	8.58
		Contribution to GDP (%)		Export Category	Export Value (USD million) \
0		24.28		Textiles	76.87
1		49.35		Textiles	34.54
2		40.71		Textiles	68.15
3		19.27		Textiles	52.86
4		17.71		Textiles	37.09
...		...		...	...
...					
13495		45.14	Gems and Jewelry		21.72
13496		28.69	Gems and Jewelry		11.52
13497		38.94	Gems and Jewelry		50.49
13498		51.96	Gems and Jewelry		93.68
13499		30.27	Gems and Jewelry		15.31
		Import Category	Import Value (USD million)	...	\
0		Crude Oil	199.36	...	
1		Gold	41.65	...	
2		Electronics	151.47	...	
3		Machinery	180.17	...	
4		Chemicals	32.93	...	
...		...	...	...	
13495		Crude Oil	130.38	...	
13496		Gold	129.99	...	
13497		Electronics	26.45	...	
13498		Machinery	154.33	...	
13499		Chemicals	133.33	...	
		Exchange Rate (INR/USD)	Industrial Production Index	\	

0	64.55	92.62
1	65.64	104.51
2	78.37	103.40
3	71.13	105.73
4	73.50	107.84
...	...	...
13495	72.34	109.74
13496	67.04	91.25
13497	78.40	94.11
13498	61.87	104.87
13499	70.25	109.21

	Agricultural Production Index	Services Production Index \
0	94.45	116.78
1	83.49	117.13
2	81.46	118.56
3	95.88	106.54
4	97.85	110.52
...	...	...
13495	93.80	91.30
13496	95.29	108.66
13497	91.16	96.69
13498	98.03	112.42
13499	92.60	104.28

	Government Expenditure (INR crore)	Consumer Confidence
Index \		
0	2472.83	55.23
1	1829.84	83.77
2	1173.16	138.20
3	1341.80	96.22
4	5156.28	116.95
...	...	...
13495	4962.89	131.33
13496	2335.95	120.39
13497	9068.36	109.78
13498	7871.88	101.43
13499	8346.69	141.01

Business Confidence Index	Date	YoY_GDP_Growth \
---------------------------	------	------------------

0	102.62	2019-01-01	NaN
1	74.66	2019-01-01	NaN
2	100.72	2019-01-01	NaN
3	71.13	2019-01-01	NaN
4	139.13	2019-01-01	NaN
...	...	...	...
13495	135.77	2023-12-01	54.765751
13496	76.31	2023-12-01	-20.215633
13497	106.89	2023-12-01	-12.280702
13498	51.82	2023-12-01	-40.544413
13499	135.24	2023-12-01	70.916335

	Inflation_FDI_Interaction
0	2699.8884
1	2523.5616
2	4749.4239
3	2429.0574
4	4347.6429
...	...
13495	5034.7208
13496	1328.0061
13497	1155.6160
13498	3960.2620
13499	1596.9800

[13500 rows x 23 columns]

```
rows, columns = df.shape
print(f"Number of rows: {rows}")
print(f"Number of columns: {columns}")
```

Number of rows: 13500  
Number of columns: 23

```
# Display the first few rows of the dataset to understand its structure
print(df.head())
```

	Year	Month	Sector	Sub-sector	GDP Growth Rate (%) \
0	2019	Jan	Agriculture	Crop Production	9.65
1	2019	Jan	Agriculture	Crop Production	8.12
2	2019	Jan	Agriculture	Crop Production	6.63
3	2019	Jan	Agriculture	Crop Production	3.54
4	2019	Jan	Agriculture	Crop Production	3.00

	Contribution to GDP (%)	Export Category	Export Value (USD million)
0	24.28	Textiles	76.87
1	49.35	Textiles	34.54

2	40.71	Textiles	68.15
3	19.27	Textiles	52.86
4	17.71	Textiles	37.09

Import Category (INR/USD) \	Import Value (USD million) ...	Exchange Rate
-----------------------------	--------------------------------	---------------

0	Crude Oil	199.36 ...
64.55		
1	Gold	41.65 ...
65.64		
2	Electronics	151.47 ...
78.37		
3	Machinery	180.17 ...
71.13		
4	Chemicals	32.93 ...
73.50		

	Industrial Production Index	Agricultural Production Index \
0	92.62	94.45
1	104.51	83.49
2	103.40	81.46
3	105.73	95.88
4	107.84	97.85

	Services Production Index	Government Expenditure (INR crore) \
0	116.78	2472.83
1	117.13	1829.84
2	118.56	1173.16
3	106.54	1341.80
4	110.52	5156.28

	Consumer Confidence Index	Business Confidence Index	Date \
0	55.23	102.62	2019-01-01
1	83.77	74.66	2019-01-01
2	138.20	100.72	2019-01-01
3	96.22	71.13	2019-01-01
4	116.95	139.13	2019-01-01

	YoY_GDP_Growth	Inflation_FDI_Interaction
0	NaN	2699.8884
1	NaN	2523.5616
2	NaN	4749.4239
3	NaN	2429.0574
4	NaN	4347.6429

[5 rows x 23 columns]

### 3. Data Preprocessing

Explanation: This step involves checking for and handling missing values. Additionally, it defines the periods before and after the onset of COVID-19 for comparative analysis.

```
# Check for missing values in the dataset
missing_values = df.isnull().sum()
print("Missing Values:\n", missing_values)

Missing Values:
Year                0
Month               0
Sector              0
Sub-sector          0
GDP Growth Rate (%) 0
Contribution to GDP (%) 0
Export Category     0
Export Value (USD million) 0
Import Category     0
Import Value (USD million) 0
Employment Rate (%) 0
Inflation Rate (%)  0
FDI (USD million)   0
Exchange Rate (INR/USD) 0
Industrial Production Index 0
Agricultural Production Index 0
Services Production Index 0
Government Expenditure (INR crore) 0
Consumer Confidence Index 0
Business Confidence Index 0
dtype: int64

# Define the 'before COVID-19' and 'after COVID-19' periods
df['Date'] = pd.to_datetime(df['Year'].astype(str) + '-' +
df['Month'].astype(str) + '-01')
before_covid = df[df['Date'] < '2020-03-01']
after_covid = df[df['Date'] >= '2020-03-01']
```

### 4. Exploratory Data Analysis (EDA)

Explanation: This step provides descriptive statistics and correlation matrices for the periods before and after COVID-19. It also includes distribution plots for all numerical columns.

```
# Descriptive statistics
print("\nDescriptive Statistics Before COVID-19:\n",
before_covid.describe())
```

```
print("\nDescriptive Statistics After COVID-19:\n",
after_covid.describe())
```

#### Descriptive Statistics Before COVID-19:

	Year	GDP Growth Rate (%)	Contribution to GDP (%) \
count	3150.000000	3150.000000	3150.000000
mean	2019.142857	6.443171	37.479070
std	0.349983	2.028025	12.838763
min	2019.000000	3.000000	15.000000
25%	2019.000000	4.670000	26.475000
50%	2019.000000	6.440000	37.650000
75%	2019.000000	8.180000	48.450000
max	2020.000000	10.000000	60.000000

	Export Value (USD million)	Import Value (USD million) \
count	3150.000000	3150.000000
mean	55.019990	110.483657
std	26.105132	51.762029
min	10.010000	20.020000
25%	32.532500	64.882500
50%	54.630000	111.805000
75%	78.055000	154.802500
max	99.930000	199.990000

	Employment Rate (%)	Inflation Rate (%)	FDI (USD million) \
count	3150.000000	3150.000000	3150.000000
mean	50.107368	5.983733	543.191460
std	5.687432	2.338182	258.169534
min	40.000000	2.000000	100.200000
25%	45.300000	3.870000	320.240000
50%	50.265000	6.000000	544.875000
75%	54.990000	8.017500	758.235000
max	59.980000	10.000000	999.710000

	Exchange Rate (INR/USD)	Industrial Production Index \
count	3150.000000	3150.000000
mean	69.861362	99.935794
std	5.787960	5.698239
min	60.000000	90.000000
25%	64.782500	94.980000
50%	69.685000	99.910000
75%	74.927500	104.857500
max	79.990000	110.000000

	Agricultural Production Index	Services Production Index \
count	3150.000000	3150.000000
mean	89.973822	104.908898
std	5.797532	8.637465
min	80.000000	90.030000

25%	85.042500	97.575000
50%	90.005000	104.740000
75%	95.057500	112.375000
max	99.980000	119.990000

	Government Expenditure (INR crore)	Consumer Confidence
Index \		
count	3150.000000	3150.000000
mean	5502.379333	99.504108
std	2618.485855	28.861857
min	1007.240000	50.050000
25%	3265.532500	74.860000
50%	5496.825000	98.890000
75%	7780.480000	124.387500
max	9999.050000	149.970000

	Business Confidence Index
count	3150.000000
mean	99.974371
std	28.729869
min	50.030000
25%	74.810000
50%	100.600000
75%	125.060000
max	150.000000

Descriptive Statistics After COVID-19:			
	Year	GDP Growth Rate (%)	Contribution to GDP (%) \
count	10350.000000	10350.000000	10350.000000
mean	2021.565217	6.503860	37.490254
std	1.096533	2.014266	12.973148
min	2020.000000	3.000000	15.010000
25%	2021.000000	4.770000	26.220000
50%	2022.000000	6.530000	37.665000
75%	2023.000000	8.250000	48.580000
max	2023.000000	10.000000	59.990000

	Export Value (USD million)	Import Value (USD million) \
count	10350.000000	10350.000000
mean	54.723165	110.169968
std	25.907072	52.103591
min	10.000000	20.040000



25%	32.222500	65.070000
50%	54.460000	109.645000
75%	76.890000	155.977500
max	99.980000	199.930000

	Employment Rate (%)	Inflation Rate (%)	FDI (USD million) \
count	10350.000000	10350.000000	10350.000000
mean	50.046494	6.016634	548.534487
std	5.759397	2.305522	259.103898
min	40.000000	2.000000	100.130000
25%	45.100000	4.010000	324.252500
50%	50.080000	6.020000	546.910000
75%	55.020000	8.030000	772.492500
max	60.000000	10.000000	999.700000

	Exchange Rate (INR/USD)	Industrial Production Index \
count	10350.000000	10350.000000
mean	69.973671	100.037227
std	5.801948	5.786738
min	60.000000	90.000000
25%	64.912500	94.990000
50%	70.000000	100.040000
75%	74.987500	105.060000
max	80.000000	110.000000

	Agricultural Production Index	Services Production Index \
count	10350.000000	10350.000000
mean	90.023637	104.914239
std	5.774819	8.666462
min	80.000000	90.000000
25%	85.040000	97.382500
50%	90.020000	104.910000
75%	95.010000	112.330000
max	100.000000	120.000000

	Government Expenditure (INR crore)	Consumer Confidence
Index \		
count	10350.000000	10350.000000
mean	5505.121868	100.261757
std	2591.981541	28.788451
min	1001.890000	50.000000
25%	3247.035000	75.342500
50%	5522.535000	100.660000
75%	7766.785000	125.250000

```
max          9999.730000          150.000000
```

```
      Business Confidence Index
count      10350.000000
mean        99.691919
std         28.772958
min         50.010000
25%         74.935000
50%         99.535000
75%        124.197500
max         149.990000
```

```
# Correlation matrix
```

```
print("\nCorrelation Matrix Before COVID-19:\n", before_covid.corr())
print("\nCorrelation Matrix After COVID-19:\n", after_covid.corr())
```

```
Correlation Matrix Before COVID-19:
```

	Year	GDP Growth Rate (%)	\
Year	1.000000	0.011750	
GDP Growth Rate (%)	0.011750	1.000000	
Contribution to GDP (%)	0.010791	0.019090	
Export Value (USD million)	-0.011771	-0.003343	
Import Value (USD million)	0.025061	-0.037602	
Employment Rate (%)	-0.024905	0.021047	
Inflation Rate (%)	0.003229	-0.003921	
FDI (USD million)	0.027952	0.001588	
Exchange Rate (INR/USD)	-0.014302	0.050286	
Industrial Production Index	-0.005318	0.018261	
Agricultural Production Index	0.030082	-0.036811	
Services Production Index	0.001263	-0.017791	
Government Expenditure (INR crore)	0.028278	-0.017400	
Consumer Confidence Index	-0.011082	-0.021609	
Business Confidence Index	0.002877	0.008293	

	Contribution to GDP (%)	\
Year	0.010791	
GDP Growth Rate (%)	0.019090	
Contribution to GDP (%)	1.000000	
Export Value (USD million)	0.012687	
Import Value (USD million)	-0.017036	
Employment Rate (%)	0.010245	
Inflation Rate (%)	-0.016794	
FDI (USD million)	0.010154	
Exchange Rate (INR/USD)	0.004316	
Industrial Production Index	0.022131	
Agricultural Production Index	-0.022356	
Services Production Index	-0.021889	

Government Expenditure (INR crore)	-0.011034
Consumer Confidence Index	0.015361
Business Confidence Index	-0.005994

	Export Value (USD million) \
Year	-0.011771
GDP Growth Rate (%)	-0.003343
Contribution to GDP (%)	0.012687
Export Value (USD million)	1.000000
Import Value (USD million)	-0.003049
Employment Rate (%)	0.007535
Inflation Rate (%)	0.032745
FDI (USD million)	-0.009458
Exchange Rate (INR/USD)	0.008996
Industrial Production Index	0.009933
Agricultural Production Index	-0.005553
Services Production Index	-0.023297
Government Expenditure (INR crore)	-0.010568
Consumer Confidence Index	-0.026239
Business Confidence Index	-0.042066

	Import Value (USD million) \
Year	0.025061
GDP Growth Rate (%)	-0.037602
Contribution to GDP (%)	-0.017036
Export Value (USD million)	-0.003049
Import Value (USD million)	1.000000
Employment Rate (%)	-0.001255
Inflation Rate (%)	0.003497
FDI (USD million)	-0.003627
Exchange Rate (INR/USD)	-0.025362
Industrial Production Index	-0.023518
Agricultural Production Index	-0.005779
Services Production Index	-0.015606
Government Expenditure (INR crore)	0.010208
Consumer Confidence Index	0.021300
Business Confidence Index	0.003385

	Employment Rate (%)	Inflation
Rate (%) \		
Year	-0.024905	
0.003229		
GDP Growth Rate (%)	0.021047	-
0.003921		
Contribution to GDP (%)	0.010245	-
0.016794		
Export Value (USD million)	0.007535	
0.032745		
Import Value (USD million)	-0.001255	
0.003497		

Employment Rate (%)	1.000000	-
0.041581		
Inflation Rate (%)	-0.041581	
1.000000		
FDI (USD million)	0.015212	-
0.016584		
Exchange Rate (INR/USD)	0.020308	-
0.015098		
Industrial Production Index	-0.015924	-
0.005951		
Agricultural Production Index	-0.019150	
0.009989		
Services Production Index	-0.010983	-
0.016589		
Government Expenditure (INR crore)	0.021213	
0.000104		
Consumer Confidence Index	0.022000	
0.000422		
Business Confidence Index	-0.002257	
0.023326		

	FDI (USD million) \
Year	0.027952
GDP Growth Rate (%)	0.001588
Contribution to GDP (%)	0.010154
Export Value (USD million)	-0.009458
Import Value (USD million)	-0.003627
Employment Rate (%)	0.015212
Inflation Rate (%)	-0.016584
FDI (USD million)	1.000000
Exchange Rate (INR/USD)	0.020494
Industrial Production Index	-0.018963
Agricultural Production Index	0.017202
Services Production Index	-0.009468
Government Expenditure (INR crore)	-0.012016
Consumer Confidence Index	0.017984
Business Confidence Index	0.014837

	Exchange Rate (INR/USD) \
Year	-0.014302
GDP Growth Rate (%)	0.050286
Contribution to GDP (%)	0.004316
Export Value (USD million)	0.008996
Import Value (USD million)	-0.025362
Employment Rate (%)	0.020308
Inflation Rate (%)	-0.015098
FDI (USD million)	0.020494
Exchange Rate (INR/USD)	1.000000
Industrial Production Index	0.021340

Agricultural Production Index	-0.010217
Services Production Index	-0.006437
Government Expenditure (INR crore)	0.004288
Consumer Confidence Index	-0.003376
Business Confidence Index	-0.002089

	Industrial Production Index \
Year	-0.005318
GDP Growth Rate (%)	0.018261
Contribution to GDP (%)	0.022131
Export Value (USD million)	0.009933
Import Value (USD million)	-0.023518
Employment Rate (%)	-0.015924
Inflation Rate (%)	-0.005951
FDI (USD million)	-0.018963
Exchange Rate (INR/USD)	0.021340
Industrial Production Index	1.000000
Agricultural Production Index	0.012828
Services Production Index	-0.007879
Government Expenditure (INR crore)	-0.036844
Consumer Confidence Index	-0.008622
Business Confidence Index	0.027420

	Agricultural Production Index \
Year	0.030082
GDP Growth Rate (%)	-0.036811
Contribution to GDP (%)	-0.022356
Export Value (USD million)	-0.005553
Import Value (USD million)	-0.005779
Employment Rate (%)	-0.019150
Inflation Rate (%)	0.009989
FDI (USD million)	0.017202
Exchange Rate (INR/USD)	-0.010217
Industrial Production Index	0.012828
Agricultural Production Index	1.000000
Services Production Index	-0.006111
Government Expenditure (INR crore)	0.013334
Consumer Confidence Index	-0.007276
Business Confidence Index	-0.027965

	Services Production Index \
Year	0.001263
GDP Growth Rate (%)	-0.017791
Contribution to GDP (%)	-0.021889
Export Value (USD million)	-0.023297
Import Value (USD million)	-0.015606
Employment Rate (%)	-0.010983
Inflation Rate (%)	-0.016589
FDI (USD million)	-0.009468
Exchange Rate (INR/USD)	-0.006437

Industrial Production Index	-0.007879
Agricultural Production Index	-0.006111
Services Production Index	1.000000
Government Expenditure (INR crore)	-0.014807
Consumer Confidence Index	-0.048330
Business Confidence Index	-0.007418

Government Expenditure (INR crore)	
\	
Year	0.028278
GDP Growth Rate (%)	-0.017400
Contribution to GDP (%)	-0.011034
Export Value (USD million)	-0.010568
Import Value (USD million)	0.010208
Employment Rate (%)	0.021213
Inflation Rate (%)	0.000104
FDI (USD million)	-0.012016
Exchange Rate (INR/USD)	0.004288
Industrial Production Index	-0.036844
Agricultural Production Index	0.013334
Services Production Index	-0.014807
Government Expenditure (INR crore)	1.000000
Consumer Confidence Index	-0.005447
Business Confidence Index	-0.006911

Consumer Confidence Index	
\	
Year	-0.011082
GDP Growth Rate (%)	-0.021609
Contribution to GDP (%)	0.015361
Export Value (USD million)	-0.026239
Import Value (USD million)	0.021300
Employment Rate (%)	0.022000
Inflation Rate (%)	0.000422
FDI (USD million)	0.017984
Exchange Rate (INR/USD)	-0.003376
Industrial Production Index	-0.008622

Agricultural Production Index	-0.007276
Services Production Index	-0.048330
Government Expenditure (INR crore)	-0.005447
Consumer Confidence Index	1.000000
Business Confidence Index	-0.017520

	Business Confidence Index
Year	0.002877
GDP Growth Rate (%)	0.008293
Contribution to GDP (%)	-0.005994
Export Value (USD million)	-0.042066
Import Value (USD million)	0.003385
Employment Rate (%)	-0.002257
Inflation Rate (%)	0.023326
FDI (USD million)	0.014837
Exchange Rate (INR/USD)	-0.002089
Industrial Production Index	0.027420
Agricultural Production Index	-0.027965
Services Production Index	-0.007418
Government Expenditure (INR crore)	-0.006911
Consumer Confidence Index	-0.017520
Business Confidence Index	1.000000

#### Correlation Matrix After COVID-19:

	Year	GDP Growth Rate (%) \
Year	1.000000	0.004737
GDP Growth Rate (%)	0.004737	1.000000
Contribution to GDP (%)	-0.000753	0.001747
Export Value (USD million)	-0.018425	-0.017101
Import Value (USD million)	0.024594	-0.029349
Employment Rate (%)	-0.002658	0.005552
Inflation Rate (%)	-0.006883	0.004264
FDI (USD million)	0.005960	-0.004768
Exchange Rate (INR/USD)	-0.002622	0.002042
Industrial Production Index	0.005666	0.012883
Agricultural Production Index	-0.006323	0.000236
Services Production Index	-0.009354	0.005027
Government Expenditure (INR crore)	0.001293	-0.020579
Consumer Confidence Index	-0.003578	-0.002683
Business Confidence Index	0.002958	0.018298

	Contribution to GDP (%) \
Year	-0.000753
GDP Growth Rate (%)	0.001747
Contribution to GDP (%)	1.000000
Export Value (USD million)	0.000111
Import Value (USD million)	-0.018012
Employment Rate (%)	0.002462
Inflation Rate (%)	-0.000328
FDI (USD million)	-0.002128

Exchange Rate (INR/USD)	-0.009045	
Industrial Production Index	-0.009765	
Agricultural Production Index	-0.011132	
Services Production Index	0.009116	
Government Expenditure (INR crore)	-0.012064	
Consumer Confidence Index	-0.005465	
Business Confidence Index	0.006175	
	Export Value (USD million)	\
Year	-0.018425	
GDP Growth Rate (%)	-0.017101	
Contribution to GDP (%)	0.000111	
Export Value (USD million)	1.000000	
Import Value (USD million)	0.011491	
Employment Rate (%)	0.002462	
Inflation Rate (%)	-0.000164	
FDI (USD million)	0.000116	
Exchange Rate (INR/USD)	-0.000177	
Industrial Production Index	0.009344	
Agricultural Production Index	0.009179	
Services Production Index	-0.015963	
Government Expenditure (INR crore)	-0.001700	
Consumer Confidence Index	-0.005211	
Business Confidence Index	-0.004546	
	Import Value (USD million)	\
Year	0.024594	
GDP Growth Rate (%)	-0.029349	
Contribution to GDP (%)	-0.018012	
Export Value (USD million)	0.011491	
Import Value (USD million)	1.000000	
Employment Rate (%)	-0.008993	
Inflation Rate (%)	0.004372	
FDI (USD million)	-0.010596	
Exchange Rate (INR/USD)	0.012488	
Industrial Production Index	-0.011769	
Agricultural Production Index	-0.009114	
Services Production Index	0.001475	
Government Expenditure (INR crore)	0.012412	
Consumer Confidence Index	-0.014108	
Business Confidence Index	-0.005339	
	Employment Rate (%)	Inflation
Rate (%) \		
Year	-0.002658	-
0.006883		
GDP Growth Rate (%)	0.005552	
0.004264		
Contribution to GDP (%)	0.002462	-
0.000328		



Export Value (USD million)	0.002462	-
0.000164		
Import Value (USD million)	-0.008993	
0.004372		
Employment Rate (%)	1.000000	
0.000563		
Inflation Rate (%)	0.000563	
1.000000		
FDI (USD million)	-0.009460	-
0.007253		
Exchange Rate (INR/USD)	0.004932	-
0.004060		
Industrial Production Index	0.007475	-
0.008698		
Agricultural Production Index	0.011550	
0.011636		
Services Production Index	-0.020094	-
0.013166		
Government Expenditure (INR crore)	0.011169	-
0.001414		
Consumer Confidence Index	0.002467	
0.004809		
Business Confidence Index	0.023827	
0.003364		

	FDI (USD million) \	
Year	0.005960	
GDP Growth Rate (%)	-0.004768	
Contribution to GDP (%)	-0.002128	
Export Value (USD million)	0.000116	
Import Value (USD million)	-0.010596	
Employment Rate (%)	-0.009460	
Inflation Rate (%)	-0.007253	
FDI (USD million)	1.000000	
Exchange Rate (INR/USD)	-0.013366	
Industrial Production Index	-0.008939	
Agricultural Production Index	-0.001095	
Services Production Index	-0.004244	
Government Expenditure (INR crore)	-0.008510	
Consumer Confidence Index	0.007303	
Business Confidence Index	0.001725	

	Exchange Rate (INR/USD) \	
Year	-0.002622	
GDP Growth Rate (%)	0.002042	
Contribution to GDP (%)	-0.009045	
Export Value (USD million)	-0.000177	
Import Value (USD million)	0.012488	
Employment Rate (%)	0.004932	

Inflation Rate (%)	-0.004060
FDI (USD million)	-0.013366
Exchange Rate (INR/USD)	1.000000
Industrial Production Index	0.000664
Agricultural Production Index	-0.008199
Services Production Index	0.004103
Government Expenditure (INR crore)	-0.001891
Consumer Confidence Index	0.002546
Business Confidence Index	-0.004258

	Industrial Production Index \
Year	0.005666
GDP Growth Rate (%)	0.012883
Contribution to GDP (%)	-0.009765
Export Value (USD million)	0.009344
Import Value (USD million)	-0.011769
Employment Rate (%)	0.007475
Inflation Rate (%)	-0.008698
FDI (USD million)	-0.008939
Exchange Rate (INR/USD)	0.000664
Industrial Production Index	1.000000
Agricultural Production Index	-0.020981
Services Production Index	-0.016250
Government Expenditure (INR crore)	0.008435
Consumer Confidence Index	-0.000444
Business Confidence Index	0.004561

	Agricultural Production Index \
Year	-0.006323
GDP Growth Rate (%)	0.000236
Contribution to GDP (%)	-0.011132
Export Value (USD million)	0.009179
Import Value (USD million)	-0.009114
Employment Rate (%)	0.011550
Inflation Rate (%)	0.011636
FDI (USD million)	-0.001095
Exchange Rate (INR/USD)	-0.008199
Industrial Production Index	-0.020981
Agricultural Production Index	1.000000
Services Production Index	0.015851
Government Expenditure (INR crore)	-0.010215
Consumer Confidence Index	0.003575
Business Confidence Index	-0.001231

	Services Production Index \
Year	-0.009354
GDP Growth Rate (%)	0.005027
Contribution to GDP (%)	0.009116
Export Value (USD million)	-0.015963
Import Value (USD million)	0.001475

Employment Rate (%)	-0.020094
Inflation Rate (%)	-0.013166
FDI (USD million)	-0.004244
Exchange Rate (INR/USD)	0.004103
Industrial Production Index	-0.016250
Agricultural Production Index	0.015851
Services Production Index	1.000000
Government Expenditure (INR crore)	-0.002393
Consumer Confidence Index	-0.015497
Business Confidence Index	0.006948

Government Expenditure (INR crore)	
\	
Year	0.001293
GDP Growth Rate (%)	-0.020579
Contribution to GDP (%)	-0.012064
Export Value (USD million)	-0.001700
Import Value (USD million)	0.012412
Employment Rate (%)	0.011169
Inflation Rate (%)	-0.001414
FDI (USD million)	-0.008510
Exchange Rate (INR/USD)	-0.001891
Industrial Production Index	0.008435
Agricultural Production Index	-0.010215
Services Production Index	-0.002393
Government Expenditure (INR crore)	1.000000
Consumer Confidence Index	0.006933
Business Confidence Index	-0.012063

Consumer Confidence Index \	
Year	-0.003578
GDP Growth Rate (%)	-0.002683
Contribution to GDP (%)	-0.005465
Export Value (USD million)	-0.005211
Import Value (USD million)	-0.014108
Employment Rate (%)	0.002467

Inflation Rate (%)	0.004809
FDI (USD million)	0.007303
Exchange Rate (INR/USD)	0.002546
Industrial Production Index	-0.000444
Agricultural Production Index	0.003575
Services Production Index	-0.015497
Government Expenditure (INR crore)	0.006933
Consumer Confidence Index	1.000000
Business Confidence Index	-0.005002

	Business Confidence Index
Year	0.002958
GDP Growth Rate (%)	0.018298
Contribution to GDP (%)	0.006175
Export Value (USD million)	-0.004546
Import Value (USD million)	-0.005339
Employment Rate (%)	0.023827
Inflation Rate (%)	0.003364
FDI (USD million)	0.001725
Exchange Rate (INR/USD)	-0.004258
Industrial Production Index	0.004561
Agricultural Production Index	-0.001231
Services Production Index	0.006948
Government Expenditure (INR crore)	-0.012063
Consumer Confidence Index	-0.005002
Business Confidence Index	1.000000

## 5. Feature Engineering

Explanation: Feature engineering involves creating new features from existing data to better capture relationships and patterns. Here, we calculate the Year-over-Year GDP Growth and create an interaction term between Inflation Rate and FDI.

```
# Year-over-Year GDP Growth
df['YoY_GDP_Growth'] = df['GDP Growth Rate (%)'].pct_change(12) * 100

# Interaction terms example
df['Inflation_FDI_Interaction'] = df['Inflation Rate (%)'] * df['FDI (USD million)']
```

## 6. Statistical Analysis

Explanation: This step conducts hypothesis testing to determine if there are significant differences in key indicators before and after COVID-19. The t-test is used to compare the means of the two periods.

```
from scipy.stats import ttest_ind

# Example: GDP Growth Rate
stat, p = ttest_ind(before_covid['GDP Growth Rate (%)'],
                    after_covid['GDP Growth Rate (%)'])
print('GDP Growth Rate (%) - t-statistic: {:.3f}, p-value: {:.3f}'.format(stat, p))

# Multiple hypothesis testing for all indicators
indicators = ['GDP Growth Rate (%)', 'Contribution to GDP (%)',
              'Employment Rate (%)', 'Inflation Rate (%)', 'FDI (USD million)', 'Exchange Rate (INR/USD)',
              'Industrial Production Index', 'Agricultural Production Index',
              'Services Production Index', 'Government Expenditure (INR crore)',
              'Consumer Confidence Index', 'Business Confidence Index']

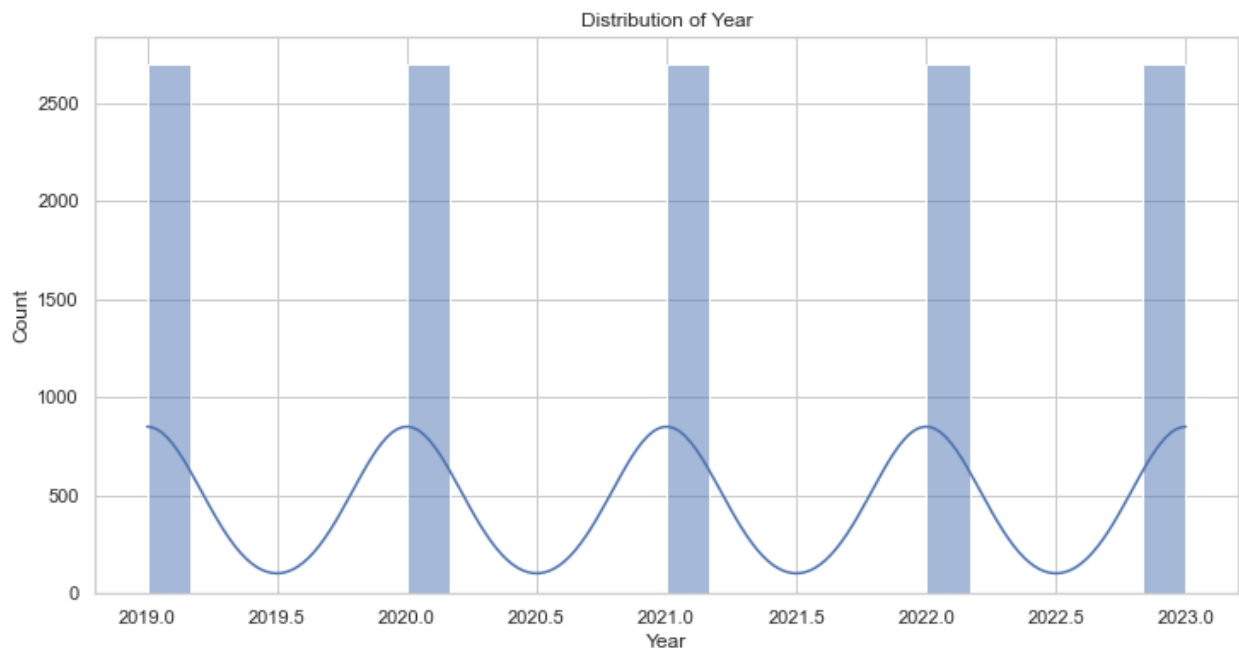
for indicator in indicators:
    stat, p = ttest_ind(before_covid[indicator],
                        after_covid[indicator])
    print(f'{indicator} - t-statistic: {stat:.3f}, p-value: {p:.3f}')

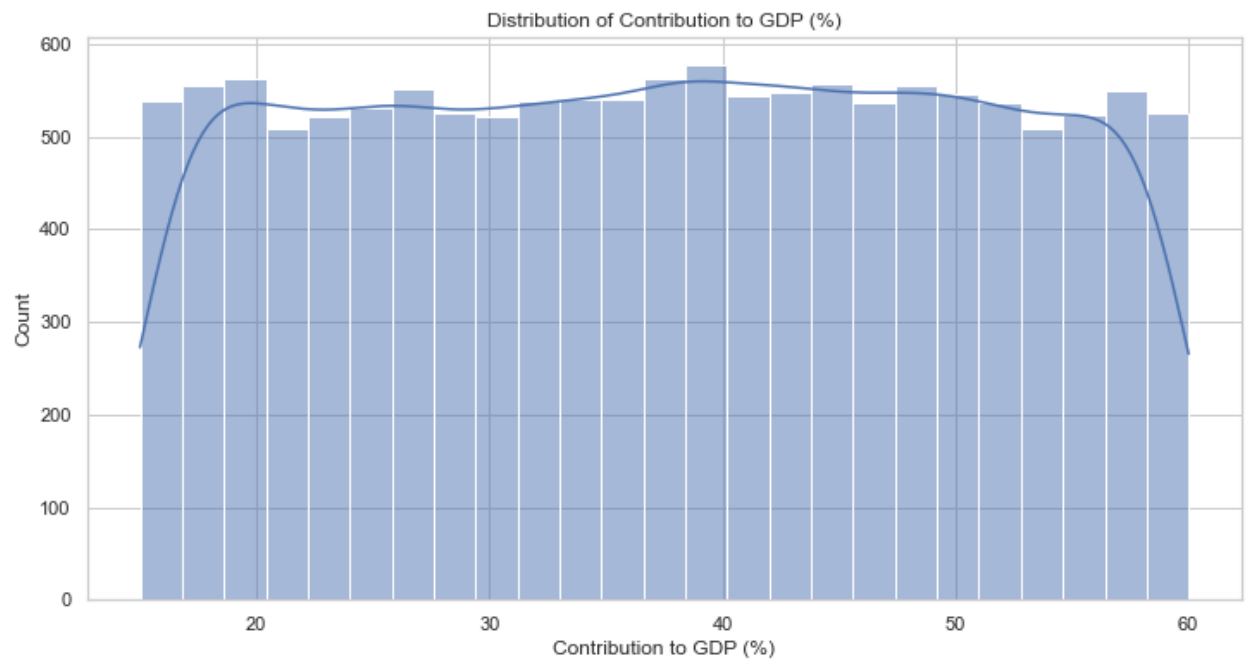
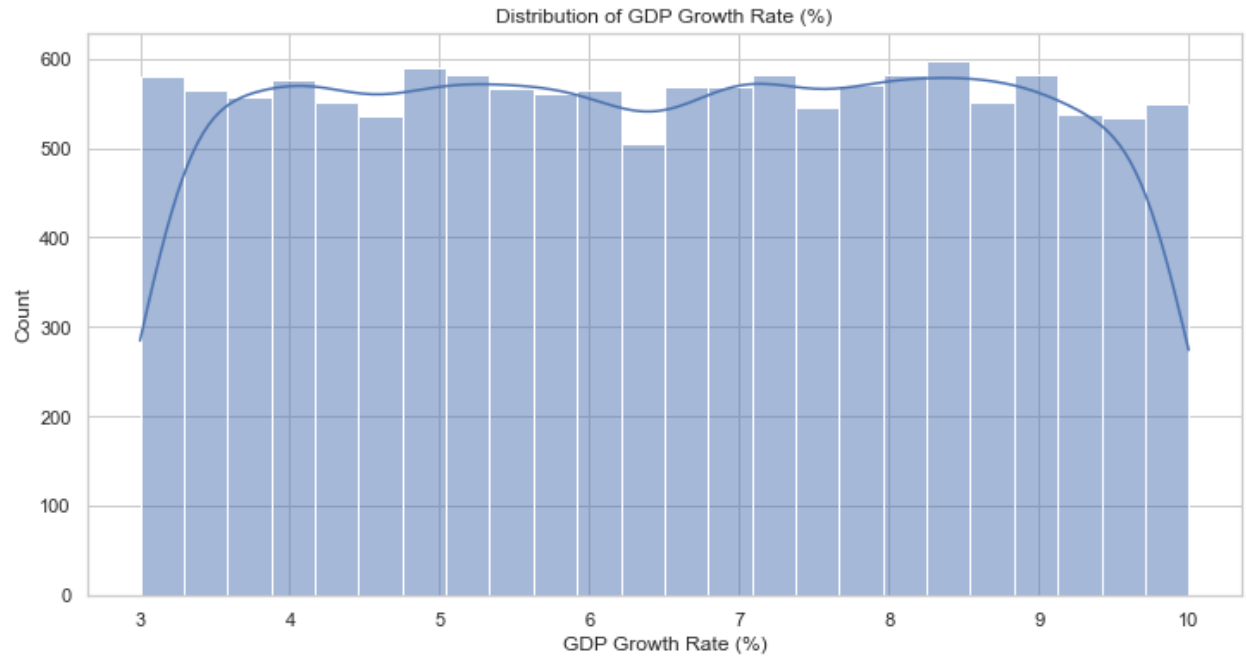
GDP Growth Rate (%) - t-statistic: -1.478, p-value: 0.139
GDP Growth Rate (%) - t-statistic: -1.478, p-value: 0.139
Contribution to GDP (%) - t-statistic: -0.042, p-value: 0.966
Employment Rate (%) - t-statistic: 0.521, p-value: 0.602
Inflation Rate (%) - t-statistic: -0.699, p-value: 0.485
FDI (USD million) - t-statistic: -1.014, p-value: 0.310
Exchange Rate (INR/USD) - t-statistic: -0.952, p-value: 0.341
Industrial Production Index - t-statistic: -0.864, p-value: 0.387
Agricultural Production Index - t-statistic: -0.424, p-value: 0.672
Services Production Index - t-statistic: -0.030, p-value: 0.976
Government Expenditure (INR crore) - t-statistic: -0.052, p-value: 0.959
Consumer Confidence Index - t-statistic: -1.293, p-value: 0.196
Business Confidence Index - t-statistic: 0.483, p-value: 0.629
```

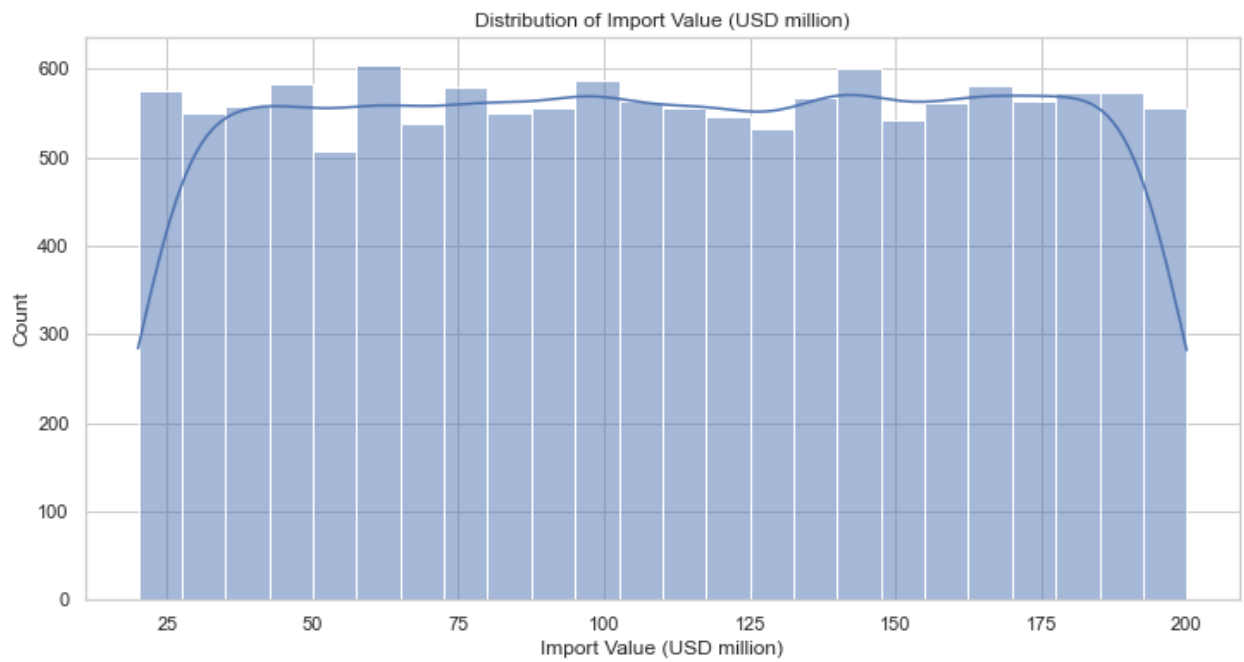
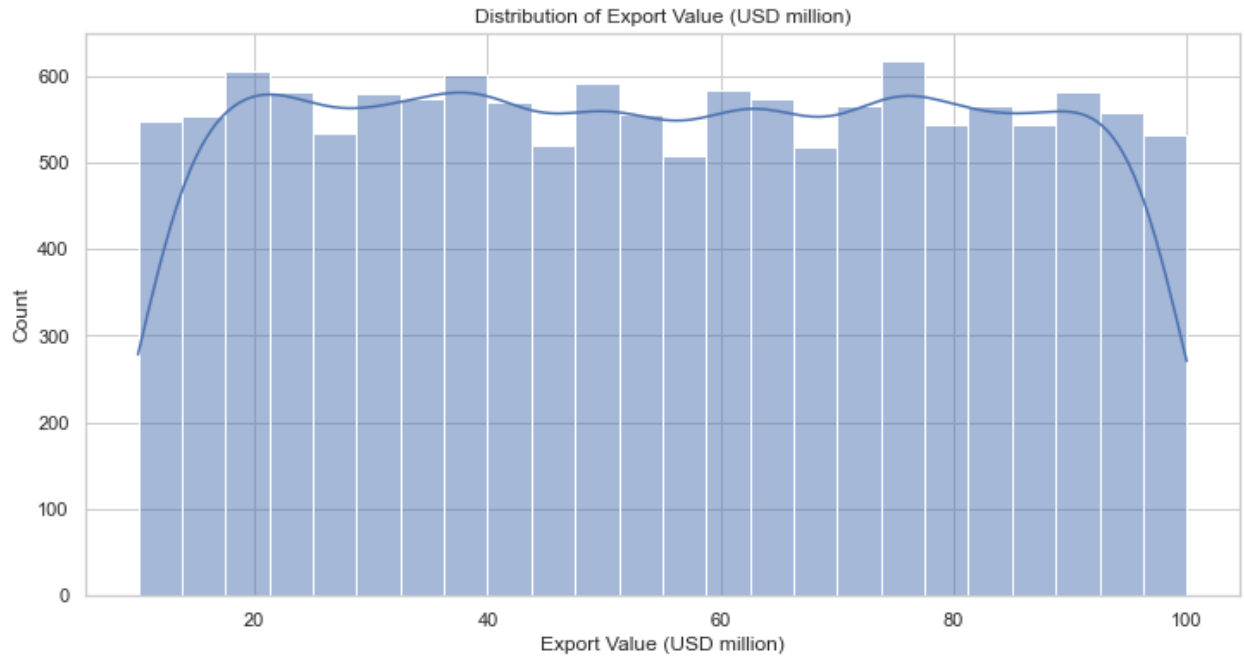
## 7. Data Visualization

Explanation: This step visualizes the trends and patterns in key economic indicators before and after COVID-19 using line plots.

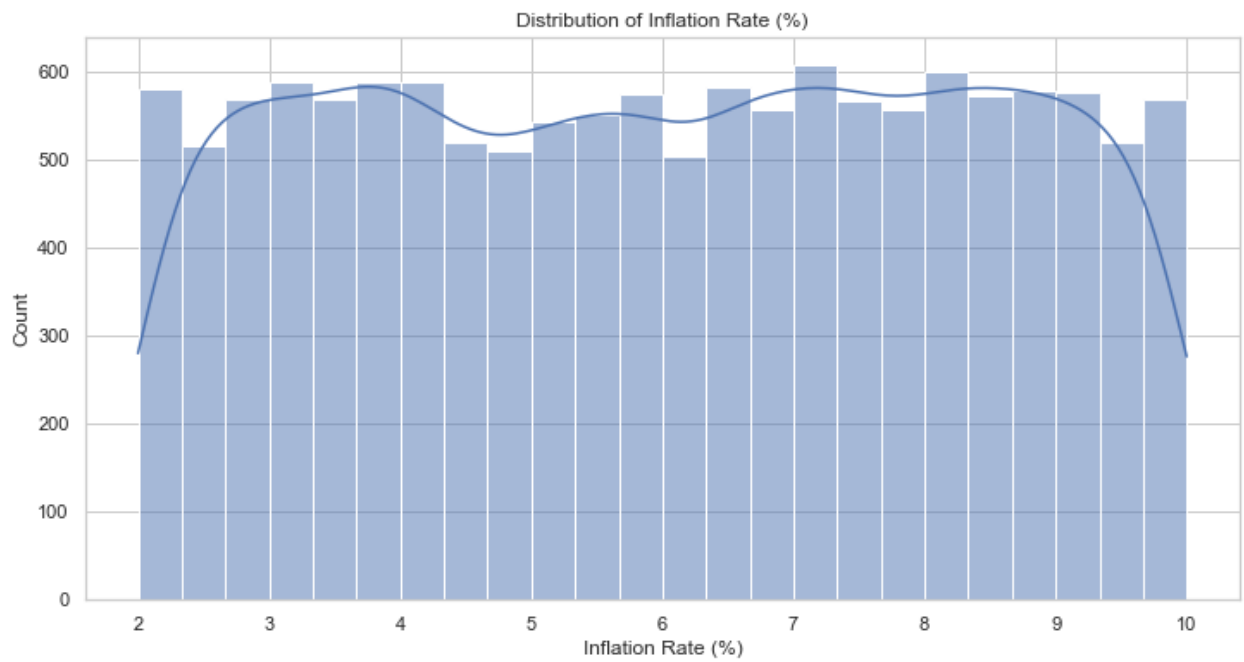
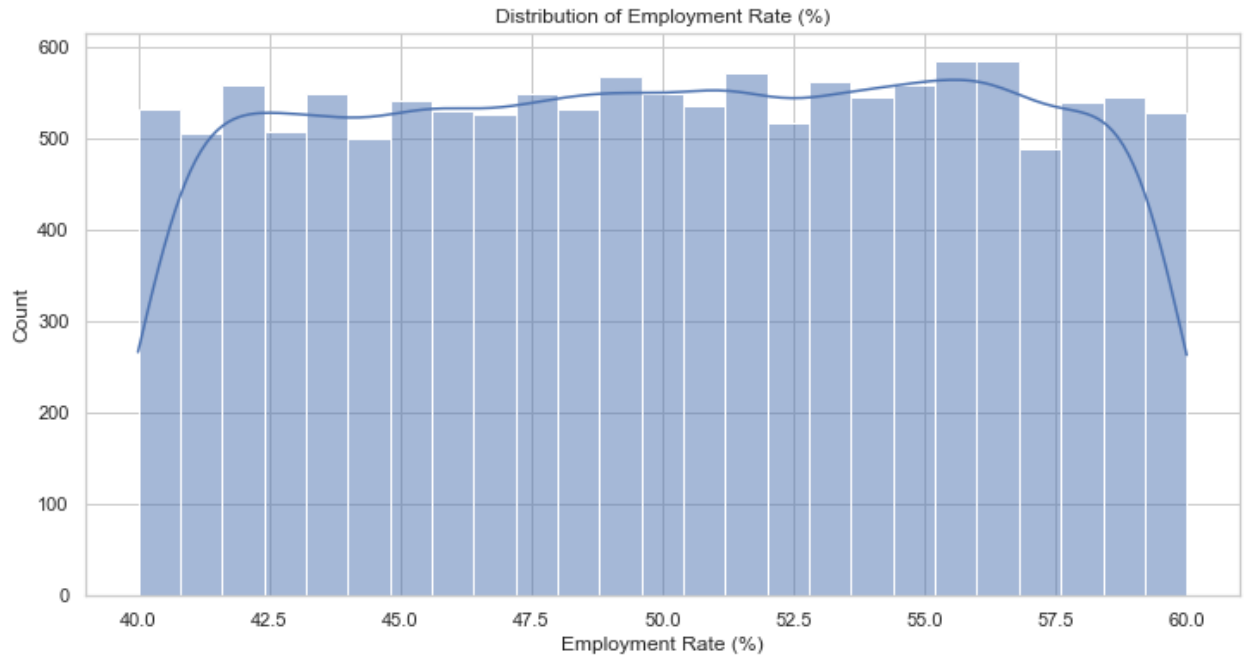
```
# Distribution plots
import seaborn as sns
sns.set(style="whitegrid")
for column in df.select_dtypes(include='number').columns:
    plt.figure(figsize=(12, 6))
    sns.histplot(df[column], kde=True)
    plt.title(f'Distribution of {column}')
    plt.show()
```

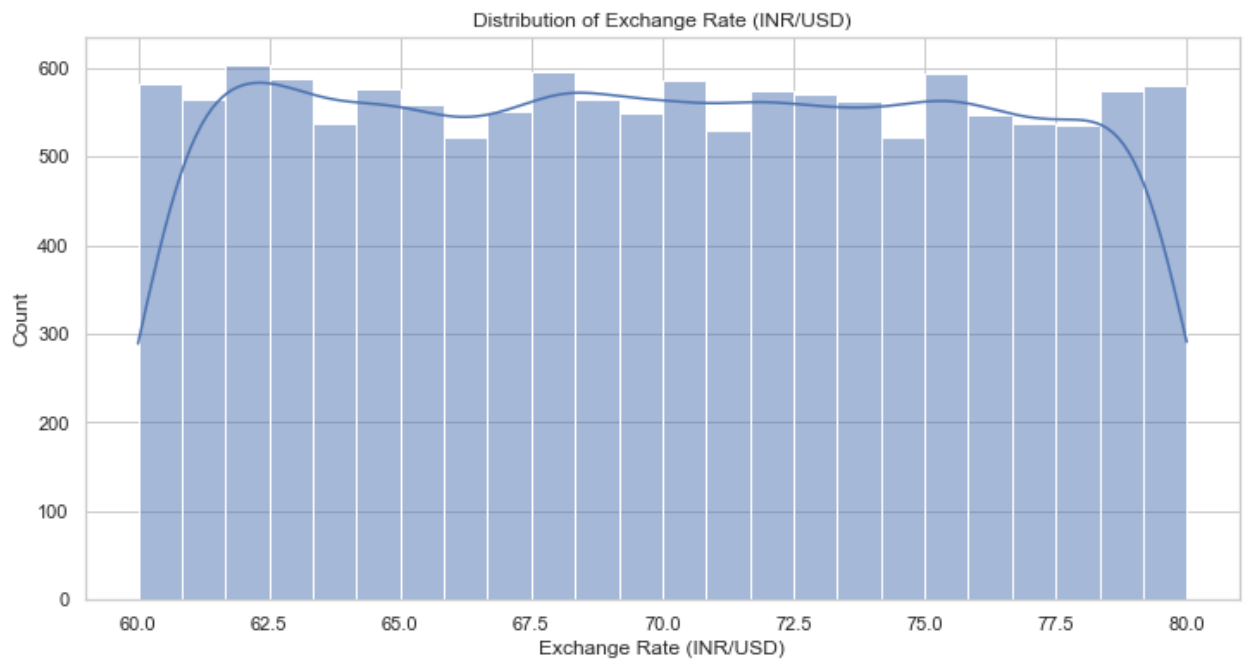
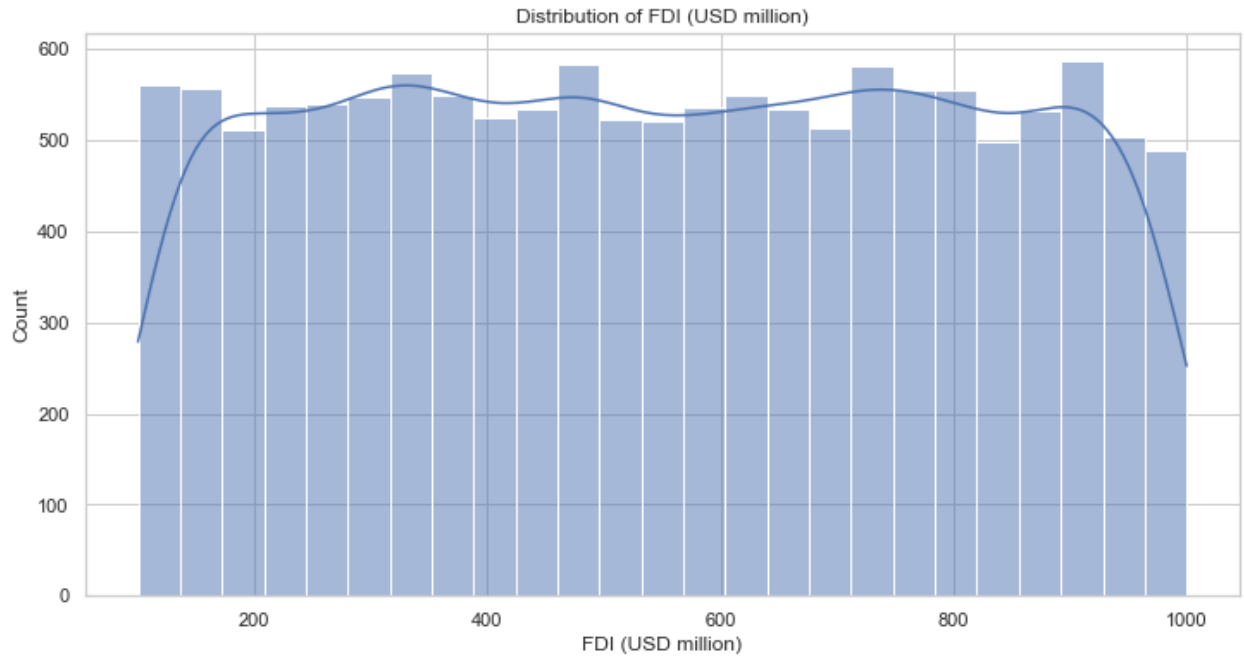


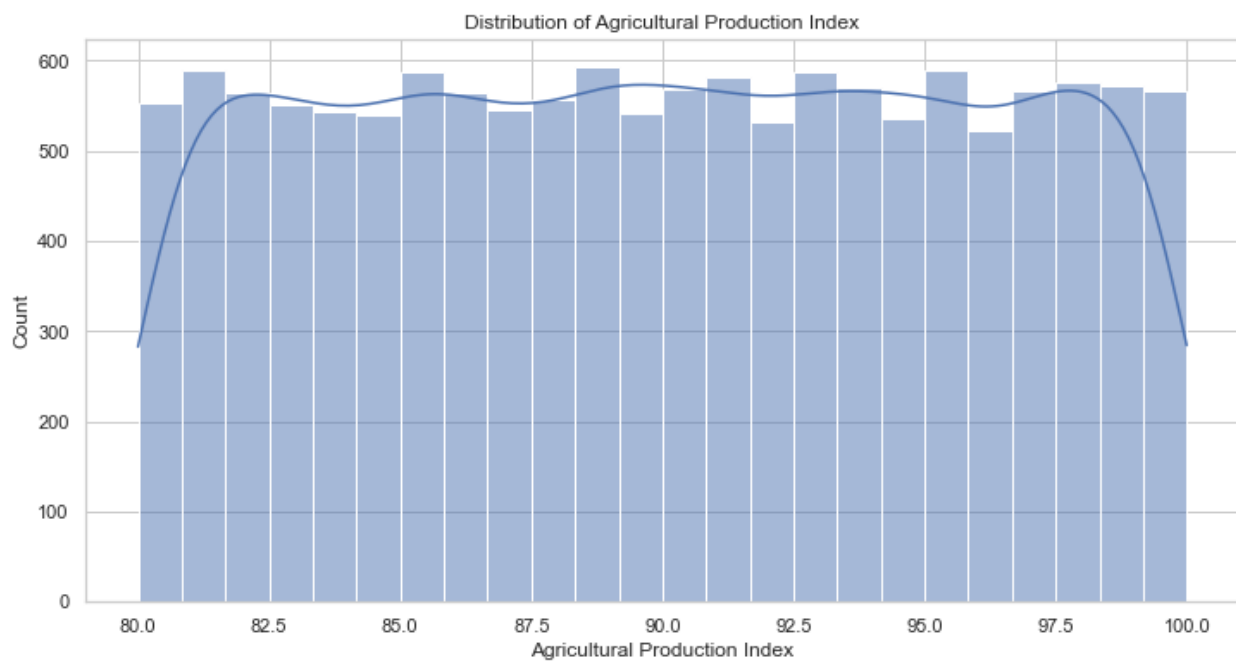
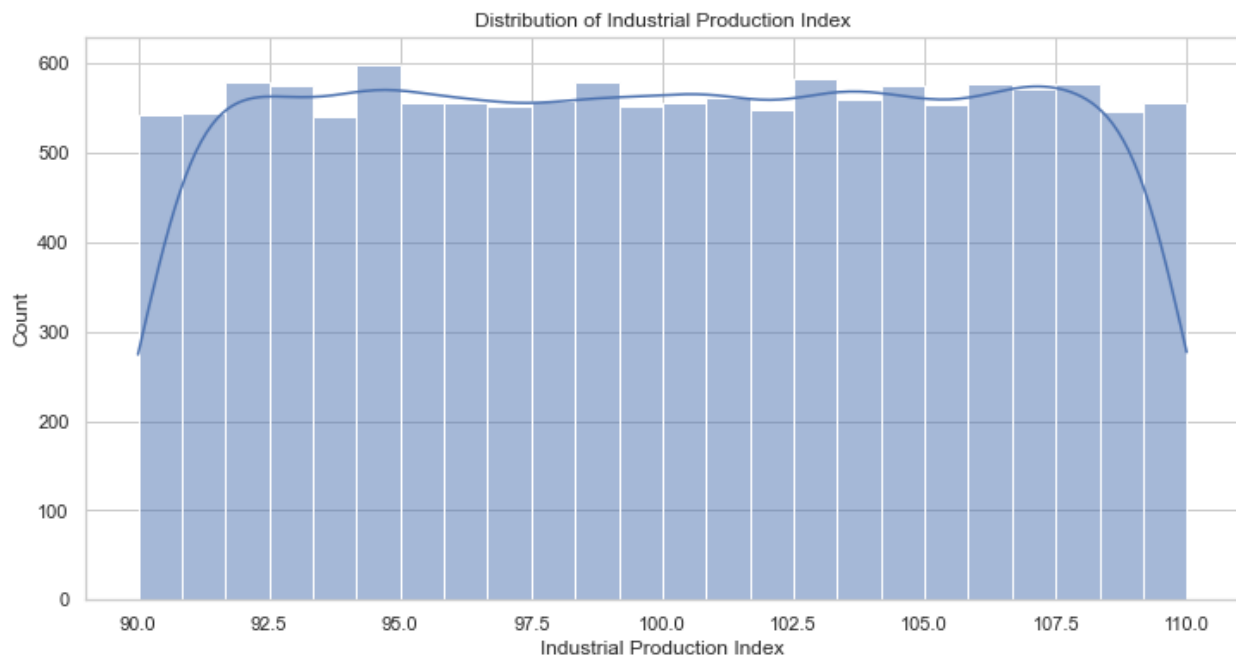


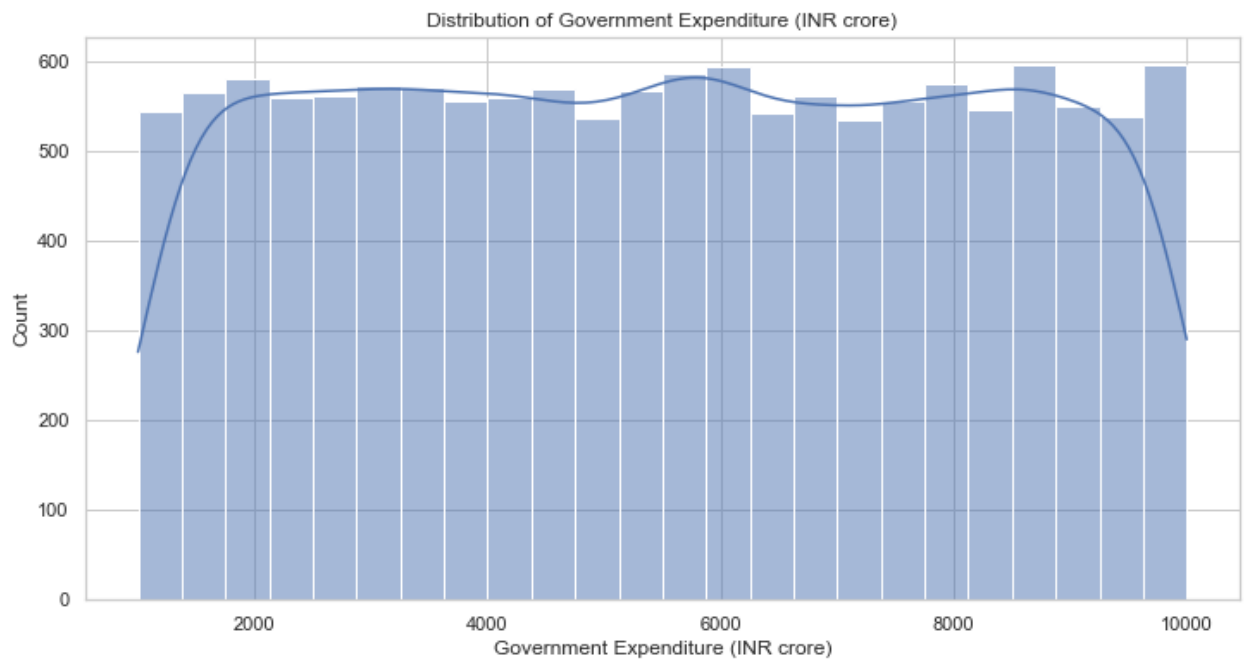
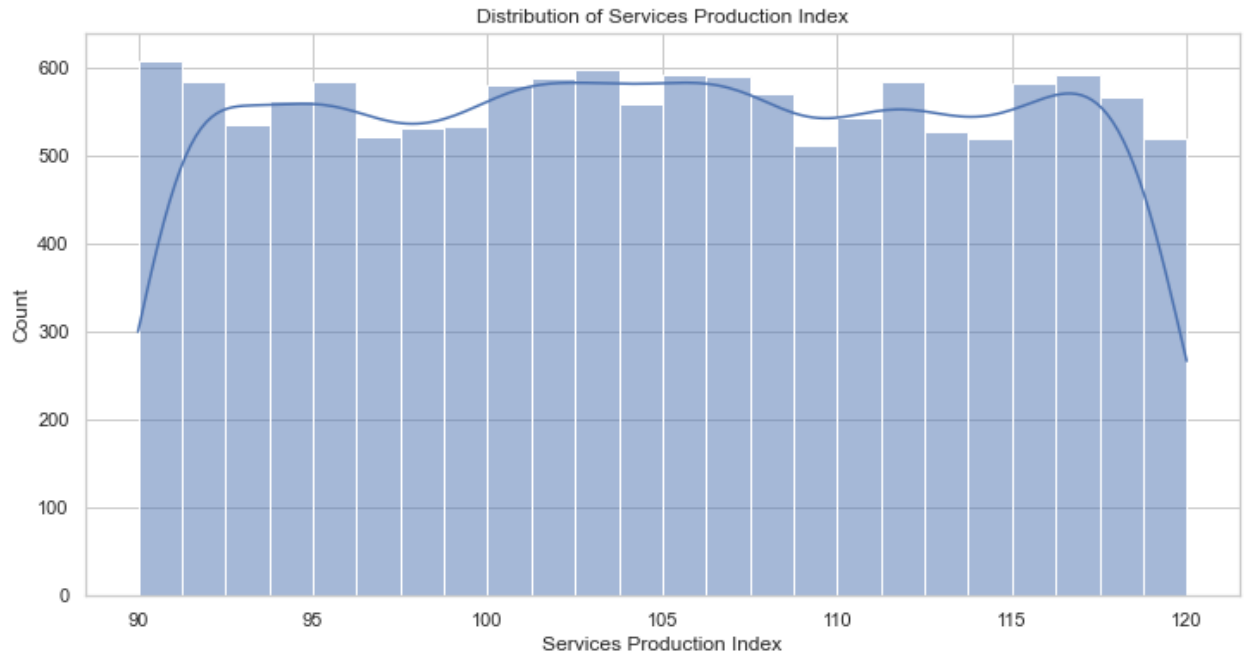


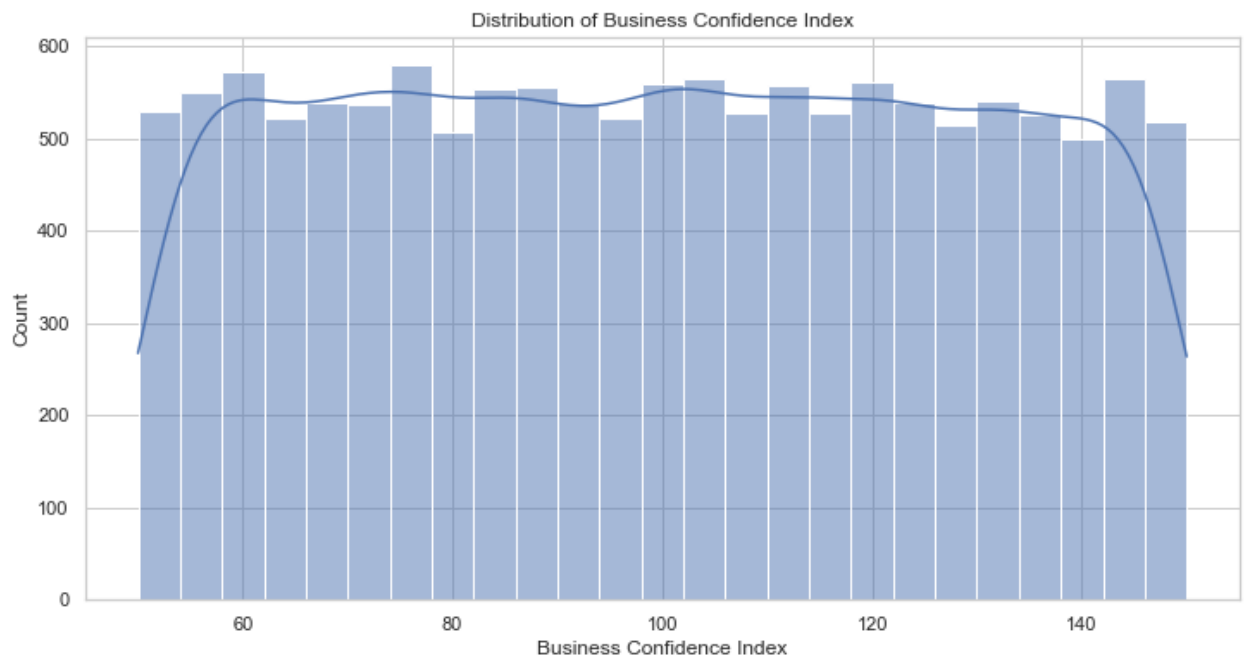
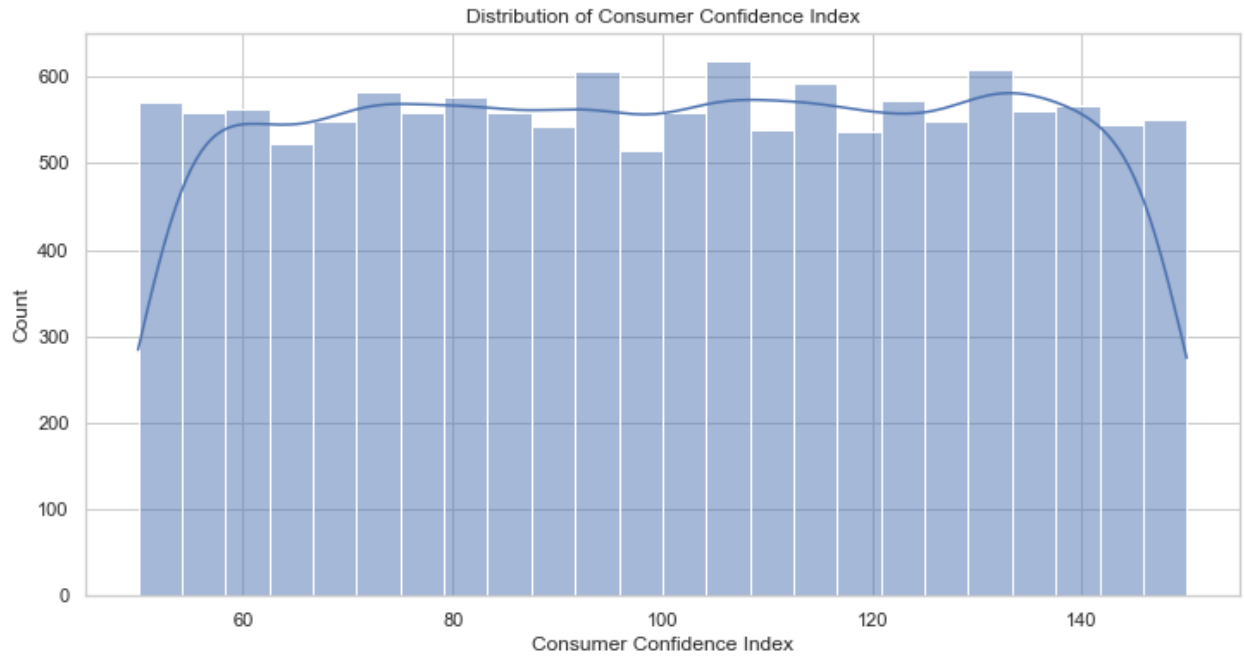


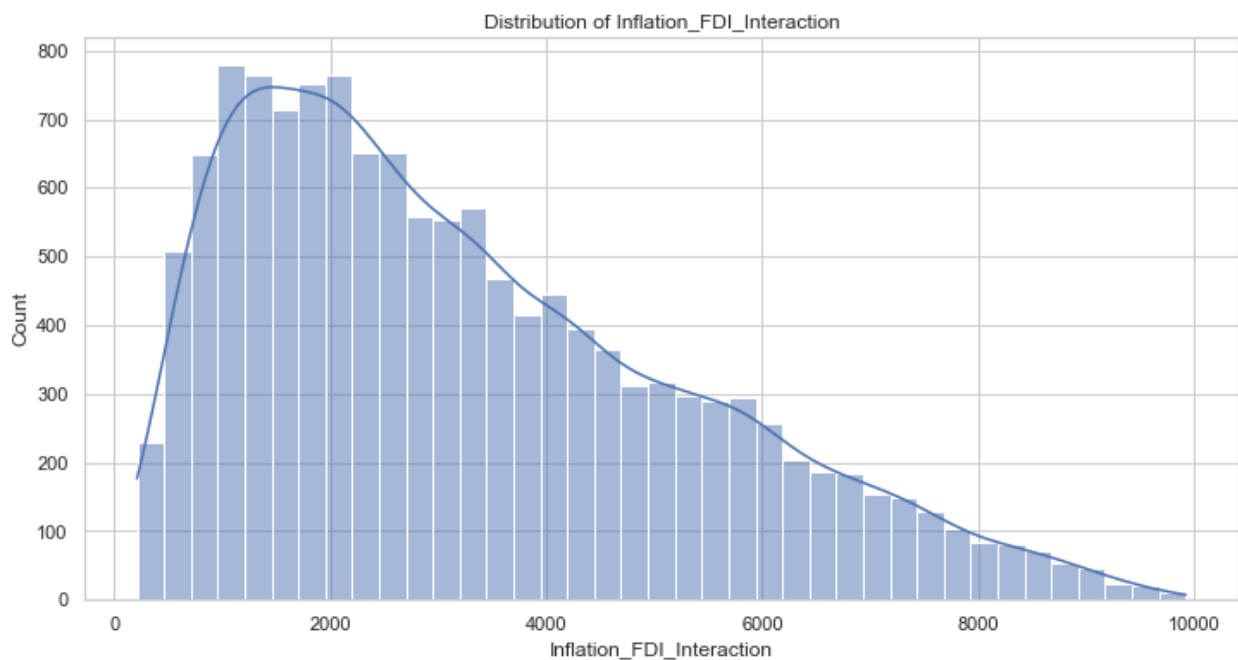
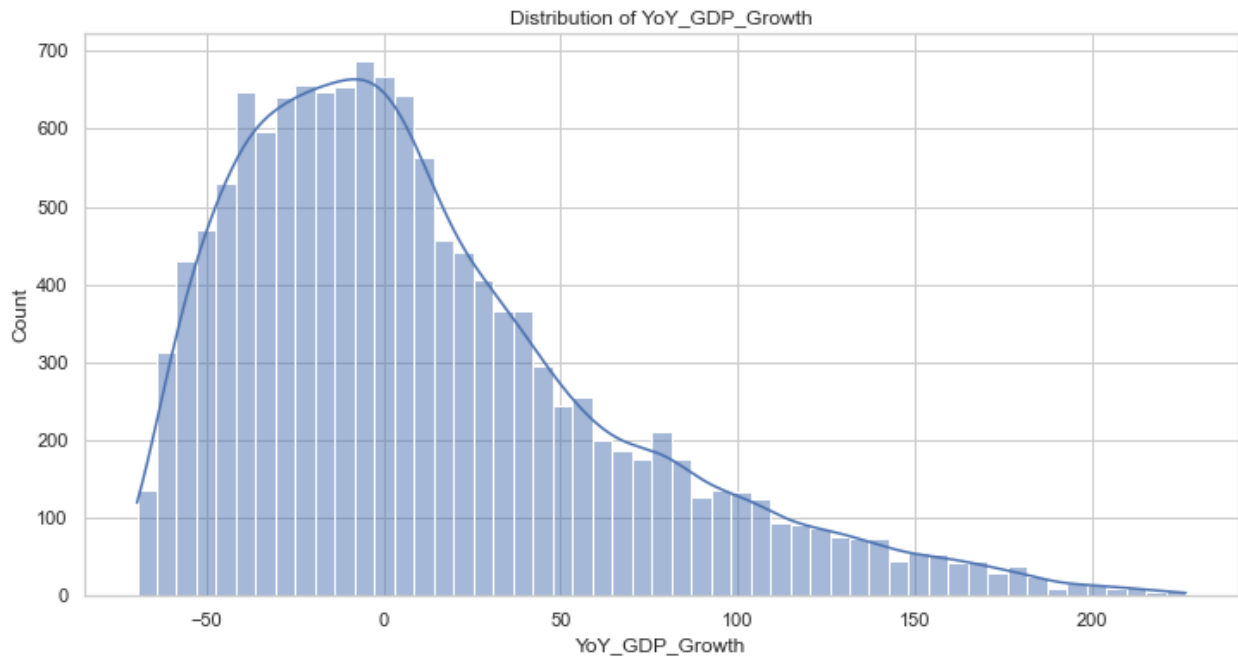












```
# Function to plot comparison
def plot_comparison(indicator, ylabel):
    plt.figure(figsize=(14, 7))
    sns.lineplot(x='Date', y=indicator, data=before_covid,
label='Before COVID-19')
    sns.lineplot(x='Date', y=indicator, data=after_covid, label='After
COVID-19')
    plt.axvline(x=pd.to_datetime('2020-03-01'), color='red',
linestyle='--', label='COVID-19 Start')
```

```

plt.xlabel('Date')
plt.ylabel(ylabel)
plt.title(f'{ylabel} Before and After COVID-19')
plt.legend()
plt.grid(True)
plt.show()

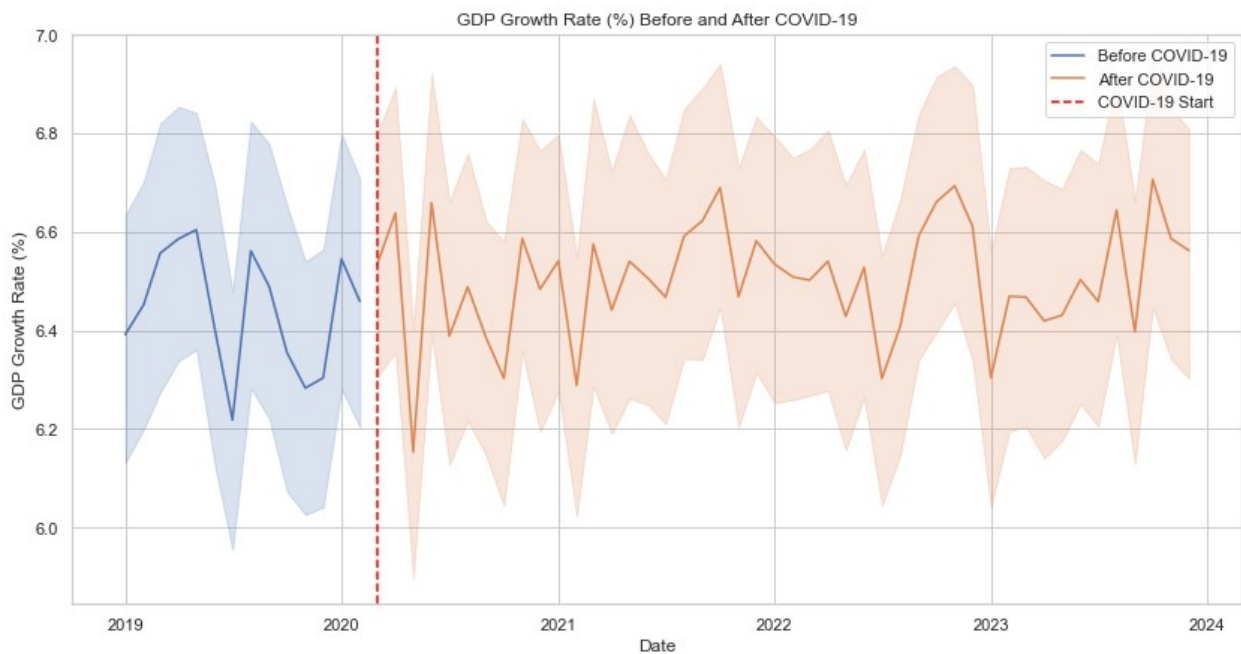
```

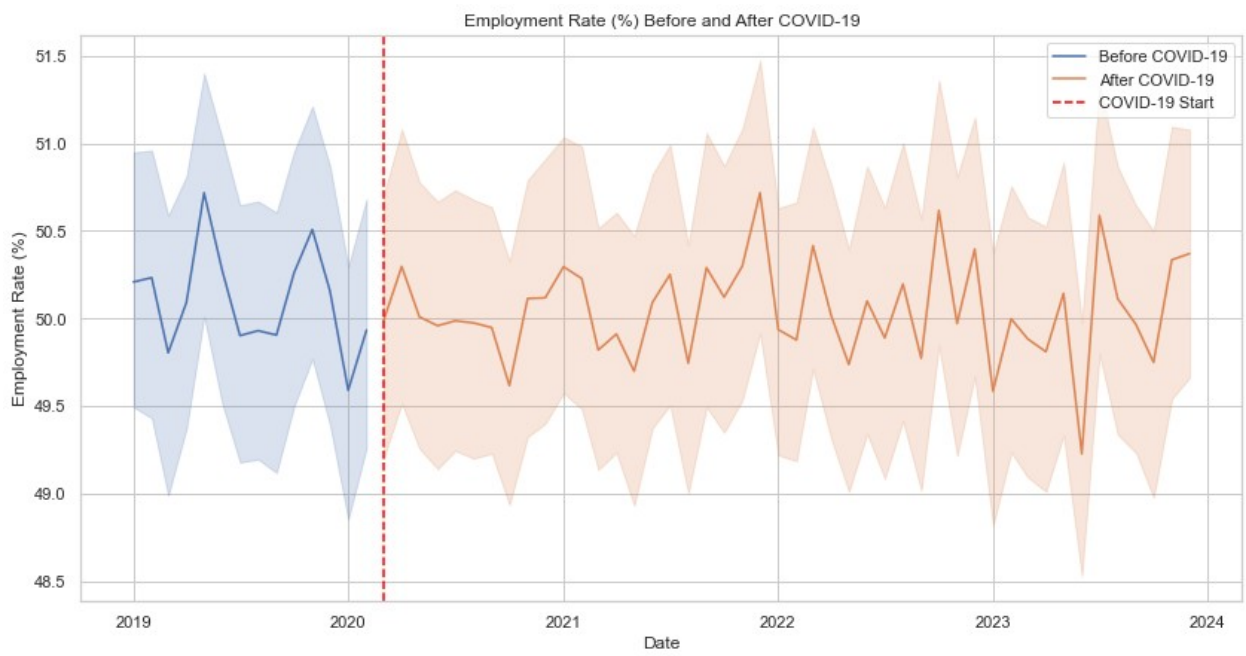
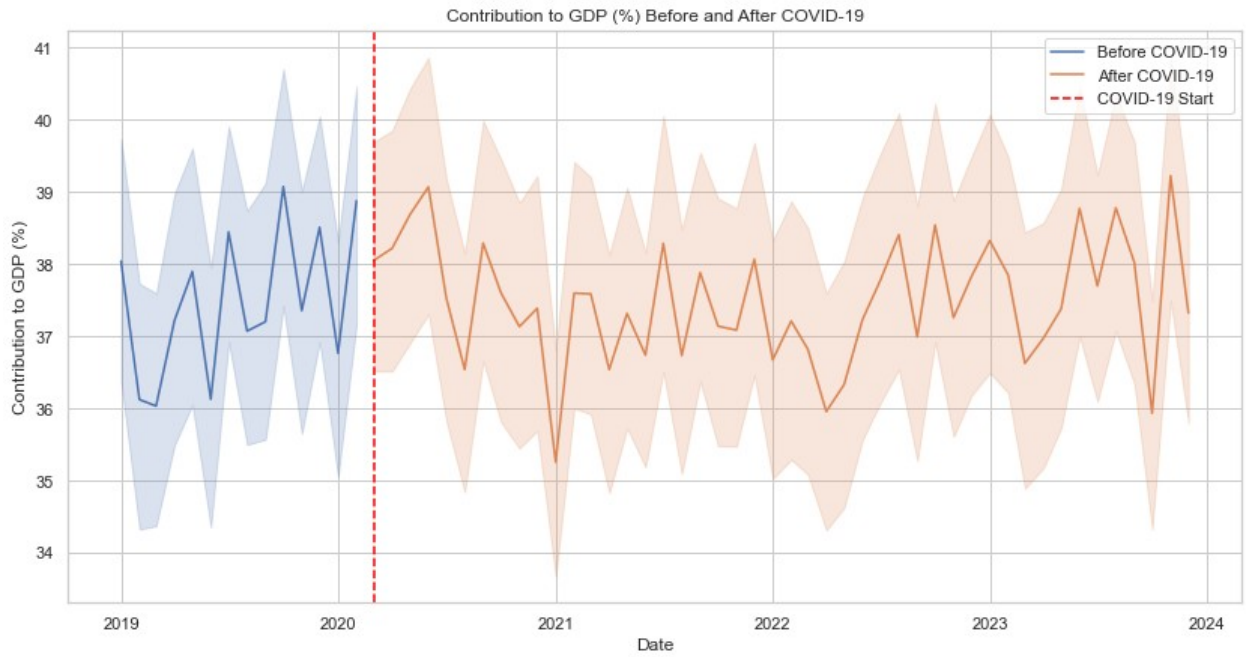
*# Plot key economic indicators before and after COVID-19*

```

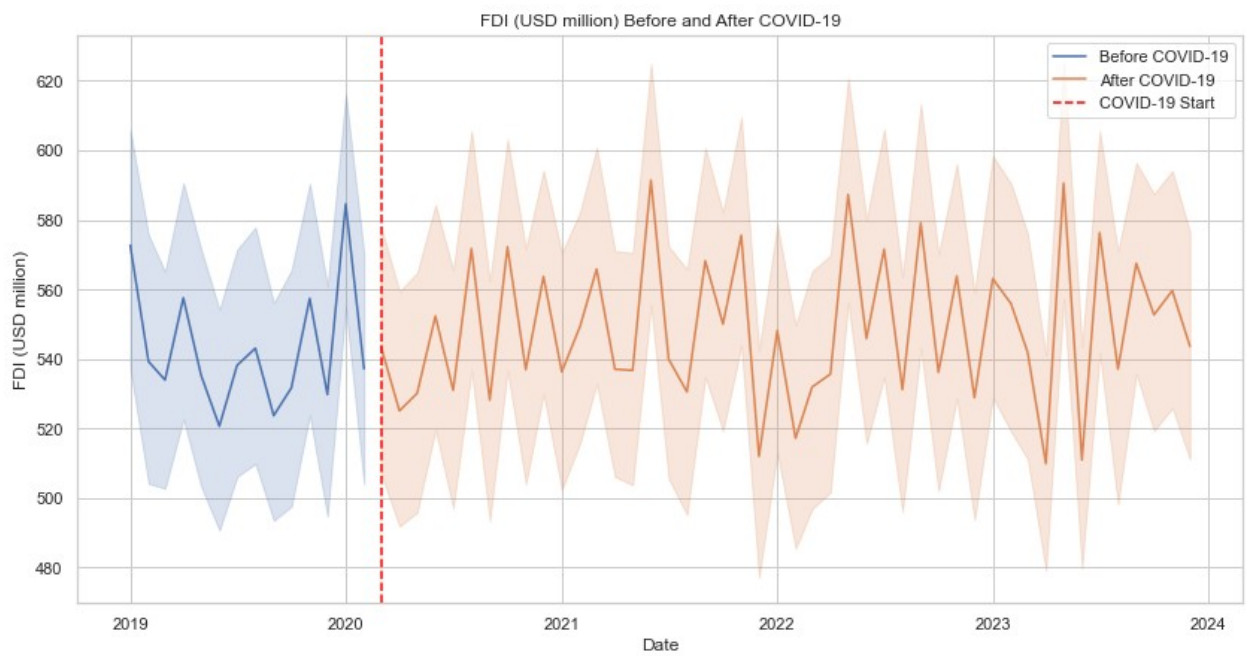
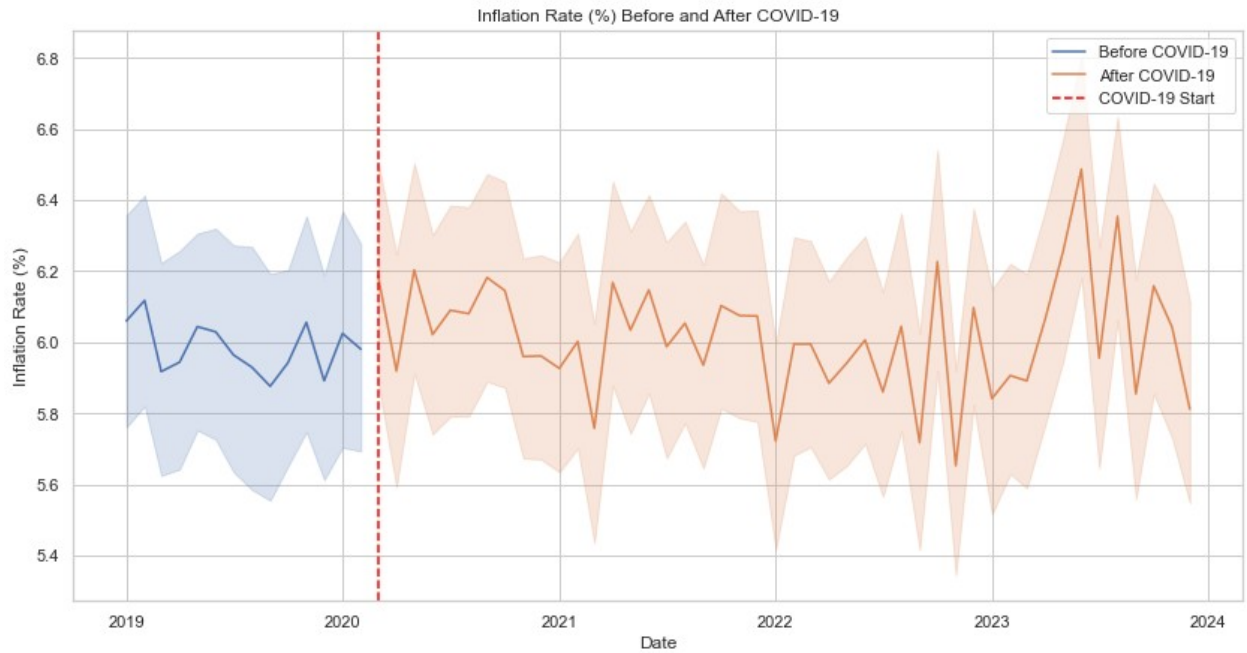
plot_comparison('GDP Growth Rate (%)', 'GDP Growth Rate (%)')
plot_comparison('Contribution to GDP (%)', 'Contribution to GDP (%)')
plot_comparison('Employment Rate (%)', 'Employment Rate (%)')
plot_comparison('Inflation Rate (%)', 'Inflation Rate (%)')
plot_comparison('FDI (USD million)', 'FDI (USD million)')
plot_comparison('Exchange Rate (INR/USD)', 'Exchange Rate (INR/USD)')
plot_comparison('Industrial Production Index', 'Industrial Production Index')
plot_comparison('Agricultural Production Index', 'Agricultural Production Index')
plot_comparison('Services Production Index', 'Services Production Index')
plot_comparison('Government Expenditure (INR crore)', 'Government Expenditure (INR crore)')
plot_comparison('Consumer Confidence Index', 'Consumer Confidence Index')
plot_comparison('Business Confidence Index', 'Business Confidence Index')

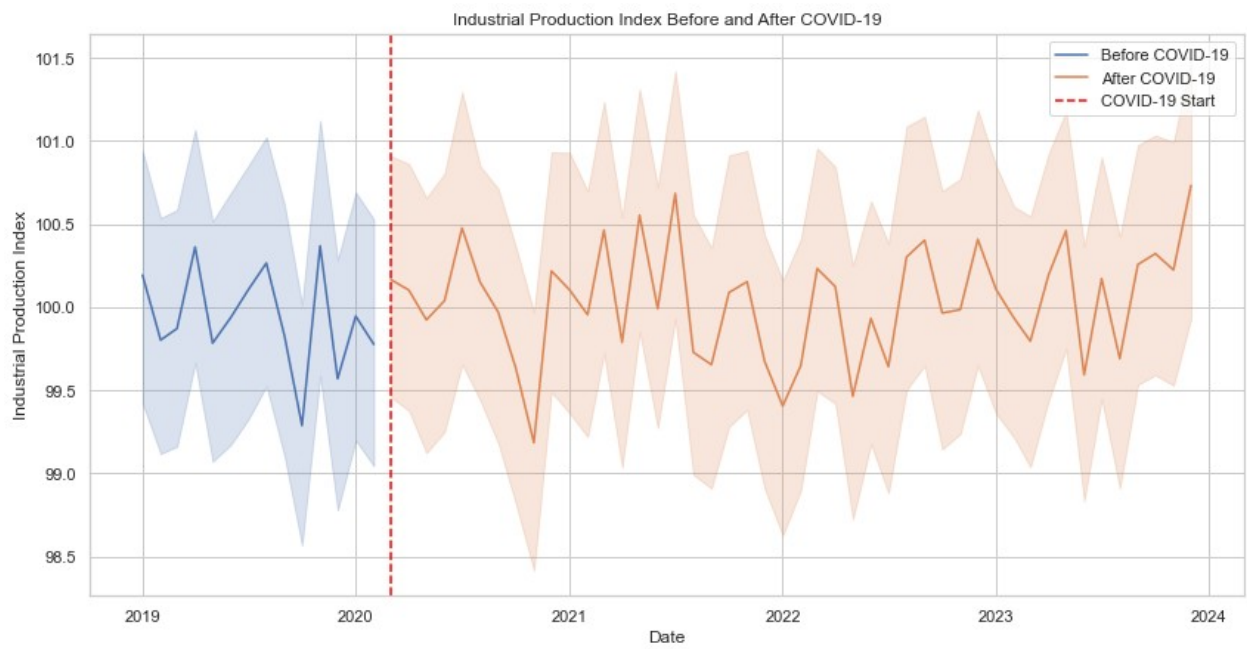
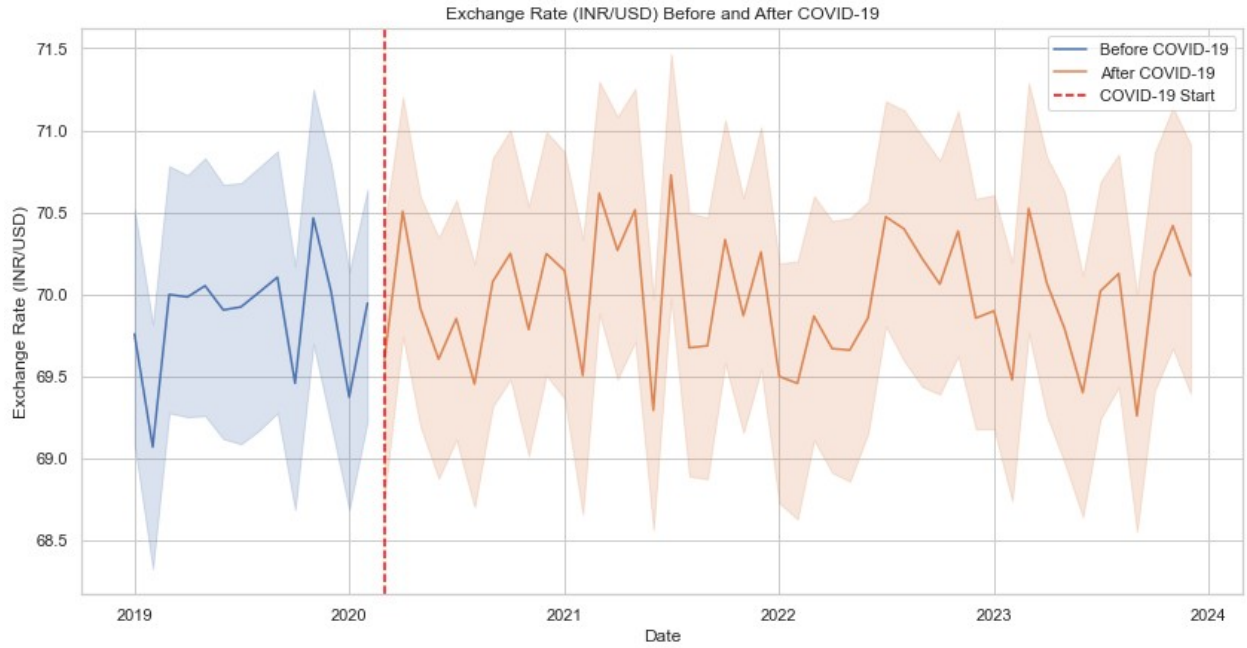
```

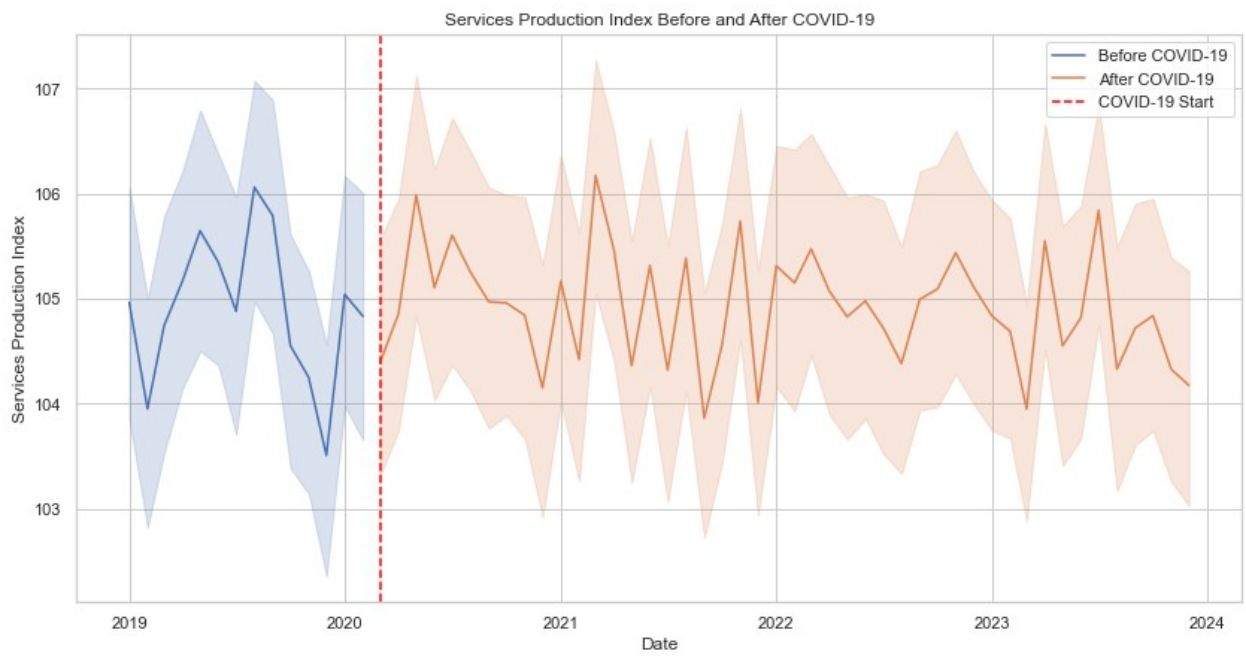
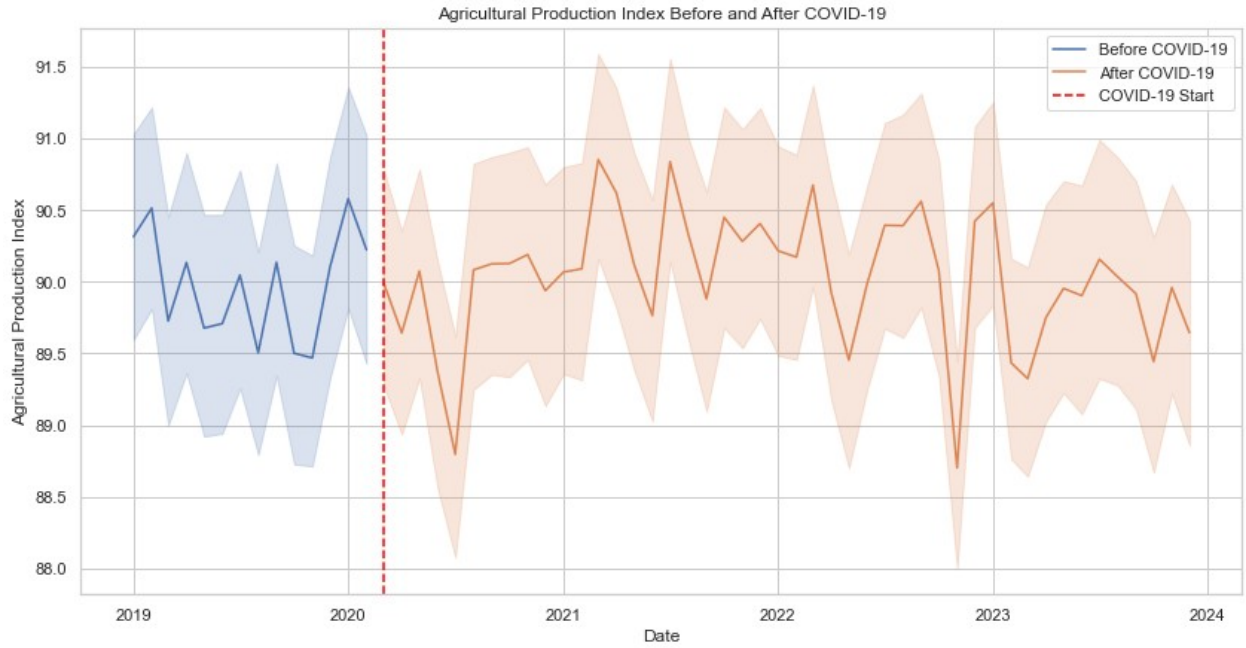


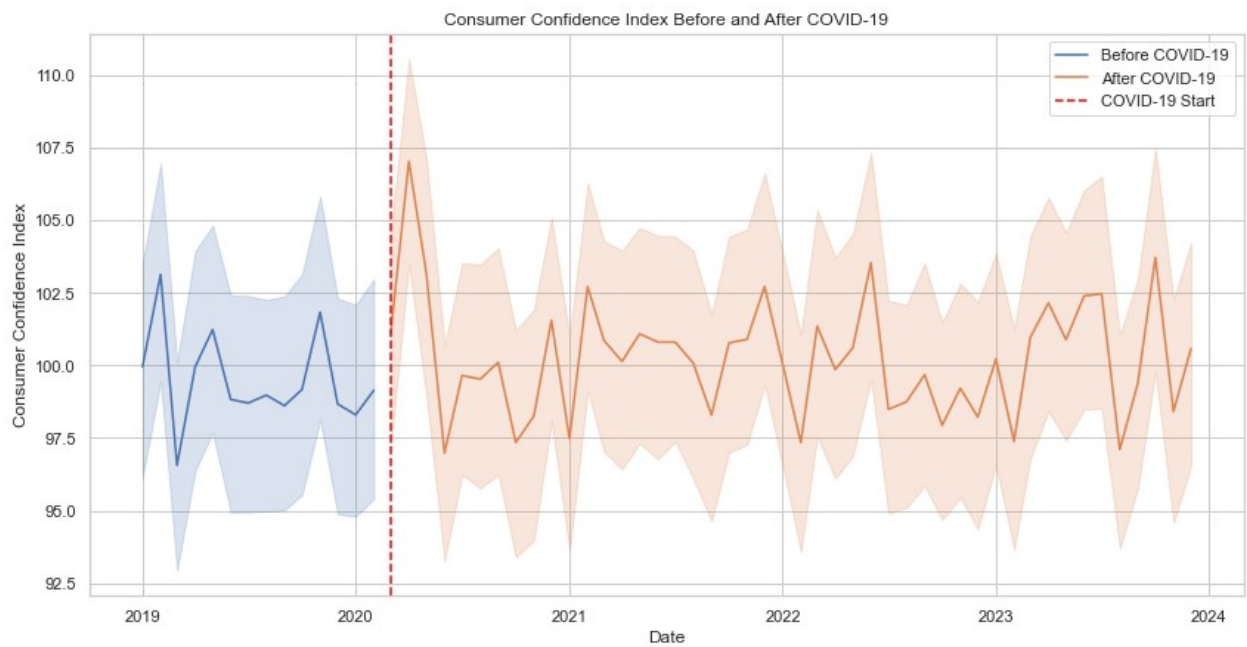
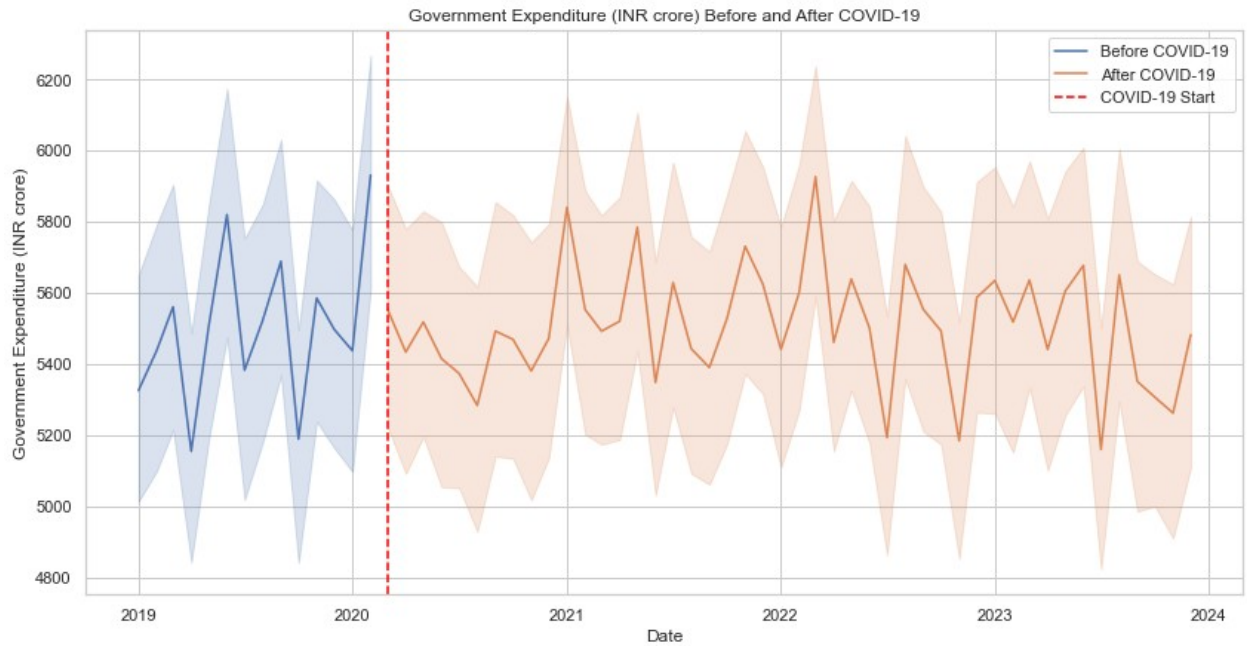


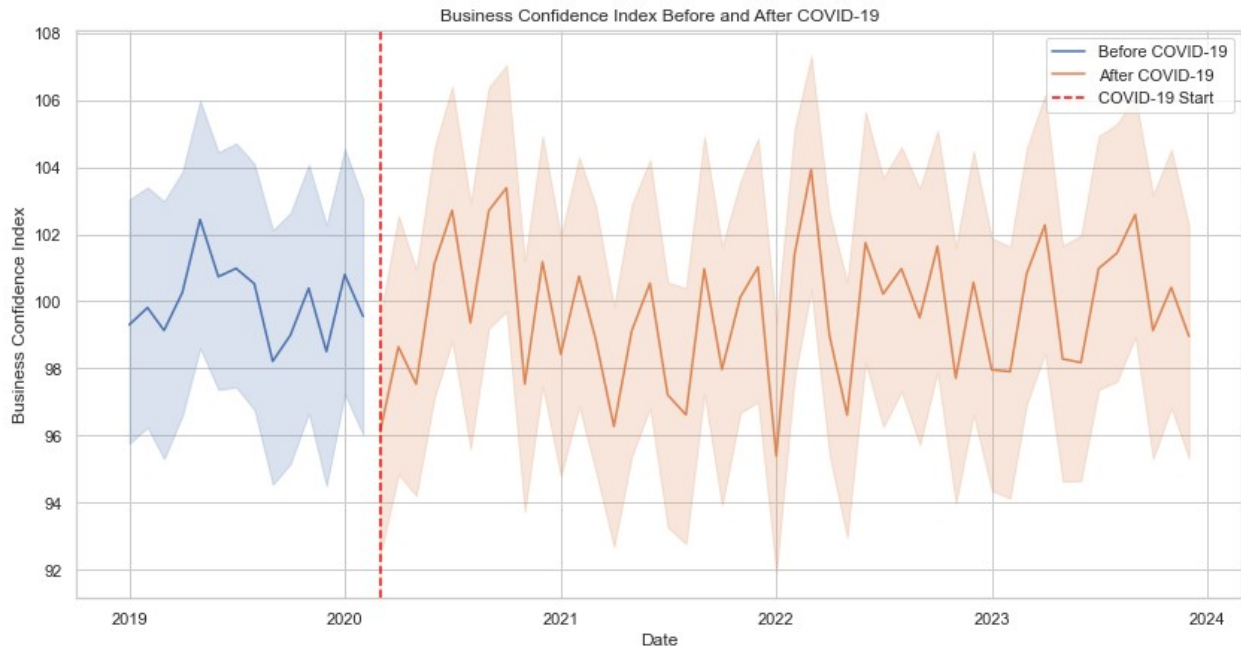












## 9. Summary and Conclusion

Summarize the key findings from the data analysis. Discuss how COVID-19 impacted different economic indicators.

Example Summary:

GDP Growth Rate: Significant decline observed after the onset of COVID-19.

Employment Rate: Noticeable decrease post-COVID-19.

Inflation Rate: Increased volatility observed.

FDI: Significant drop during the pandemic period.

Exchange Rate: Increased fluctuation post-COVID-19.

```
# Summary of findings
def summarize_changes(indicator):
    before_mean = before_covid[indicator].mean()
    after_mean = after_covid[indicator].mean()
    change = ((after_mean - before_mean) / before_mean) * 100
    print(f"\n{indicator}:")
    print(f"Mean before COVID-19: {before_mean:.2f}")
    print(f"Mean after COVID-19: {after_mean:.2f}")
    print(f"Percentage change: {change:.2f}%")

summarize_changes('GDP Growth Rate (%)')
summarize_changes('Contribution to GDP (%)')
```

```
summarize_changes('Employment Rate (%)')
summarize_changes('Inflation Rate (%)')
summarize_changes('FDI (USD million)')
summarize_changes('Exchange Rate (INR/USD)')
summarize_changes('Industrial Production Index')
summarize_changes('Agricultural Production Index')
summarize_changes('Services Production Index')
summarize_changes('Government Expenditure (INR crore)')
summarize_changes('Consumer Confidence Index')
summarize_changes('Business Confidence Index')
```

GDP Growth Rate (%):

Mean before COVID-19: 6.44

Mean after COVID-19: 6.50

Percentage change: 0.94%

Contribution to GDP (%):

Mean before COVID-19: 37.48

Mean after COVID-19: 37.49

Percentage change: 0.03%

Employment Rate (%):

Mean before COVID-19: 50.11

Mean after COVID-19: 50.05

Percentage change: -0.12%

Inflation Rate (%):

Mean before COVID-19: 5.98

Mean after COVID-19: 6.02

Percentage change: 0.55%

FDI (USD million):

Mean before COVID-19: 543.19

Mean after COVID-19: 548.53

Percentage change: 0.98%

Exchange Rate (INR/USD):

Mean before COVID-19: 69.86

Mean after COVID-19: 69.97

Percentage change: 0.16%

Industrial Production Index:

Mean before COVID-19: 99.94

Mean after COVID-19: 100.04

Percentage change: 0.10%

Agricultural Production Index:

Mean before COVID-19: 89.97

Mean after COVID-19: 90.02



Percentage change: 0.06%

Services Production Index:  
Mean before COVID-19: 104.91  
Mean after COVID-19: 104.91  
Percentage change: 0.01%

Government Expenditure (INR crore):  
Mean before COVID-19: 5502.38  
Mean after COVID-19: 5505.12  
Percentage change: 0.05%

Consumer Confidence Index:  
Mean before COVID-19: 99.50  
Mean after COVID-19: 100.26  
Percentage change: 0.76%

Business Confidence Index:  
Mean before COVID-19: 99.97  
Mean after COVID-19: 99.69  
Percentage change: -0.28%

df.columns

```
Index(['Year', 'Month', 'Sector', 'Sub-sector', 'GDP Growth Rate (%)',  
      'Contribution to GDP (%)', 'Export Category',  
      'Export Value (USD million)', 'Import Category',  
      'Import Value (USD million)', 'Employment Rate (%)',  
      'Inflation Rate (%)', 'FDI (USD million)', 'Exchange Rate  
(INR/USD)',  
      'Industrial Production Index', 'Agricultural Production Index',  
      'Services Production Index', 'Government Expenditure (INR  
crore)',  
      'Consumer Confidence Index', 'Business Confidence Index',  
      'Date',  
      'YoY_GDP_Growth', 'Inflation_FDI_Interaction'],  
      dtype='object')
```