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Practical 4 : To analyze and forecast sales trends using time series modeling techniques, including ARIMA, for effective decision-making in marketing and sales strategy.

```
import pandas as pd

df = pd.read_csv('/content/mktmix.csv')

df
```


```
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n    {\n      \"column\": \"Time period\",\n      \"properties\": {\n
\"dtype\": \"number\",\n        \"std\": 30,\n        \"min\": 1,\n
\"max\": 104,\n        \"num_unique_values\": 104,\n
\"samples\": [\n          31,\n          66,\n          65\
n        ],\n        \"semantic_type\": \"\",\n
\"description\": \"\"\n      }\n    },\n    {\n      \"column\":
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\"std\": 1578,\n        \"min\": 17431,\n        \"max\": 24944,\n
\"num_unique_values\": 102,\n        \"samples\": [\n          21546,\
n          22101,\n          20153\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    },\n    {\n      \"column\": \"Base_Price\",\n
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0.5289021254664108,\n        \"min\": 13.73572359,\n        \"max\":
16.2810198,\n        \"num_unique_values\": 17,\n        \"samples\":
[\n          15.02927551,\n          14.5850933,\n
15.79984295\n        ],\n        \"semantic_type\": \"\",\n
\"description\": \"\"\n      }\n    },\n    {\n      \"column\":
\"Radio\",\n      \"properties\": {\n        \"dtype\": \"number\",\n
\"std\": 86.99468171368089,\n        \"min\": 0.0,\n        \"max\":
399.0,\n        \"num_unique_values\": 53,\n        \"samples\": [\n
328.0,\n          267.0,\n          201.0\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    },\n    {\n      \"column\": \"InStore\",\n      \"properties\":
{\n        \"dtype\": \"number\",\n        \"std\":
13.682569850857004,\n        \"min\": 10.782,\n        \"max\":
68.119,\n        \"num_unique_values\": 104,\n        \"samples\": [\n
22.623,\n          22.227,\n          64.972\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    },\n    {\n      \"column\": \"TV\",\n      \"properties\": {\n
\"dtype\": \"number\",\n        \"std\": 42.94923109200048,\n
\"min\": 37.65617447,\n        \"max\": 240.291967,\n
\"num_unique_values\": 104,\n        \"samples\": [\n
202.9665375,\n          106.4226598,\n          177.4088659\
n        ],\n        \"semantic_type\": \"\",\n
\"description\": \"\"\n      }\n    }\n  ]\
n}","type":"dataframe","variable_name":"df"}
```
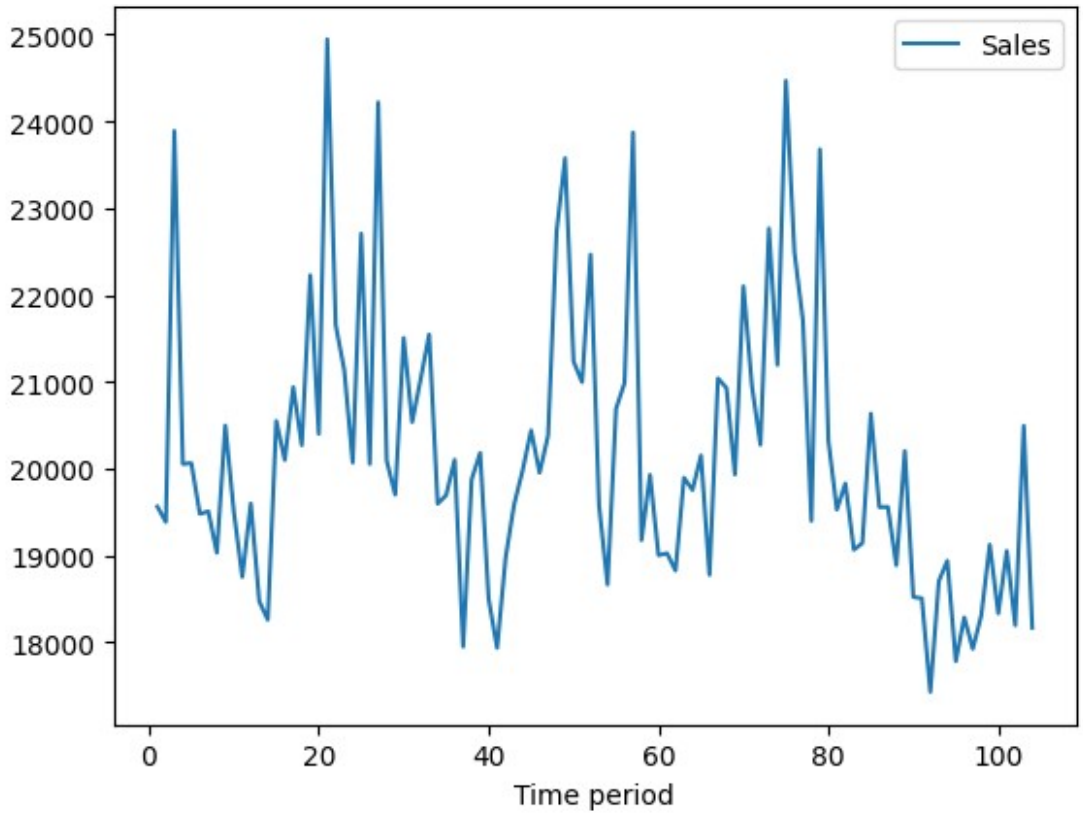
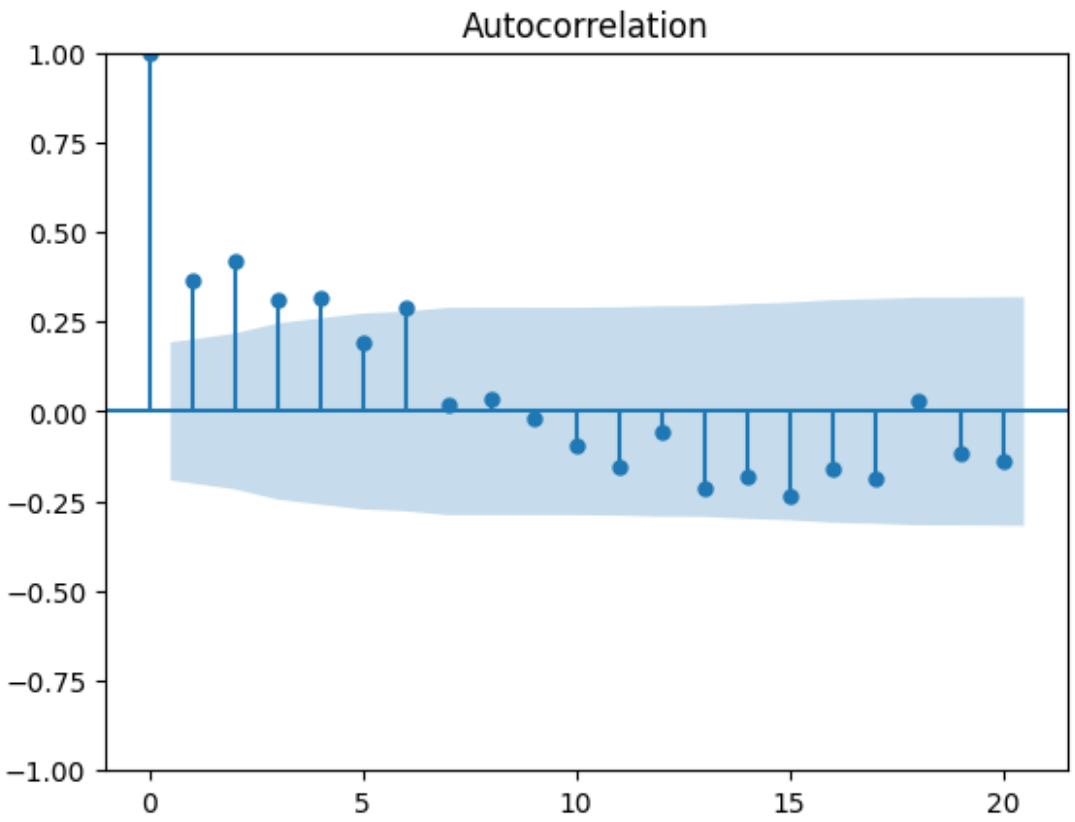

```
import matplotlib.pyplot as plt

df.plot(x='Time period', y='Sales')
plt.show()
```




```
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
plot_acf(df['Sales'], lags = 20)
plt.show()
```




```
!pip install arch

Collecting arch
  Downloading arch-7.2.0-cp311-cp311-
manylinux_2_17_x86_64.manylinux2014_x86_64.whl.metadata (13 kB)
Requirement already satisfied: numpy>=1.22.3 in
/usr/local/lib/python3.11/dist-packages (from arch) (1.26.4)
Requirement already satisfied: scipy>=1.8 in
/usr/local/lib/python3.11/dist-packages (from arch) (1.13.1)
Requirement already satisfied: pandas>=1.4 in
/usr/local/lib/python3.11/dist-packages (from arch) (2.2.2)
Requirement already satisfied: statsmodels>=0.12 in
/usr/local/lib/python3.11/dist-packages (from arch) (0.14.4)
Requirement already satisfied: python-dateutil>=2.8.2 in
/usr/local/lib/python3.11/dist-packages (from pandas>=1.4->arch)
(2.8.2)
Requirement already satisfied: pytz>=2020.1 in
/usr/local/lib/python3.11/dist-packages (from pandas>=1.4->arch)
(2025.1)
Requirement already satisfied: tzdata>=2022.7 in
/usr/local/lib/python3.11/dist-packages (from pandas>=1.4->arch)
(2025.1)
Requirement already satisfied: patsy>=0.5.6 in
/usr/local/lib/python3.11/dist-packages (from statsmodels>=0.12->arch)
```

```
(1.0.1)
Requirement already satisfied: packaging>=21.3 in
/usr/local/lib/python3.11/dist-packages (from statsmodels>=0.12->arch)
(24.2)
Requirement already satisfied: six>=1.5 in
/usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.8.2-
>pandas>=1.4->arch) (1.17.0)
Downloading arch-7.2.0-cp311-cp311-
manylinux_2_17_x86_64.manylinux2014_x86_64.whl (985 kB)
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 0.0/985.3 kB ? eta -:--:--
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 985.3/985.3 kB 52.3 MB/s eta
0:00:00
```

```
from arch.unitroot import ADF
adf = ADF(df['Sales'], lags=0)
print(adf.summary())
```

```
   Augmented Dickey-Fuller Results
====================================
Test Statistic                 -6.730
P-value                         0.000
Lags                                0
------------------------------------

Trend: Constant
Critical Values: -3.50 (1%), -2.89 (5%), -2.58 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.
```

```
!pip install pmdarima
```

```
Collecting pmdarima
  Downloading pmdarima-2.0.4-cp311-cp311-
manylinux_2_17_x86_64.manylinux2014_x86_64.manylinux_2_28_x86_64.whl.m
etadata (7.8 kB)
Requirement already satisfied: joblib>=0.11 in
/usr/local/lib/python3.11/dist-packages (from pmdarima) (1.4.2)
Requirement already satisfied: Cython!=0.29.18,!=0.29.31,>=0.29 in
/usr/local/lib/python3.11/dist-packages (from pmdarima) (3.0.12)
Requirement already satisfied: numpy>=1.21.2 in
/usr/local/lib/python3.11/dist-packages (from pmdarima) (1.26.4)
Requirement already satisfied: pandas>=0.19 in
/usr/local/lib/python3.11/dist-packages (from pmdarima) (2.2.2)
Requirement already satisfied: scikit-learn>=0.22 in
/usr/local/lib/python3.11/dist-packages (from pmdarima) (1.6.1)
Requirement already satisfied: scipy>=1.3.2 in
/usr/local/lib/python3.11/dist-packages (from pmdarima) (1.13.1)
Requirement already satisfied: statsmodels>=0.13.2 in
/usr/local/lib/python3.11/dist-packages (from pmdarima) (0.14.4)
Requirement already satisfied: urllib3 in
```

```
/usr/local/lib/python3.11/dist-packages (from pmdarima) (2.3.0)
Requirement already satisfied: setuptools!=50.0.0,>=38.6.0 in
/usr/local/lib/python3.11/dist-packages (from pmdarima) (75.1.0)
Requirement already satisfied: packaging>=17.1 in
/usr/local/lib/python3.11/dist-packages (from pmdarima) (24.2)
Requirement already satisfied: python-dateutil>=2.8.2 in
/usr/local/lib/python3.11/dist-packages (from pandas>=0.19->pmdarima)
(2.8.2)
Requirement already satisfied: pytz>=2020.1 in
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(2025.1)
Requirement already satisfied: tzdata>=2022.7 in
/usr/local/lib/python3.11/dist-packages (from pandas>=0.19->pmdarima)
(2025.1)
Requirement already satisfied: threadpoolctl>=3.1.0 in
/usr/local/lib/python3.11/dist-packages (from scikit-learn>=0.22-
>pmdarima) (3.5.0)
Requirement already satisfied: patsy>=0.5.6 in
/usr/local/lib/python3.11/dist-packages (from statsmodels>=0.13.2-
>pmdarima) (1.0.1)
Requirement already satisfied: six>=1.5 in
/usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.8.2-
>pandas>=0.19->pmdarima) (1.17.0)
Downloading pmdarima-2.0.4-cp311-cp311-
manylinux_2_17_x86_64.manylinux2014_x86_64.manylinux_2_28_x86_64.whl
(2.2 MB)
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 2.2/2.2 MB 30.2 MB/s eta
0:00:00
darima
Successfully installed pmdarima-2.0.4
```

```
import pmdarima as pm
model = pm.auto_arima(df['Sales'],max_p=2, max_q=2,
seasonal=False,trace=True)
model
```

```
/usr/local/lib/python3.11/dist-packages/sklearn/utils/
deprecation.py:151: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.11/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
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/usr/local/lib/python3.11/dist-packages/sklearn/utils/deprecation.py:1
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```

```
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/usr/local/lib/python3.11/dist-packages/sklearn/utils/deprecation.py:1
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'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(

Performing stepwise search to minimize aic
 ARIMA(2,0,2)(0,0,0)[0]             : AIC=inf, Time=0.33 sec
 ARIMA(0,0,0)(0,0,0)[0]             : AIC=2359.465, Time=0.01 sec
 ARIMA(1,0,0)(0,0,0)[0]             : AIC=inf, Time=0.01 sec
 ARIMA(0,0,1)(0,0,0)[0]             : AIC=2241.822, Time=0.06 sec
 ARIMA(1,0,1)(0,0,0)[0]             : AIC=1816.527, Time=0.05 sec
 ARIMA(2,0,1)(0,0,0)[0]             : AIC=1817.450, Time=0.06 sec

/usr/local/lib/python3.11/dist-packages/sklearn/utils/
deprecation.py:151: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.11/dist-packages/sklearn/utils/deprecation.py:1
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'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.11/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
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  warnings.warn(
/usr/local/lib/python3.11/dist-packages/sklearn/utils/deprecation.py:1
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'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.11/dist-packages/sklearn/utils/deprecation.py:1
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'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.11/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(

 ARIMA(1,0,2)(0,0,0)[0]             : AIC=1817.545, Time=0.03 sec
 ARIMA(0,0,2)(0,0,0)[0]             : AIC=inf, Time=0.09 sec
 ARIMA(2,0,0)(0,0,0)[0]             : AIC=inf, Time=0.03 sec
 ARIMA(1,0,1)(0,0,0)[0] intercept   : AIC=1811.457, Time=0.04 sec
 ARIMA(0,0,1)(0,0,0)[0] intercept   : AIC=1823.184, Time=0.02 sec
```

```
/usr/local/lib/python3.11/dist-packages/sklearn/utils/
deprecation.py:151: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.11/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.11/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.11/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.11/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(

 ARIMA(1,0,0)(0,0,0)[0] intercept   : AIC=1816.658, Time=0.04 sec
 ARIMA(2,0,1)(0,0,0)[0] intercept   : AIC=1807.850, Time=0.09 sec
 ARIMA(2,0,0)(0,0,0)[0] intercept   : AIC=1806.657, Time=0.04 sec

Best model:  ARIMA(2,0,0)(0,0,0)[0] intercept
Total fit time: 0.939 seconds

/usr/local/lib/python3.11/dist-packages/sklearn/utils/
deprecation.py:151: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(
/usr/local/lib/python3.11/dist-packages/sklearn/utils/deprecation.py:1
51: FutureWarning: 'force_all_finite' was renamed to
'ensure_all_finite' in 1.6 and will be removed in 1.8.
  warnings.warn(

ARIMA(order=(2, 0, 0), scoring_args={}, suppress_warnings=True)
```

```python
from statsmodels.tsa.arima.model  import ARIMA
model = ARIMA(df['Sales'], order=(2,0,0)).fit()
model.params
print(model.params)
model.aic
print(model.aic)
```

```
const     2.017107e+04
ar.L1     2.453862e-01
ar.L2     3.306586e-01
sigma2    1.923688e+06
```

```
dtype: float64
1806.6676239813928

resi = model.resid
from statsmodels.stats.diagnostic import acorr_ljungbox
acorr_ljungbox(resi,lags=10,boxpierce=True)

{"summary":"{\n  \"name\":
\"acorr_ljungbox(resi,lags=10,boxpierce=True)\",\n  \"rows\": 10,\n
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4.725260387068468,\n        \"min\": 0.11542799867676266,\n
\"max\": 11.124806750554027,\n        \"num_unique_values\": 10,\n
\"samples\": [\n          10.148477039192779,\n
0.5940387227870887,\n          8.44973137859981\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    },\n    {\n      \"column\": \"lb_pvalue\",\n
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\"max\": 0.8811252810732884,\n        \"num_unique_values\": 10,\n
\"samples\": [\n          0.33859949774590375,\n
0.7430296261336649,\n          0.20697058951684041\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    },\n    {\n      \"column\": \"bp_stat\",\n      \"properties\":
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\"max\": 10.277066921519122,\n        \"num_unique_values\": 10,\n
\"samples\": [\n          9.41126510201009,\n
0.5727111105939605,\n          7.861877744375427\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    },\n    {\n      \"column\": \"bp_pvalue\",\n
\"properties\": {\n        \"dtype\": \"number\",\n        \"std\":
0.25532672549138075,\n        \"min\": 0.24330740282916474,\n
\"max\": 0.8916636104649807,\n        \"num_unique_values\": 10,\n
\"samples\": [\n          0.40020866744426387,\n
0.7509955480258834,\n          0.24839819326951695\n        ],\n
\"semantic_type\": \"\",\n        \"description\": \"\"\n      }\
n    }\n  ]\n}","type":"dataframe"}

model.forecast(steps=3)

104    19786.898722
105    19414.796883
106    19858.460296
Name: predicted_mean, dtype: float64
```