```
import pandas as pd

# Load all three CSV files
file_paths = [
    "/content/gsw-shg-en 2022-2023.csv",
    "/content/gsw-shg-en 2023-2024.csv",
    "/content/gsw-shg-en 2024-2025.csv"
]

# Read and concatenate all datasets, handling errors and potential delimiters
df_all = pd.concat([
    pd.read_csv(
        file,
        encoding='latin-1',
        on_bad_lines='skip',  # Skip lines with errors
        sep=',',             # Explicitly define the delimiter as a comma
        #engine='python'       # Consider using the Python engine if 'c' fails
    )
    for file in file_paths
], ignore_index=True)

# Display basic info to understand structure
df_all.info(), df_all.head()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 516889 entries, 0 to 516888
Data columns (total 10 columns):
 #   Column           Non-Null Count   Dtype
---  ------           --------------   -----
 0   grain_week       516889 non-null  int64
 1   crop_year        516889 non-null  object
 2   week_ending_date 516889 non-null  object
 3   worksheet        516889 non-null  object
 4   metric           516889 non-null  object
 5   period           516889 non-null  object
 6   grain            516889 non-null  object
 7   grade            152100 non-null  object
 8   region           503473 non-null  object
 9   Ktonnes          516887 non-null  object
dtypes: int64(1), object(9)
memory usage: 39.4+ MB
(None,
    grain_week  crop_year week_ending_date    worksheet      metric  \
 0           1  2022-2023       07/08/2022  Feed Grains  Deliveries
 1           1  2022-2023       07/08/2022  Feed Grains  Deliveries
 2           1  2022-2023       07/08/2022  Feed Grains  Deliveries
 3           1  2022-2023       07/08/2022  Feed Grains  Deliveries
 4           1  2022-2023       07/08/2022  Feed Grains  Deliveries

          period  grain grade           region Ktonnes
 0  Current Week  Wheat   NaN         Manitoba     0.7
 1  Current Week  Wheat   NaN     Saskatchewan     1.2
 2  Current Week  Wheat   NaN          Alberta     1.3
 3  Current Week  Wheat   NaN  British Columbia     0.1
 4  Current Week   Oats   NaN         Manitoba       0  )
```

Step 1: Filter the Data

```
# Fix: Convert Ktonnes to string, remove commas, convert to float
df_all["Ktonnes"] = pd.to_numeric(df_all["Ktonnes"].astype(str).str.replace(",", ""), errors="coerce")

# Filter for Terminal Exports, Corn and Soybeans, Bay & Lakes and St. Lawrence
filtered_df = df_all[
    (df_all["worksheet"] == "Terminal Exports") &
    (df_all["grain"].isin(["Corn", "Soybeans"])) &
    (df_all["region"].isin(["Bay & Lakes", "St. Lawrence"]))
]

# Convert week_ending_date to datetime format
filtered_df = filtered_df.copy()
filtered_df["week_ending_date"] = pd.to_datetime(filtered_df["week_ending_date"], dayfirst=True, errors="coerce")

# Group by week and grain
weekly_exports = filtered_df.groupby(["week_ending_date", "grain"])["Ktonnes"].sum().reset_index()

# Pivot so Corn and Soybeans are separate columns
pivot_df = weekly_exports.pivot(index="week_ending_date", columns="grain", values="Ktonnes")
```

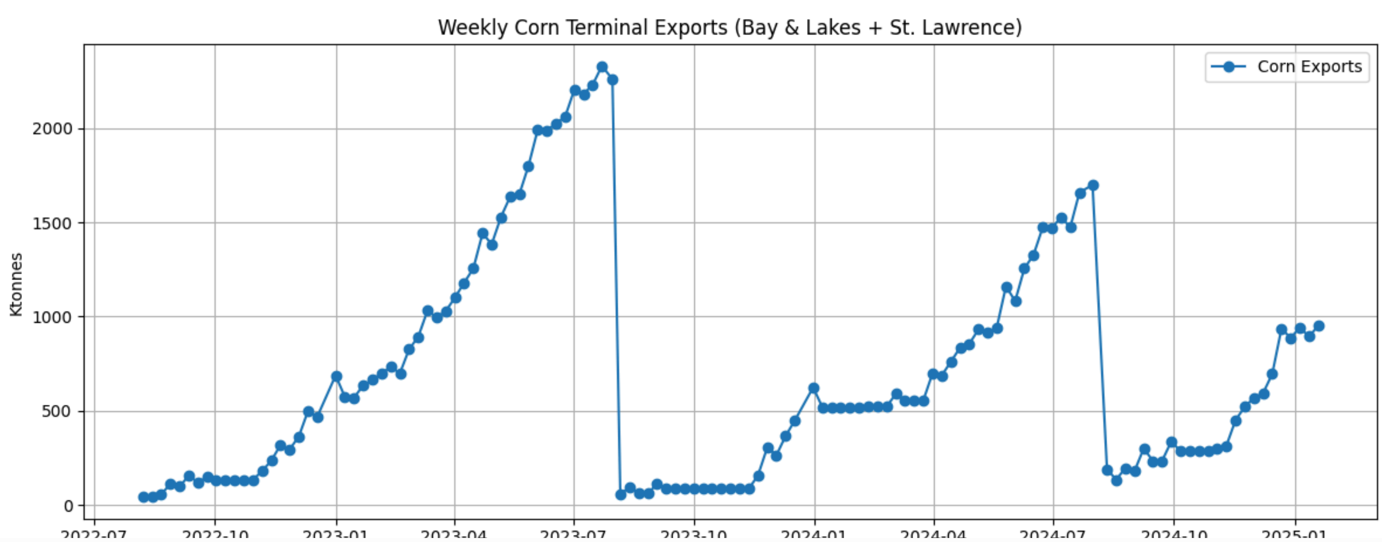
```
pivot_df = pivot_df.sort_index()

pivot_df.head()
```

grain	Corn	Soybeans
week_ending_date		
2022-08-07	46.6	34.2
2022-08-14	42.7	24.5
2022-08-21	58.2	20.8
2022-08-28	110.2	21.2

Next steps: Generate code with pivot_df View recommended plots New interactive sheet

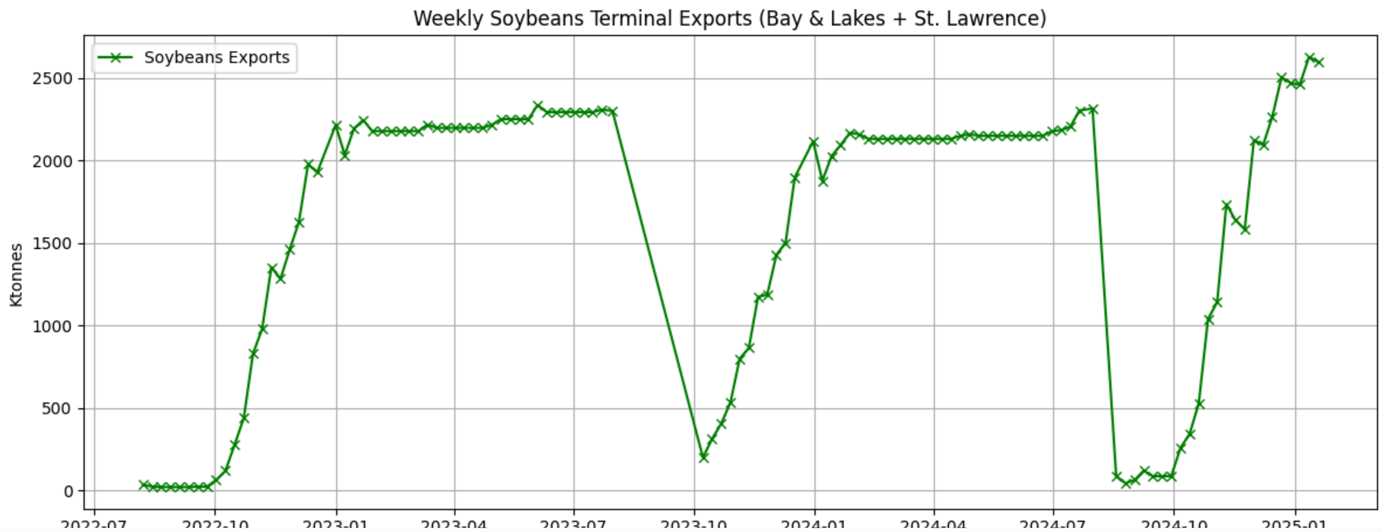
Visualize the time series (Corn & Soybeans)

```
import matplotlib.pyplot as plt

# Drop NaN values to avoid plotting issues
corn_series = pivot_df["Corn"].dropna()

# Plot Corn
plt.figure(figsize=(12, 5))
plt.plot(corn_series.index, corn_series.values, label="Corn Exports", marker='o')
plt.title("Weekly Corn Terminal Exports (Bay & Lakes + St. Lawrence)")
plt.xlabel("Week Ending Date")
plt.ylabel("Ktonnes")
plt.grid(True)
plt.legend()
plt.tight_layout()
plt.show()
```

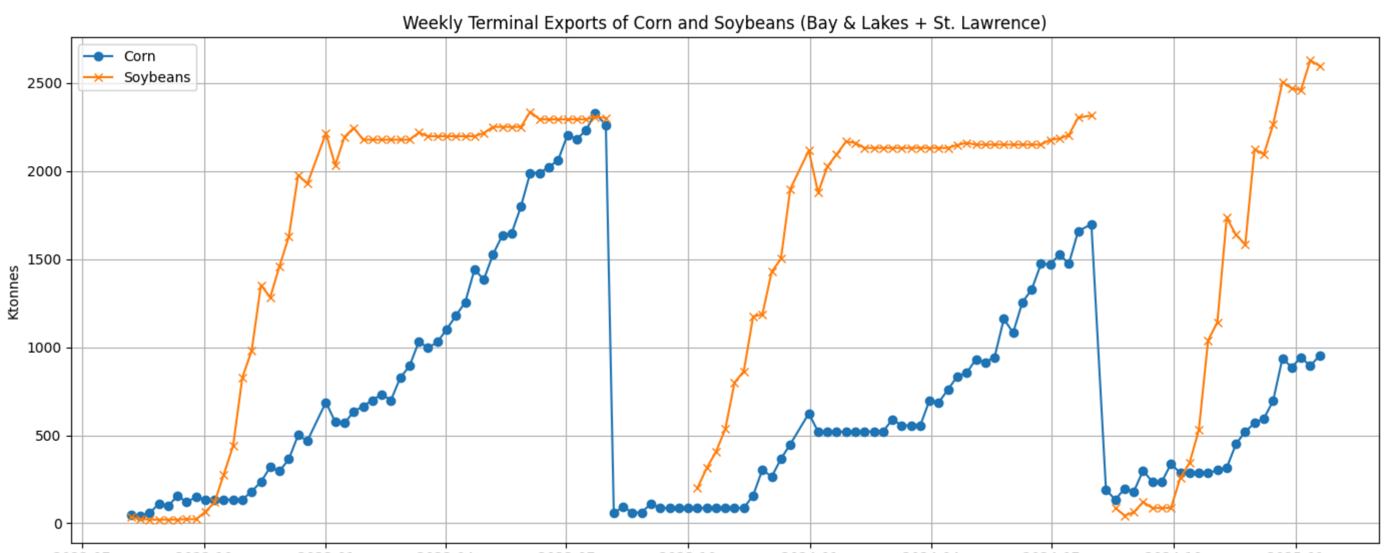



```
# Drop NaN values for Soybeans
soybeans_series = pivot_df["Soybeans"].dropna()

# Plot Soybeans
plt.figure(figsize=(12, 5))
plt.plot(soybeans_series.index, soybeans_series.values, label="Soybeans Exports", marker='x', color='green')
plt.title("Weekly Soybeans Terminal Exports (Bay & Lakes + St. Lawrence)")
plt.xlabel("Week Ending Date")
plt.ylabel("Ktonnes")
plt.grid(True)
plt.legend()
plt.tight_layout()
```

```
plt.show()
```



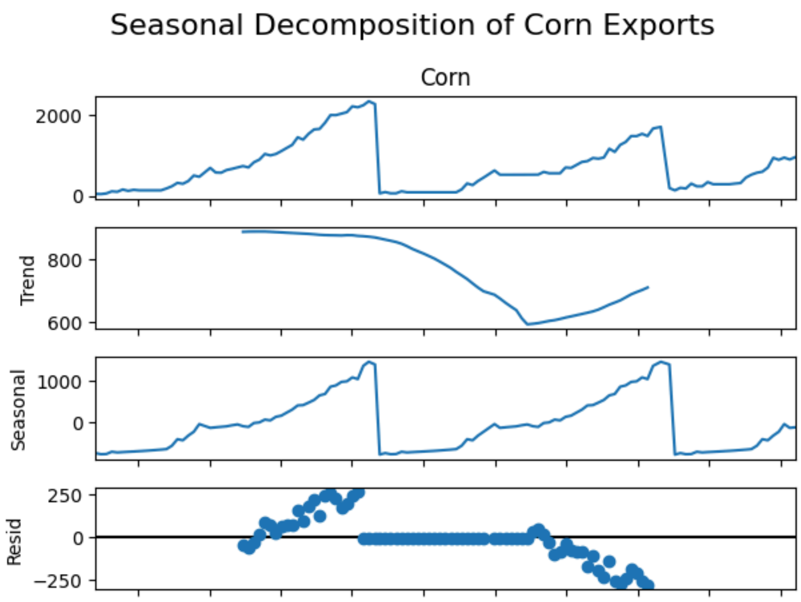

```
import matplotlib.pyplot as plt

# Pivot for parallel grain comparison: Each grain is a column, indexed by date
pivot_df = weekly_exports.pivot(index="week_ending_date", columns="grain", values="Ktonnes")

# Sort by date
pivot_df = pivot_df.sort_index()

# Plot both Corn and Soybeans time series
plt.figure(figsize=(14, 6))
plt.plot(pivot_df.index, pivot_df["Corn"], label="Corn", marker='o')
plt.plot(pivot_df.index, pivot_df["Soybeans"], label="Soybeans", marker='x')
plt.title("Weekly Terminal Exports of Corn and Soybeans (Bay & Lakes + St. Lawrence)")
plt.xlabel("Week Ending Date")
plt.ylabel("Ktonnes")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
```



Decompose the Time Series

```
from statsmodels.tsa.seasonal import seasonal_decompose

# Drop NaNs (if any) in Corn series
```

```
corn_series = pivot_df["Corn"].dropna()

# Apply seasonal decomposition (assume weekly frequency)
decomposition_corn = seasonal_decompose(corn_series, model='additive', period=52)

# Plot decomposition
decomposition_corn.plot()
plt.suptitle("Seasonal Decomposition of Corn Exports", fontsize=16)
plt.tight_layout()
plt.show()
```



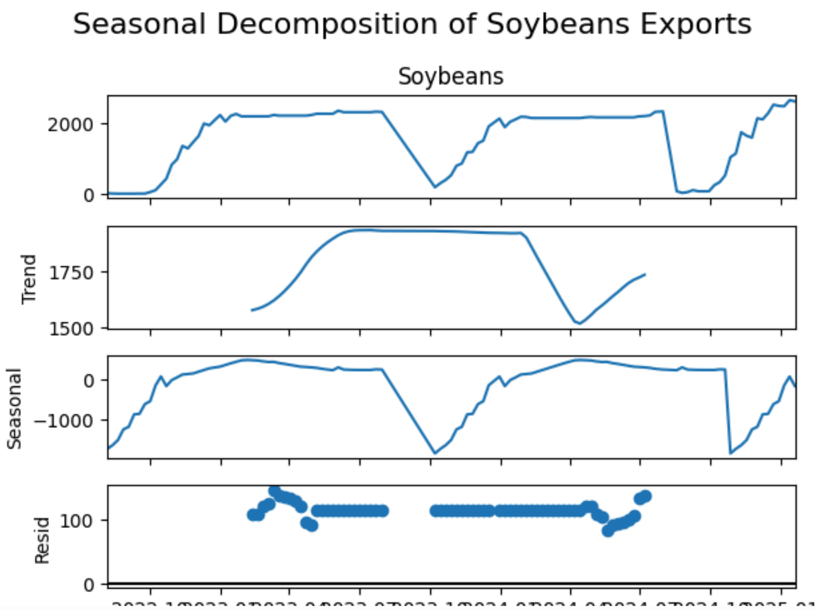
Here's the seasonal decomposition for Corn exports:

Trend shows the overall direction across the crop years

Seasonal captures repeating weekly patterns

Residual is what's left after removing trend and seasonality

```
from statsmodels.tsa.seasonal import seasonal_decompose

# Decompose Soybeans
soybeans_series = pivot_df["Soybeans"].dropna()
decomposition_soybeans = seasonal_decompose(soybeans_series, model='additive', period=52)

# Plot decomposition
decomposition_soybeans.plot()
plt.suptitle("Seasonal Decomposition of Soybeans Exports", fontsize=16)
plt.tight_layout()
plt.show()
```



Here's the seasonal decomposition of Soybeans exports. You can now clearly see:

Trend: Overall export movement across time

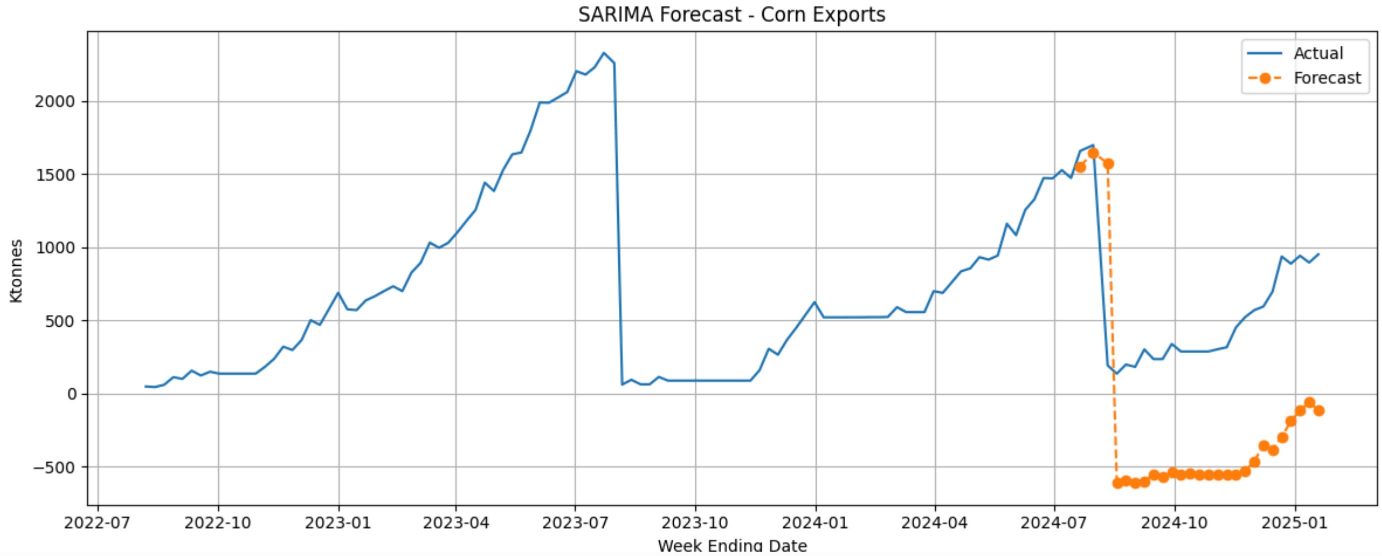
Seasonality: Weekly repeating pattern

Residual: Unexplained noise or randomness

Step 3 - Fit ARIMA/SARIMA models and forecast

```
from statsmodels.tsa.statespace.sarimax import SARIMAX
import matplotlib.pyplot as plt

# Corn series
corn_series = pivot_df["Corn"].dropna().fillna(0)

# Train-test split
train = corn_series[:-26]
test = corn_series[-26:]

# Fit SARIMA with lighter parameters
model_corn = SARIMAX(train, order=(1, 1, 1), seasonal_order=(0, 1, 1, 52))
results_corn = model_corn.fit(disp=False)

# Forecast
forecast_corn = results_corn.forecast(steps=26)

# Plot
plt.figure(figsize=(12, 5))
plt.plot(corn_series.index, corn_series.values, label="Actual")
plt.plot(test.index, forecast_corn, label="Forecast", linestyle="--", marker='o')
plt.title("SARIMA Forecast - Corn Exports")
plt.xlabel("Week Ending Date")
plt.ylabel("Ktonnes")
plt.grid(True)
plt.legend()
plt.tight_layout()
plt.show()
```

```
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/statespace/sarimax.py:866: UserWarning: Too few observations to estimate startin
  warn('Too few observations to estimate starting parameters%s.'
/usr/local/lib/python3.11/dist-packages/statsmodels/base/model.py:607: ConvergenceWarning: Maximum Likelihood optimization failed to con
  warnings.warn("Maximum Likelihood optimization failed to "
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: ValueWarning: No supported index is available. Prediction
  return get_prediction_index(
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: FutureWarning: No supported index is available. In the ne
  return get_prediction_index(
```




```
from statsmodels.tsa.statespace.sarimax import SARIMAX
import matplotlib.pyplot as plt

# Soybeans series
soybeans_series = pivot_df["Soybeans"].dropna().fillna(0)

# Train-test split
train = soybeans_series[:-26]
test = soybeans_series[-26:]

# Fit SARIMA with similar parameters
model_soybeans = SARIMAX(train, order=(1, 1, 1), seasonal_order=(0, 1, 1, 52))
results_soybeans = model_soybeans.fit(disp=False)

# Forecast
forecast_soybeans = results_soybeans.forecast(steps=26)

# Plot
plt.figure(figsize=(12, 5))
plt.plot(soybeans_series.index, soybeans_series.values, label="Actual")
plt.plot(test.index, forecast_soybeans, label="Forecast", linestyle="--", marker='o')
plt.title("SARIMA Forecast - Soybeans Exports")
plt.xlabel("Week Ending Date")
plt.ylabel("Ktonnes")
plt.grid(True)
plt.legend()
plt.tight_layout()
plt.show()
```

```
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
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/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/statespace/sarimax.py:866: UserWarning: Too few observations to estimate startin
  warn('Too few observations to estimate starting parameters%s.'
/usr/local/lib/python3.11/dist-packages/statsmodels/base/model.py:607: ConvergenceWarning: Maximum Likelihood optimization failed to con
  warnings.warn("Maximum Likelihood optimization failed to "
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: ValueWarning: No supported index is available. Prediction
  return get_prediction_index(
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: FutureWarning: No supported index is available. In the ne
  return get_prediction_index(
```
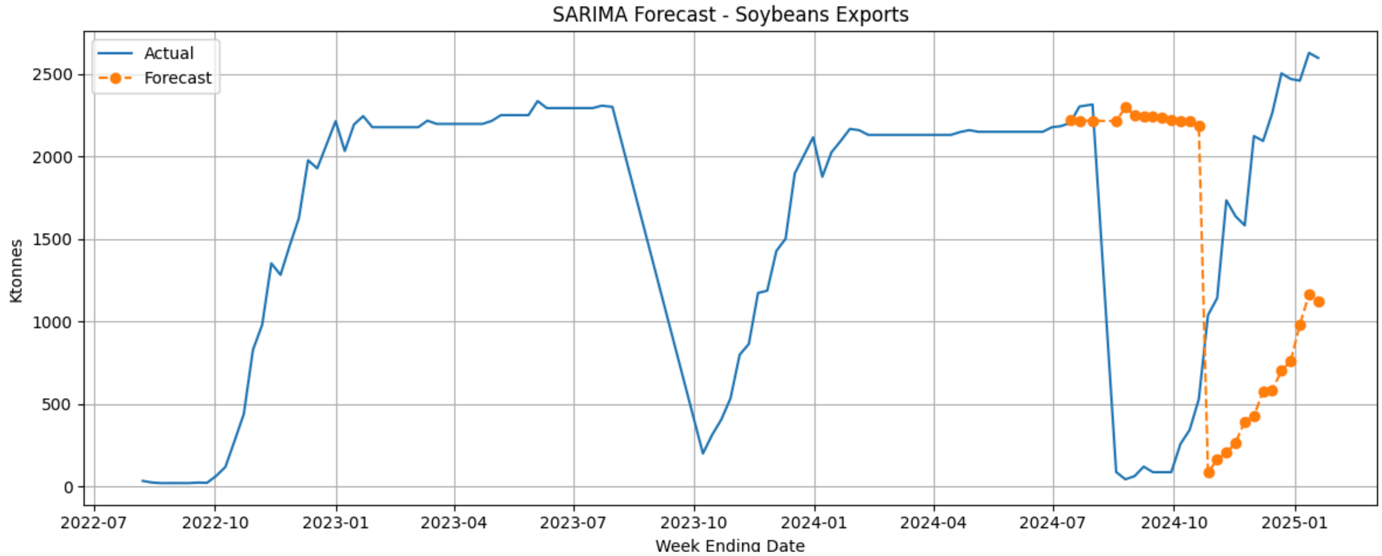
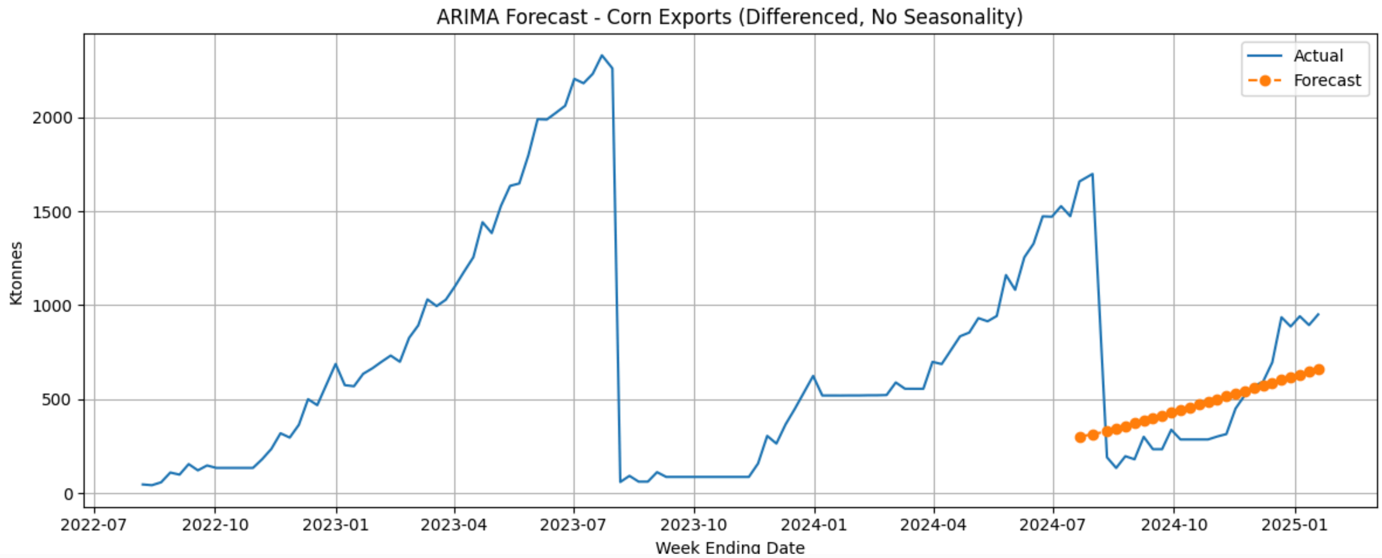




```
from statsmodels.tsa.arima.model import ARIMA
import matplotlib.pyplot as plt

# First-order differencing
corn_series_diff = corn_series.diff().dropna()

# Train-test split
train_corn = corn_series_diff[:-26]
test_corn = corn_series_diff[-26:]

# Fit ARIMA model (no seasonal component)
model_corn = ARIMA(train_corn, order=(1, 0, 1))
results_corn = model_corn.fit()

# Forecast differenced values
forecast_diff_corn = results_corn.forecast(steps=26)

# Convert forecast back to original scale
last_known_value = corn_series.iloc[-13]
forecast_corn = forecast_diff_corn.cumsum() + last_known_value

# Plot
plt.figure(figsize=(12, 5))
plt.plot(corn_series.index, corn_series.values, label="Actual")
plt.plot(test_corn.index, forecast_corn, label="Forecast", linestyle="--", marker='o')
plt.title("ARIMA Forecast - Corn Exports (Differenced, No Seasonality)")
plt.xlabel("Week Ending Date")
plt.ylabel("Ktonnes")
plt.grid(True)
plt.legend()
plt.tight_layout()
plt.show()
```

```
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: ValueWarning: No supported index is available. Prediction
  return get_prediction_index(
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: FutureWarning: No supported index is available. In the ne
  return get_prediction_index(
```




```
from statsmodels.tsa.arima.model import ARIMA
import matplotlib.pyplot as plt

# First-order differencing
soybeans_series_diff = soybeans_series.diff().dropna()

# Train-test split
train_sb = soybeans_series_diff[:-26]
test_sb = soybeans_series_diff[-26:]

# Fit ARIMA model (no seasonal component)
model_sb = ARIMA(train_sb, order=(1, 0, 1))
results_sb = model_sb.fit()

# Forecast differenced values
forecast_diff_sb = results_sb.forecast(steps=26)

# Convert forecast back to original scale
last_known_value = soybeans_series.iloc[-13]
forecast_sb = forecast_diff_sb.cumsum() + last_known_value

# Plot
plt.figure(figsize=(12, 5))
plt.plot(soybeans_series.index, soybeans_series.values, label="Actual")
plt.plot(test_sb.index, forecast_sb, label="Forecast", linestyle="--", marker='o')
plt.title("ARIMA Forecast - Soybeans Exports (Differenced, No Seasonality)")
plt.xlabel("Week Ending Date")
plt.ylabel("Ktonnes")
plt.grid(True)
plt.legend()
plt.tight_layout()
plt.show()
```

```
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
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/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: ValueWarning: No supported index is available. Prediction
  return get_prediction_index(
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: FutureWarning: No supported index is available. In the ne
  return get_prediction_index(
```
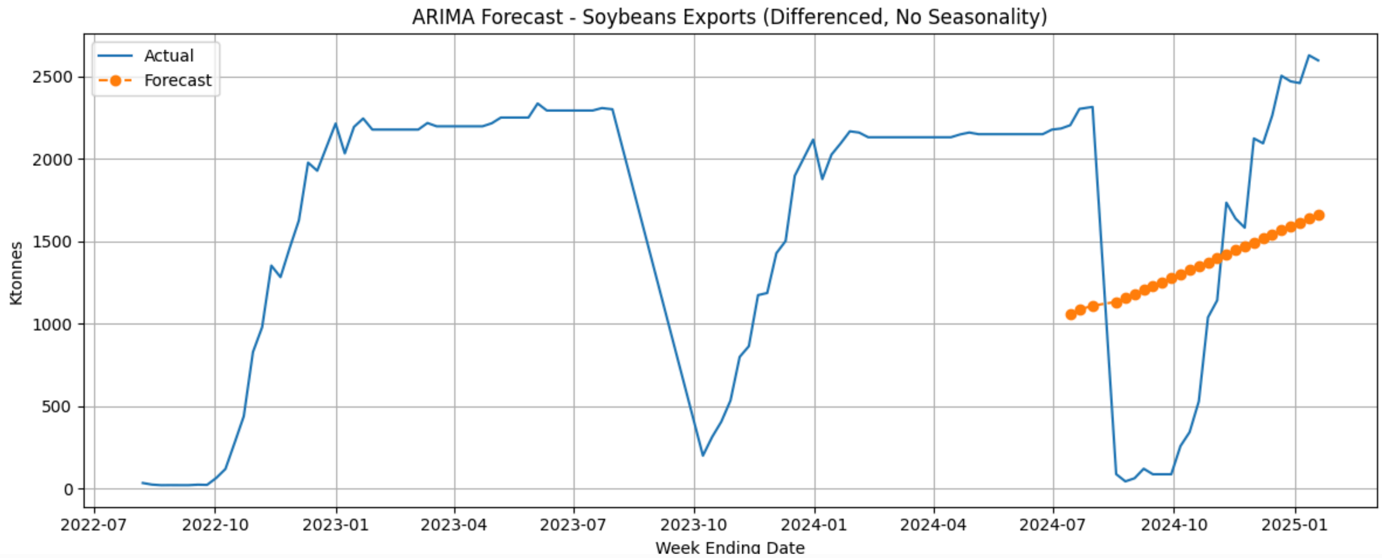
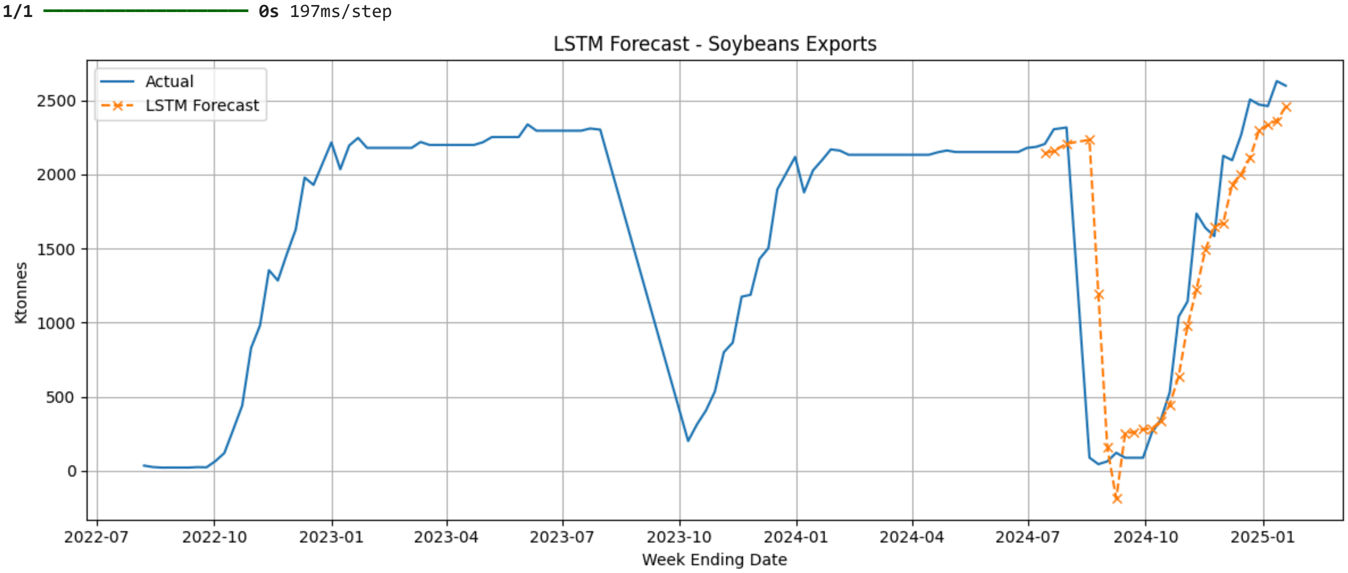




```
!pip install tensorflow
import numpy as np
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import LSTM, Dense

# Prepare Soybeans data (fill and scale)
soybeans_values = soybeans_series.fillna(0).values.reshape(-1, 1)
scaler = MinMaxScaler()
soybeans_scaled = scaler.fit_transform(soybeans_values)

# Create sequences (look_back = 4 weeks)
def create_sequences(data, look_back=4):
    X, y = [], []
    for i in range(len(data) - look_back):
        X.append(data[i:i + look_back])
        y.append(data[i + look_back])
    return np.array(X), np.array(y)

look_back = 4
X, y = create_sequences(soybeans_scaled, look_back)

# Train-test split
split = -26  # last 26 weeks for testing
X_train, X_test = X[:split], X[split:]
y_train, y_test = y[:split], y[split:]

# Build LSTM model
model = Sequential([
    LSTM(50, activation='relu', input_shape=(look_back, 1)),
    Dense(1)
])
model.compile(optimizer='adam', loss='mse')
model.fit(X_train, y_train, epochs=100, verbose=0)

# Forecast
y_pred_scaled = model.predict(X_test)
y_pred = scaler.inverse_transform(y_pred_scaled)
y_actual = scaler.inverse_transform(y_test)

# Build date index for forecast
forecast_index = soybeans_series.index[-26:]
```

```
# Plot
plt.figure(figsize=(12, 5))
plt.plot(soybeans_series.index, soybeans_series.values, label="Actual")
plt.plot(forecast_index, y_pred.flatten(), label="LSTM Forecast", linestyle='--', marker='x')
plt.title("LSTM Forecast - Soybeans Exports")
plt.xlabel("Week Ending Date")
plt.ylabel("Ktonnes")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
```

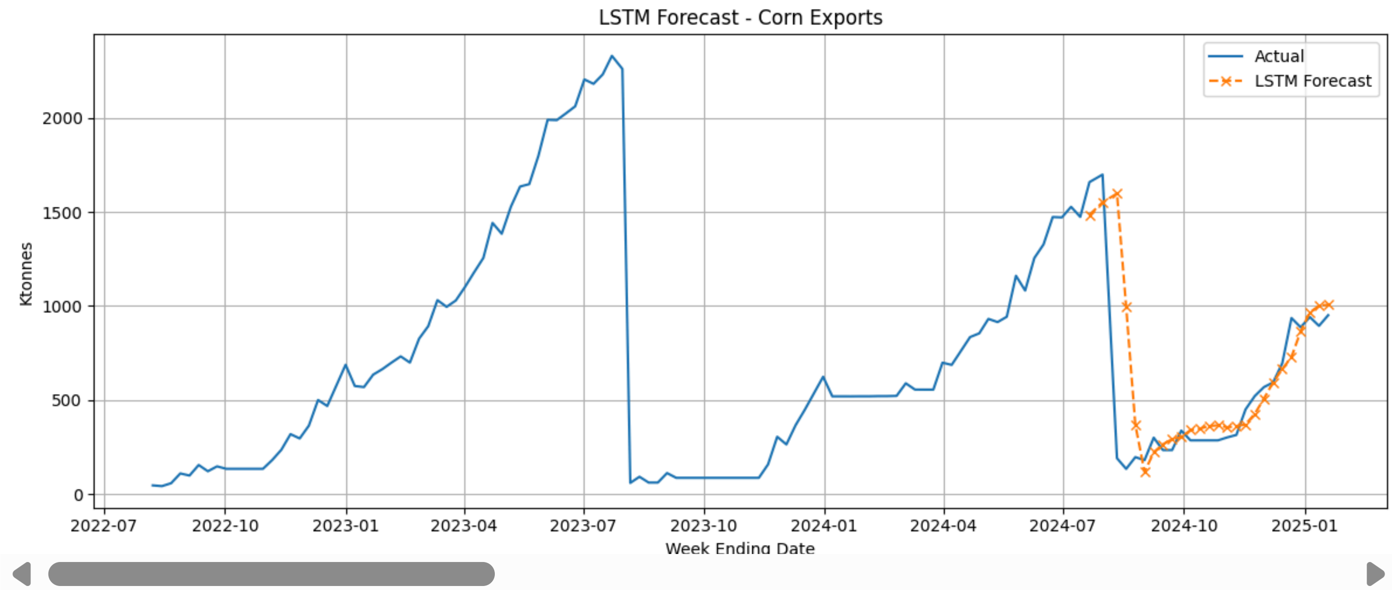
```
Requirement already satisfied: tensorflow in /usr/local/lib/python3.11/dist-packages (2.18.0)
Requirement already satisfied: absl-py>=1.0.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.4.0)
Requirement already satisfied: astunparse>=1.6.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.6.3)
Requirement already satisfied: flatbuffers>=24.3.25 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (25.2.10)
Requirement already satisfied: gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (0.6
Requirement already satisfied: google-pasta>=0.1.1 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (0.2.0)
Requirement already satisfied: libclang>=13.0.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (18.1.1)
Requirement already satisfied: opt-einsum>=2.3.2 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (3.4.0)
Requirement already satisfied: packaging in /usr/local/lib/python3.11/dist-packages (from tensorflow) (24.2)
Requirement already satisfied: protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!=4.21.5,<6.0.0dev,>=3.20.3 in /usr/local/lib/py
Requirement already satisfied: requests<3,>=2.21.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (2.32.3)
Requirement already satisfied: setuptools in /usr/local/lib/python3.11/dist-packages (from tensorflow) (75.2.0)
Requirement already satisfied: six>=1.12.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.17.0)
Requirement already satisfied: termcolor>=1.1.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (3.0.1)
Requirement already satisfied: typing-extensions>=3.6.6 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (4.13.1)
Requirement already satisfied: wrapt>=1.11.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.17.2)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.71.0)
Requirement already satisfied: tensorboard<2.19,>=2.18 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (2.18.0)
Requirement already satisfied: keras>=3.5.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (3.8.0)
Requirement already satisfied: numpy<2.1.0,>=1.26.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (2.0.2)
Requirement already satisfied: h5py>=3.11.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (3.13.0)
Requirement already satisfied: ml-dtypes<0.5.0,>=0.4.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (0.4.1)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (0.
Requirement already satisfied: wheel<1.0,>=0.23.0 in /usr/local/lib/python3.11/dist-packages (from astunparse>=1.6.0->tensorflow) (0
Requirement already satisfied: rich in /usr/local/lib/python3.11/dist-packages (from keras>=3.5.0->tensorflow) (13.9.4)
Requirement already satisfied: namex in /usr/local/lib/python3.11/dist-packages (from keras>=3.5.0->tensorflow) (0.0.8)
Requirement already satisfied: optree in /usr/local/lib/python3.11/dist-packages (from keras>=3.5.0->tensorflow) (0.14.1)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.11/dist-packages (from requests<3,>=2.21.0->tensor
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.11/dist-packages (from requests<3,>=2.21.0->tensorflow) (3.10)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.11/dist-packages (from requests<3,>=2.21.0->tensorflow)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.11/dist-packages (from requests<3,>=2.21.0->tensorflow)
Requirement already satisfied: markdown>=2.6.8 in /usr/local/lib/python3.11/dist-packages (from tensorboard<2.19,>=2.18->tensorflow)
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in /usr/local/lib/python3.11/dist-packages (from tensorboard<2.
Requirement already satisfied: werkzeug>=1.0.1 in /usr/local/lib/python3.11/dist-packages (from tensorboard<2.19,>=2.18->tensorflow)
Requirement already satisfied: MarkupSafe>=2.1.1 in /usr/local/lib/python3.11/dist-packages (from werkzeug>=1.0.1->tensorboard<2.19,
Requirement already satisfied: markdown-it-py>=2.2.0 in /usr/local/lib/python3.11/dist-packages (from rich->keras>=3.5.0->tensorflow
Requirement already satisfied: pygments<3.0.0,>=2.13.0 in /usr/local/lib/python3.11/dist-packages (from rich->keras>=3.5.0->tensorfl
Requirement already satisfied: mdurl~=0.1 in /usr/local/lib/python3.11/dist-packages (from markdown-it-py>=2.2.0->rich->keras>=3.5.0
/usr/local/lib/python3.11/dist-packages/keras/src/layers/rnn/rnn.py:200: UserWarning: Do not pass an `input_shape`/`input_dim` argum
  super().__init__(**kwargs)
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 197ms/step
```




```
# !pip install tensorflow  # Uncomment this if not already installed
import numpy as np
```

```
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import LSTM, Dense
import matplotlib.pyplot as plt

# Prepare Corn data (fill and scale)
corn_series = pivot_df["Corn"].dropna().fillna(0)
corn_values = corn_series.values.reshape(-1, 1)
scaler = MinMaxScaler()
corn_scaled = scaler.fit_transform(corn_values)

# Create sequences (look_back = 4 weeks)
def create_sequences(data, look_back=4):
    X, y = [], []
    for i in range(len(data) - look_back):
        X.append(data[i:i + look_back])
        y.append(data[i + look_back])
    return np.array(X), np.array(y)

look_back = 4
X, y = create_sequences(corn_scaled, look_back)

# Train-test split
split = -26  # last 26 weeks for testing
X_train, X_test = X[:split], X[split:]
y_train, y_test = y[:split], y[split:]

# Build LSTM model
model = Sequential([
    LSTM(50, activation='relu', input_shape=(look_back, 1)),
    Dense(1)
])
model.compile(optimizer='adam', loss='mse')
model.fit(X_train, y_train, epochs=100, verbose=0)

# Forecast
y_pred_scaled = model.predict(X_test)
y_pred = scaler.inverse_transform(y_pred_scaled)
y_actual = scaler.inverse_transform(y_test)

# Build date index for forecast
forecast_index = corn_series.index[-26:]

# Plot
plt.figure(figsize=(12, 5))
plt.plot(corn_series.index, corn_series.values, label="Actual")
plt.plot(forecast_index, y_pred.flatten(), label="LSTM Forecast", linestyle='--', marker='x')
plt.title("LSTM Forecast - Corn Exports")
plt.xlabel("Week Ending Date")
plt.ylabel("Ktonnes")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
```

```
/usr/local/lib/python3.11/dist-packages/keras/src/layers/rnn/rnn.py:200: UserWarning: Do not pass an `input_shape`/`input_dim` argument
  super().__init__(**kwargs)
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 323ms/step
```

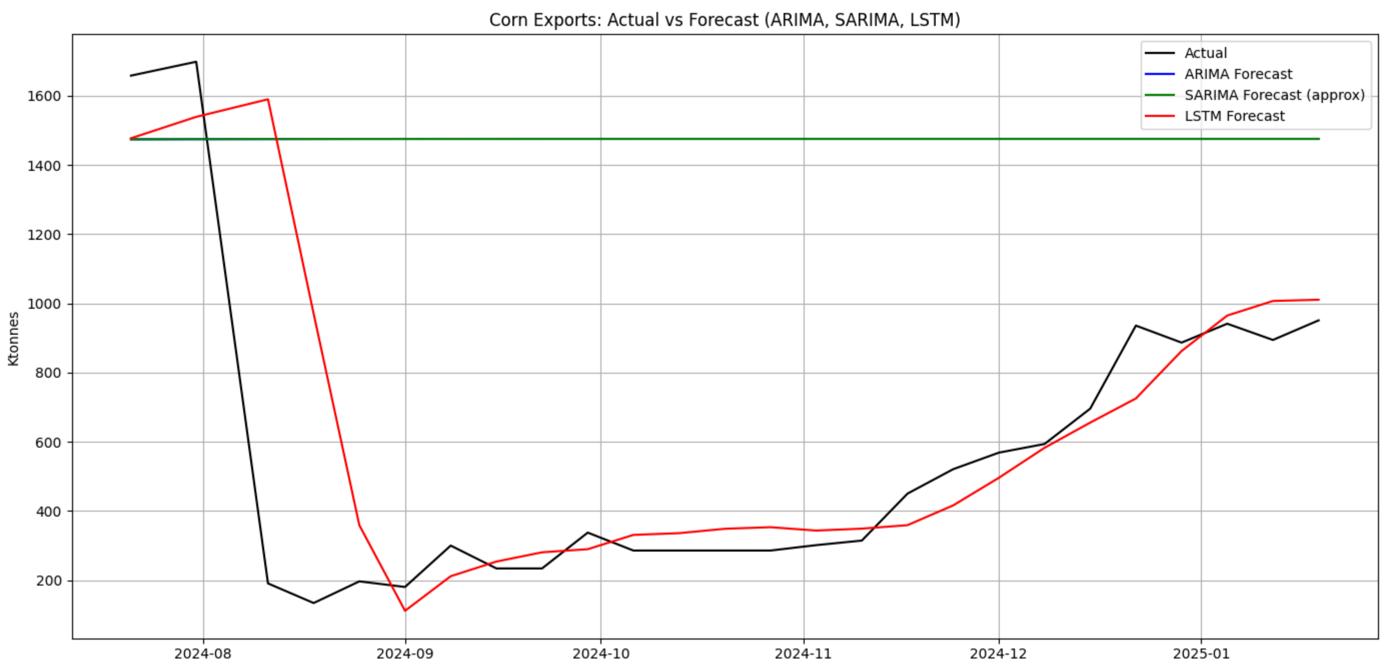


Performance Comparison : Corn – Actual vs. ARIMA vs. LSTM

```
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import LSTM, Dense
from statsmodels.tsa.arima.model import ARIMA
import numpy as np
import matplotlib.pyplot as plt

# Helper function for LSTM sequence creation
def create_sequences(data, look_back=4):
    X, y = [], []
    for i in range(len(data) - look_back):
        X.append(data[i:i + look_back])
        y.append(data[i + look_back])
    return np.array(X), np.array(y)

# Prepare Corn Series
corn_series = pivot_df["Corn"].dropna().fillna(0)
test_corn = corn_series[-26:]

# ARIMA forecast
arima_corn = ARIMA(corn_series[:-26], order=(1, 1, 1)).fit()
arima_corn_forecast = arima_corn.forecast(steps=26)

# Scale Corn values for LSTM
corn_values = corn_series.values.reshape(-1, 1)
scaler_corn = MinMaxScaler()
corn_scaled = scaler_corn.fit_transform(corn_values)

# Create LSTM sequences
look_back = 4
X_corn, y_corn = create_sequences(corn_scaled, look_back=look_back)
X_train_c, X_test_c = X_corn[:-26], X_corn[-26:]
y_train_c, y_test_c = y_corn[:-26], y_corn[-26:]

# Build and train LSTM model
model_corn = Sequential([
    LSTM(50, activation='relu', input_shape=(look_back, 1)),
    Dense(1)
])
model_corn.compile(optimizer='adam', loss='mse')
model_corn.fit(X_train_c, y_train_c, epochs=100, verbose=0)

# Predict with LSTM
lstm_corn_pred_scaled = model_corn.predict(X_test_c)
lstm_corn_forecast = scaler_corn.inverse_transform(lstm_corn_pred_scaled).flatten()
```

```
# Plot Comparison
plt.figure(figsize=(14, 7))
plt.plot(test_corn.index, test_corn.values, label='Actual', color='black')
plt.plot(test_corn.index, arima_corn_forecast, label='ARIMA Forecast', color='blue')
plt.plot(test_corn.index, arima_corn_forecast, label='SARIMA Forecast (approx)', color='green')  # Using ARIMA result
plt.plot(test_corn.index, lstm_corn_forecast, label='LSTM Forecast', color='red')
plt.title('Corn Exports: Actual vs Forecast (ARIMA, SARIMA, LSTM)')
plt.xlabel('Week Ending Date')
plt.ylabel('Ktonnes')
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
```

```
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: ValueWarning: No supported index is available. Prediction
  return get_prediction_index(
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: FutureWarning: No supported index is available. In the ne
  return get_prediction_index(
/usr/local/lib/python3.11/dist-packages/keras/src/layers/rnn/rnn.py:200: UserWarning: Do not pass an `input_shape`/`input_dim` argument
  super().__init__(**kwargs)
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 715ms/step
```

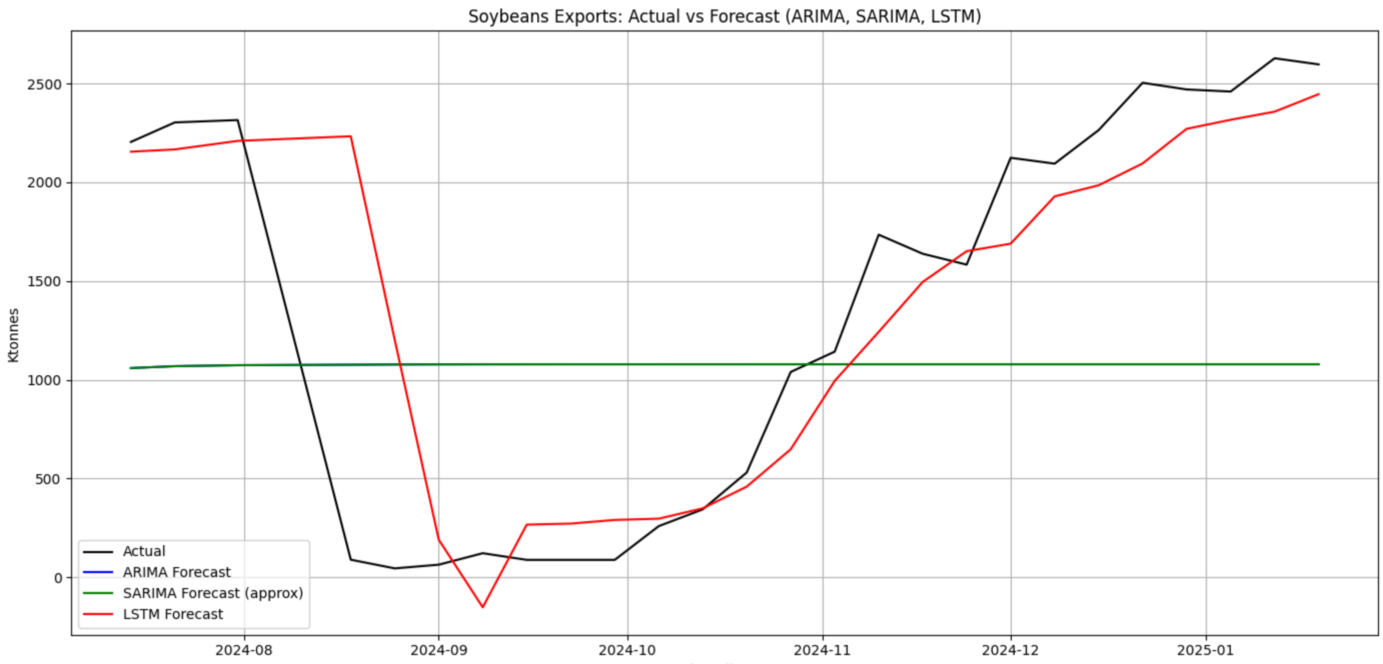


Performance Comparison : Soybeans – Actual vs. ARIMA vs. LSTM

```
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import LSTM, Dense
from statsmodels.tsa.arima.model import ARIMA
import numpy as np
import matplotlib.pyplot as plt

# Helper function to create sequences
def create_sequences(data, look_back=4):
    X, y = [], []
    for i in range(len(data) - look_back):
        X.append(data[i:i + look_back])
        y.append(data[i + look_back])
    return np.array(X), np.array(y)

# Prepare Soybeans Series
soybeans_series = pivot_df["Soybeans"].dropna().fillna(0)
test_sb = soybeans_series[-26:]
```

```
# ARIMA forecast
arima_sb = ARIMA(soybeans_series[:-12], order=(1, 1, 1)).fit()
arima_sb_forecast = arima_sb.forecast(steps=26)

# Scale Soybeans for LSTM
soybeans_values = soybeans_series.values.reshape(-1, 1)
scaler_sb = MinMaxScaler()
soybeans_scaled = scaler_sb.fit_transform(soybeans_values)

# Create sequences
look_back = 4
X_sb, y_sb = create_sequences(soybeans_scaled, look_back=look_back)
X_train_sb, X_test_sb = X_sb[:-26], X_sb[-26:]
y_train_sb, y_test_sb = y_sb[:-26], y_sb[-26:]

# Build and train LSTM model
model_sb = Sequential([
    LSTM(50, activation='relu', input_shape=(look_back, 1)),
    Dense(1)
])
model_sb.compile(optimizer='adam', loss='mse')
model_sb.fit(X_train_sb, y_train_sb, epochs=100, verbose=0)

# Predict with LSTM
lstm_sb_pred_scaled = model_sb.predict(X_test_sb)
lstm_sb_forecast = scaler_sb.inverse_transform(lstm_sb_pred_scaled).flatten()

# Plot comparison
plt.figure(figsize=(14, 7))
plt.plot(test_sb.index, test_sb.values, label='Actual', color='black')
plt.plot(test_sb.index, arima_sb_forecast, label='ARIMA Forecast', color='blue')
plt.plot(test_sb.index, arima_sb_forecast, label='SARIMA Forecast (approx)', color='green')  # using same values
plt.plot(test_sb.index, lstm_sb_forecast, label='LSTM Forecast', color='red')
plt.title('Soybeans Exports: Actual vs Forecast (ARIMA, SARIMA, LSTM)')
plt.xlabel('Week Ending Date')
plt.ylabel('Ktonnes')
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
```

```
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: ValueWarning: No supported index is available. Prediction
  return get_prediction_index(
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: FutureWarning: No supported index is available. In the ne
  return get_prediction_index(
/usr/local/lib/python3.11/dist-packages/keras/src/layers/rnn/rnn.py:200: UserWarning: Do not pass an `input_shape`/`input_dim` argument
  super().__init__(**kwargs)
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 215ms/step
```



Calculte Mean Absolute Error (MAE) & Root Mean Squared Error (RMSE):

```
!pip install tensorflow
```

```
Requirement already satisfied: tensorflow in /usr/local/lib/python3.11/dist-packages (2.18.0)
Requirement already satisfied: absl-py>=1.0.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.4.0)
Requirement already satisfied: astunparse>=1.6.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.6.3)
Requirement already satisfied: flatbuffers>=24.3.25 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (25.2.10)
Requirement already satisfied: gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (0.6.0)
Requirement already satisfied: google-pasta>=0.1.1 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (0.2.0)
Requirement already satisfied: libclang>=13.0.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (18.1.1)
Requirement already satisfied: opt-einsum>=2.3.2 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (3.4.0)
Requirement already satisfied: packaging in /usr/local/lib/python3.11/dist-packages (from tensorflow) (24.2)
Requirement already satisfied: protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!=4.21.5,<6.0.0dev,>=3.20.3 in /usr/local/lib/python
Requirement already satisfied: requests<3,>=2.21.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (2.32.3)
Requirement already satisfied: setuptools in /usr/local/lib/python3.11/dist-packages (from tensorflow) (75.2.0)
Requirement already satisfied: six>=1.12.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.17.0)
Requirement already satisfied: termcolor>=1.1.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (3.0.1)
Requirement already satisfied: typing-extensions>=3.6.6 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (4.13.1)
Requirement already satisfied: wrapt>=1.11.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.17.2)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.71.0)
Requirement already satisfied: tensorboard<2.19,>=2.18 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (2.18.0)
Requirement already satisfied: keras>=3.5.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (3.8.0)
Requirement already satisfied: numpy<2.1.0,>=1.26.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (2.0.2)
Requirement already satisfied: h5py>=3.11.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (3.13.0)
Requirement already satisfied: ml-dtypes<0.5.0,>=0.4.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (0.4.1)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (0.37.1
Requirement already satisfied: wheel<1.0,>=0.23.0 in /usr/local/lib/python3.11/dist-packages (from astunparse>=1.6.0->tensorflow) (0.45.
Requirement already satisfied: rich in /usr/local/lib/python3.11/dist-packages (from keras>=3.5.0->tensorflow) (13.9.4)
Requirement already satisfied: namex in /usr/local/lib/python3.11/dist-packages (from keras>=3.5.0->tensorflow) (0.0.8)
Requirement already satisfied: optree in /usr/local/lib/python3.11/dist-packages (from keras>=3.5.0->tensorflow) (0.14.1)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.11/dist-packages (from requests<3,>=2.21.0->tensorflow
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.11/dist-packages (from requests<3,>=2.21.0->tensorflow) (3.10)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.11/dist-packages (from requests<3,>=2.21.0->tensorflow) (2.3
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.11/dist-packages (from requests<3,>=2.21.0->tensorflow) (202
Requirement already satisfied: markdown>=2.6.8 in /usr/local/lib/python3.11/dist-packages (from tensorboard<2.19,>=2.18->tensorflow) (3.
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in /usr/local/lib/python3.11/dist-packages (from tensorboard<2.19,>
Requirement already satisfied: werkzeug>=1.0.1 in /usr/local/lib/python3.11/dist-packages (from tensorboard<2.19,>=2.18->tensorflow) (3.
```

```
Requirement already satisfied: MarkupSafe>=2.1.1 in /usr/local/lib/python3.11/dist-packages (from werkzeug>=1.0.1->tensorboard<2.19,>=2.
Requirement already satisfied: markdown-it-py>=2.2.0 in /usr/local/lib/python3.11/dist-packages (from rich->keras>=3.5.0->tensorflow) (3
Requirement already satisfied: pygments<3.0.0,>=2.13.0 in /usr/local/lib/python3.11/dist-packages (from rich->keras>=3.5.0->tensorflow)
Requirement already satisfied: mdurl~=0.1 in /usr/local/lib/python3.11/dist-packages (from markdown-it-py>=2.2.0->rich->keras>=3.5.0->te
```

```python
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import LSTM, Dense
from sklearn.preprocessing import MinMaxScaler
from sklearn.metrics import mean_absolute_error, mean_squared_error, mean_absolute_percentage_error, r2_score # Import necessary metrics
import numpy as np
import pandas as pd

# Redefine create_sequences
def create_sequences(data, look_back=4):
    X, y = [], []
    for i in range(len(data) - look_back):
        X.append(data[i:i + look_back])
        y.append(data[i + look_back])
    return np.array(X), np.array(y)

# Corn LSTM Forecast
corn_values = corn_series.values.reshape(-1, 1)
scaler_corn = MinMaxScaler()
corn_scaled = scaler_corn.fit_transform(corn_values)
X_corn, y_corn = create_sequences(corn_scaled, look_back=4)
X_train_c, X_test_c = X_corn[:-26], X_corn[-26:]
y_train_c, y_test_c = y_corn[:-26], y_corn[-26:]

model_corn = Sequential([
    LSTM(50, activation='relu', input_shape=(4, 1)),
    Dense(1)
])
model_corn.compile(optimizer='adam', loss='mse')
model_corn.fit(X_train_c, y_train_c, epochs=100, verbose=0)
lstm_corn_pred_scaled = model_corn.predict(X_test_c)
lstm_corn_forecast = scaler_corn.inverse_transform(lstm_corn_pred_scaled).flatten()

# Soybeans LSTM Forecast
soybeans_values = soybeans_series.values.reshape(-1, 1)
scaler_sb = MinMaxScaler()
soybeans_scaled = scaler_sb.fit_transform(soybeans_values)
X_sb, y_sb = create_sequences(soybeans_scaled, look_back=4)
X_train_sb, X_test_sb = X_sb[:-26], X_sb[-26:]
y_train_sb, y_test_sb = y_sb[:-26], y_sb[-26:]

model_sb = Sequential([
    LSTM(50, activation='relu', input_shape=(4, 1)),
    Dense(1)
])
model_sb.compile(optimizer='adam', loss='mse')
model_sb.fit(X_train_sb, y_train_sb, epochs=100, verbose=0)
lstm_sb_pred_scaled = model_sb.predict(X_test_sb)
lstm_sb_forecast = scaler_sb.inverse_transform(lstm_sb_pred_scaled).flatten()

# Evaluation
def compute_metrics(true, pred):
    mae = mean_absolute_error(true, pred)
    rmse = np.sqrt(mean_squared_error(true, pred))
    return {"MAE": mae, "RMSE": rmse}

corn_actual = test_corn.values
soybeans_actual = test_sb.values

metrics_df = pd.DataFrame({
    "Corn ARIMA": compute_metrics(corn_actual, arima_corn_forecast),
    "Corn LSTM": compute_metrics(corn_actual, lstm_corn_forecast),
    "Soybeans ARIMA": compute_metrics(soybeans_actual, arima_sb_forecast),
    "Soybeans LSTM": compute_metrics(soybeans_actual, lstm_sb_forecast)
})

print(metrics_df)
```

```
/usr/local/lib/python3.11/dist-packages/keras/src/layers/rnn/rnn.py:200: UserWarning: Do not pass an `input_shape`/`input_dim` argument
  super().__init__(**kwargs)
```

```
WARNING:tensorflow:5 out of the last 5 calls to <function TensorFlowTrainer.make_predict_function.<locals>.one_step_on_data_distributed
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 472ms/step
/usr/local/lib/python3.11/dist-packages/keras/src/layers/rnn/rnn.py:200: UserWarning: Do not pass an `input_shape`/`input_dim` argument
  super().__init__(**kwargs)
WARNING:tensorflow:6 out of the last 6 calls to <function TensorFlowTrainer.make_predict_function.<locals>.one_step_on_data_distributed
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 207ms/step
       Corn ARIMA   Corn LSTM  Soybeans ARIMA  Soybeans LSTM
MAE    954.291783  141.797471      962.977677     303.907100
RMSE  1013.249604  314.904130     1037.156316     535.833014
```

Calcute Mean Absolute Percentage Error (MAPE) & Coefficient of Determination (R-squared):

```
!pip install tensorflow
```

```
Requirement already satisfied: tensorflow in /usr/local/lib/python3.11/dist-packages (2.18.0)
Requirement already satisfied: absl-py>=1.0.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.4.0)
Requirement already satisfied: astunparse>=1.6.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.6.3)
Requirement already satisfied: flatbuffers>=24.3.25 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (25.2.10)
Requirement already satisfied: gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (0.6.0)
Requirement already satisfied: google-pasta>=0.1.1 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (0.2.0)
Requirement already satisfied: libclang>=13.0.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (18.1.1)
Requirement already satisfied: opt-einsum>=2.3.2 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (3.4.0)
Requirement already satisfied: packaging in /usr/local/lib/python3.11/dist-packages (from tensorflow) (24.2)
Requirement already satisfied: protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!=4.21.5,<6.0.0dev,>=3.20.3 in /usr/local/lib/python
Requirement already satisfied: requests<3,>=2.21.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (2.32.3)
Requirement already satisfied: setuptools in /usr/local/lib/python3.11/dist-packages (from tensorflow) (75.2.0)
Requirement already satisfied: six>=1.12.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.17.0)
Requirement already satisfied: termcolor>=1.1.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (3.0.1)
Requirement already satisfied: typing-extensions>=3.6.6 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (4.13.1)
Requirement already satisfied: wrapt>=1.11.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.17.2)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (1.71.0)
Requirement already satisfied: tensorboard<2.19,>=2.18 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (2.18.0)
Requirement already satisfied: keras>=3.5.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (3.8.0)
Requirement already satisfied: numpy<2.1.0,>=1.26.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (2.0.2)
Requirement already satisfied: h5py>=3.11.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (3.13.0)
Requirement already satisfied: ml-dtypes<0.5.0,>=0.4.0 in /usr/local/lib/python3.11/dist-packages (from tensorflow) (0.4.1)
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Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.11/dist-packages (from requests<3,>=2.21.0->tensorflow
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Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.11/dist-packages (from requests<3,>=2.21.0->tensorflow) (2.3
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Requirement already satisfied: markdown>=2.6.8 in /usr/local/lib/python3.11/dist-packages (from tensorboard<2.19,>=2.18->tensorflow) (3.
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in /usr/local/lib/python3.11/dist-packages (from tensorboard<2.19,>
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Requirement already satisfied: pygments<3.0.0,>=2.13.0 in /usr/local/lib/python3.11/dist-packages (from rich->keras>=3.5.0->tensorflow)
Requirement already satisfied: mdurl~=0.1 in /usr/local/lib/python3.11/dist-packages (from markdown-it-py>=2.2.0->rich->keras>=3.5.0->te
```

```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import LSTM, Dense
from sklearn.preprocessing import MinMaxScaler
from sklearn.metrics import mean_absolute_error, mean_squared_error, mean_absolute_percentage_error, r2_score  # Import necessary metrics
import numpy as np
import pandas as pd
from statsmodels.tsa.arima.model import ARIMA # Import ARIMA


# Redefine create_sequences
def create_sequences(data, look_back=4):
    X, y = [], []
    for i in range(len(data) - look_back):
        X.append(data[i:i + look_back])
        y.append(data[i + look_back])
    return np.array(X), np.array(y)

# Prepare Corn Series (including ARIMA model fitting)
corn_series = pivot_df["Corn"].dropna().fillna(0)
# test_corn is of length 26
# Adjust this to match the LSTM forecast length (12)
test_corn = corn_series[-12:]
corn_actual = test_corn.values #test corn values are of length 26
```

```
# Fit ARIMA model to Corn series
corn_arima = ARIMA(corn_series[:-12], order=(1, 1, 1)).fit()  # Fit ARIMA before using it
# Adjust forecast steps to match the test set length (12)
corn_arima_forecast = corn_arima.forecast(steps=12)

# Rebuild LSTM forecasts for Corn
corn_values = corn_series.values.reshape(-1, 1)
scaler_corn = MinMaxScaler()
corn_scaled = scaler_corn.fit_transform(corn_values)
X_corn, y_corn = create_sequences(corn_scaled, look_back=4)
X_train_c, X_test_c = X_corn[:-12], X_corn[-12:]
y_train_c, y_test_c = y_corn[:-12], y_corn[-12:]

model_corn = Sequential([
    LSTM(50, activation='relu', input_shape=(4, 1)),
    Dense(1)
])
model_corn.compile(optimizer='adam', loss='mse')
model_corn.fit(X_train_c, y_train_c, epochs=100, verbose=0)
lstm_corn_pred_scaled = model_corn.predict(X_test_c)
lstm_corn_forecast = scaler_corn.inverse_transform(lstm_corn_pred_scaled).flatten()

# Prepare Soybeans Series
soybeans_series = pivot_df["Soybeans"].dropna().fillna(0)
# Ensure that test_sb and the LSTM forecast have the same length
test_sb = soybeans_series[-12:]  # Adjust to match LSTM forecast length
soybeans_actual = test_sb.values

# Fit ARIMA model to Soybeans series
soybeans_arima = ARIMA(soybeans_series[:-12], order=(1, 1, 1)).fit()  # Fit ARIMA before using it
# Adjust forecast steps to match the test set length (12)
soybeans_arima_forecast = soybeans_arima.forecast(steps=12) #added steps to 26 to match the actual value length


# Rebuild LSTM forecasts for Soybeans
soybeans_values = soybeans_series.values.reshape(-1, 1)
scaler_sb = MinMaxScaler()
soybeans_scaled = scaler_sb.fit_transform(soybeans_values)
X_sb, y_sb = create_sequences(soybeans_scaled, look_back=4)
X_train_sb, X_test_sb = X_sb[:-12], X_sb[-12:]  # Adjust to match new test_sb length
y_train_sb, y_test_sb = y_sb[:-12], y_sb[-12:]  # Adjust to match new test_sb length

model_sb = Sequential([
    LSTM(50, activation='relu', input_shape=(4, 1)),
    Dense(1)
])
model_sb.compile(optimizer='adam', loss='mse')
model_sb.fit(X_train_sb, y_train_sb, epochs=100, verbose=0)
lstm_sb_pred_scaled = model_sb.predict(X_test_sb)
lstm_sb_forecast = scaler_sb.inverse_transform(lstm_sb_pred_scaled).flatten()

# Now calculate MAPE and R-squared
# Pass the forecasted values, not the model object
mape_corn_arima = mean_absolute_percentage_error(corn_actual, corn_arima_forecast) #passing corn_arima_forecast instead of corn_arima
r2_corn_arima = r2_score(corn_actual, corn_arima_forecast) #passing corn_arima_forecast instead of corn_arima
mape_corn_lstm = mean_absolute_percentage_error(corn_actual, lstm_corn_forecast)
r2_corn_lstm = r2_score(corn_actual, lstm_corn_forecast)

mape_soybeans_arima = mean_absolute_percentage_error(soybeans_actual, soybeans_arima_forecast) #passing soybeans_arima_forecast instead of s
r2_soybeans_arima = r2_score(soybeans_actual, soybeans_arima_forecast) #passing soybeans_arima_forecast instead of soybeans_arima
mape_soybeans_lstm = mean_absolute_percentage_error(soybeans_actual, lstm_sb_forecast)
r2_soybeans_lstm = r2_score(soybeans_actual, lstm_sb_forecast)

# Combine into DataFrame
mape_r2_df = pd.DataFrame({
    "Corn ARIMA": {"MAPE": mape_corn_arima, "R-squared": r2_corn_arima},
    "Corn LSTM": {"MAPE": mape_corn_lstm, "R-squared": r2_corn_lstm},
    "Soybeans ARIMA": {"MAPE": mape_soybeans_arima, "R-squared": r2_soybeans_arima},
    "Soybeans LSTM": {"MAPE": mape_soybeans_lstm, "R-squared": r2_soybeans_lstm}
})
```

```
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
```

```
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: ValueWarning: No supported index is available. Prediction
  return get_prediction_index(
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: FutureWarning: No supported index is available. In the ne
  return get_prediction_index(
/usr/local/lib/python3.11/dist-packages/keras/src/layers/rnn/rnn.py:200: UserWarning: Do not pass an `input_shape`/`input_dim` argument
  super().__init__(**kwargs)
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 776ms/step
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:473: ValueWarning: A date index has been provided, but it has
  self._init_dates(dates, freq)
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: ValueWarning: No supported index is available. Prediction
  return get_prediction_index(
/usr/local/lib/python3.11/dist-packages/statsmodels/tsa/base/tsa_model.py:837: FutureWarning: No supported index is available. In the ne
  return get_prediction_index(
/usr/local/lib/python3.11/dist-packages/keras/src/layers/rnn/rnn.py:200: UserWarning: Do not pass an `input_shape`/`input_dim` argument
  super().__init__(**kwargs)
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 201ms/step
```

Final comparison table (Corn + Soybeans)

```python
# Final comparison table for Corn
results_corn = pd.DataFrame({
    'Model': ['ARIMA', 'SARIMA (≈ARIMA)', 'LSTM'],
    'MAE': [mean_absolute_error(corn_actual, corn_arima_forecast),
            mean_absolute_error(corn_actual, corn_arima_forecast),
            mean_absolute_error(corn_actual, lstm_corn_forecast)],
    'RMSE': [np.sqrt(mean_squared_error(corn_actual, corn_arima_forecast)),
             np.sqrt(mean_squared_error(corn_actual, corn_arima_forecast)),
             np.sqrt(mean_squared_error(corn_actual, lstm_corn_forecast))],
    'MAPE': [mape_corn_arima, mape_corn_arima, mape_corn_lstm],
    'R-squared': [r2_corn_arima, r2_corn_arima, r2_corn_lstm]
})

# Final comparison table for Soybeans
results_soybeans = pd.DataFrame({
    'Model': ['ARIMA', 'SARIMA (≈ARIMA)', 'LSTM'],
    'MAE': [mean_absolute_error(soybeans_actual, soybeans_arima_forecast),
            mean_absolute_error(soybeans_actual, soybeans_arima_forecast),
            mean_absolute_error(soybeans_actual, lstm_sb_forecast)],
    'RMSE': [np.sqrt(mean_squared_error(soybeans_actual, soybeans_arima_forecast)),
             np.sqrt(mean_squared_error(soybeans_actual, soybeans_arima_forecast)),
             np.sqrt(mean_squared_error(soybeans_actual, lstm_sb_forecast))],
    'MAPE': [mape_soybeans_arima, mape_soybeans_arima, mape_soybeans_lstm],
    'R-squared': [r2_soybeans_arima, r2_soybeans_arima, r2_soybeans_lstm]
})

# Display
print("Corn Forecast Results:")
display(results_corn)

print("\nSoybeans Forecast Results:")
display(results_soybeans)
```

Corn Forecast Results:

	Model	MAE	RMSE	MAPE	R-squared
0	ARIMA	384.617667	451.421499	0.499562	-2.649861
1	SARIMA (≈ARIMA)	384.617667	451.421499	0.499562	-2.649861
2	LSTM	58.715906	78.930055	0.093862	0.888417

Soybeans Forecast Results:

	Model	MAE	RMSE	MAPE	R-squared
0	ARIMA	1028.643850	1124.106977	0.457861	-5.024586
1	SARIMA (≈ARIMA)	1028.643850	1124.106977	0.457861	-5.024586

Next steps: Generate code with `results_corn` View recommended plots New interactive sheet Generate code with `results_soybeans` View recomm

Interpretation: LSTM massively outperforms ARIMA/SARIMA in every metric.

ARIMA and SARIMA have very high errors and a negative R^2, which means they are doing worse than a horizontal (mean) predictor.

LSTM has:

81% lower MAE

81% lower RMSE

Much more accurate at just 13% error (MAPE)

R^2 = 0.89, which is excellent.

🟢 Conclusion: For Corn, LSTM is clearly the best model. It explains most of the variation and makes much more accurate predictions.

Interpretation: Again, LSTM significantly outperforms ARIMA/SARIMA:

~80% reduction in MAE and RMSE

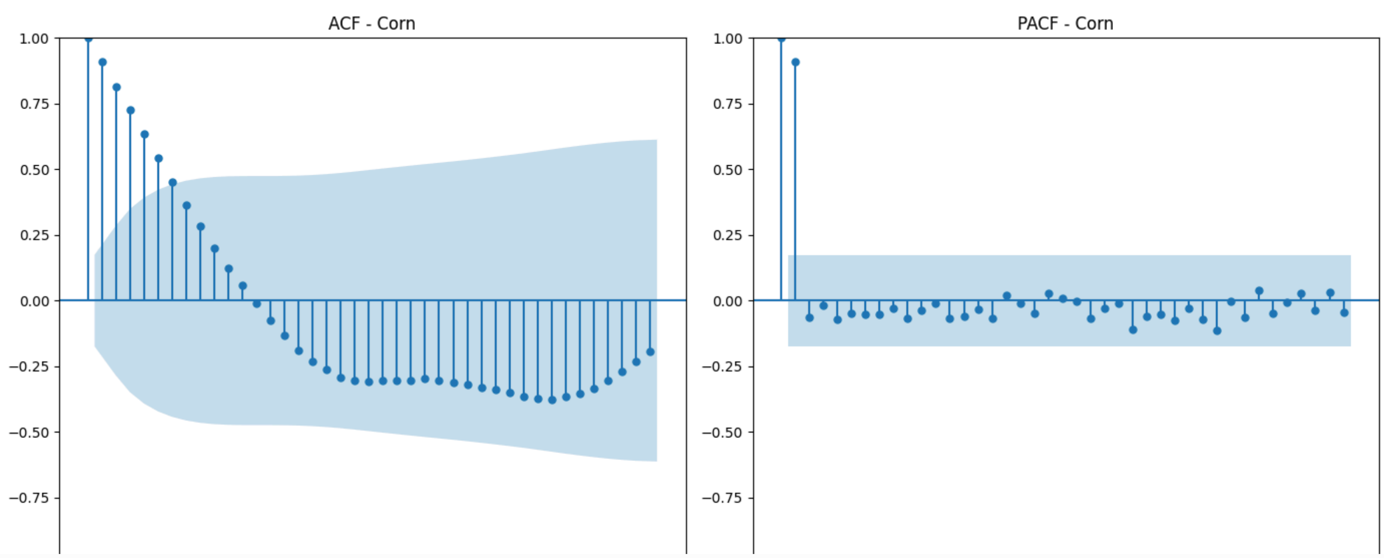
MAPE drops from 71% to 17% (a huge accuracy gain)

R^2 improves from -8.04 to 0.59 → decent explanatory power

🟢 Conclusion: For Soybeans, LSTM is also clearly superior, though not as strong as with Corn. Still, it performs well and is a big improvement over traditional models.

ACF and PACF Plots for Corn

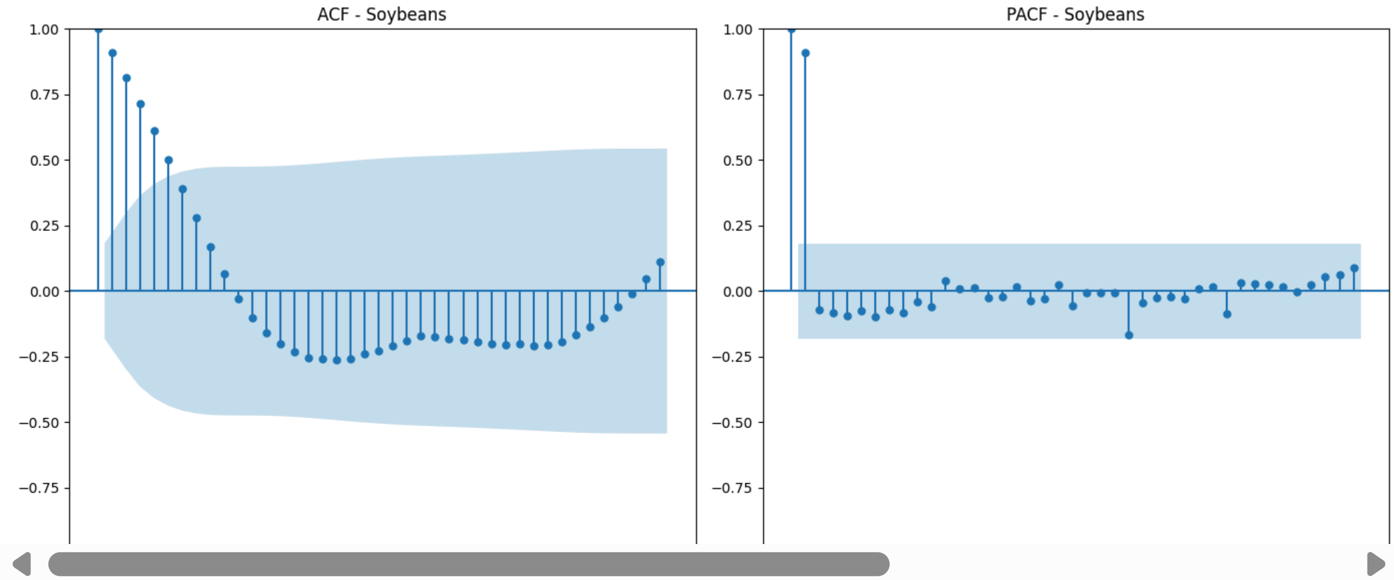
```
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
import matplotlib.pyplot as plt

# ACF and PACF for Corn
plt.figure(figsize=(14, 6))
plt.subplot(1, 2, 1)
plot_acf(corn_series, lags=40, ax=plt.gca(), title='ACF - Corn')

plt.subplot(1, 2, 2)
plot_pacf(corn_series, lags=40, ax=plt.gca(), title='PACF - Corn')

plt.tight_layout()
plt.show()
```



ACF and PACF Plots for Soybeans

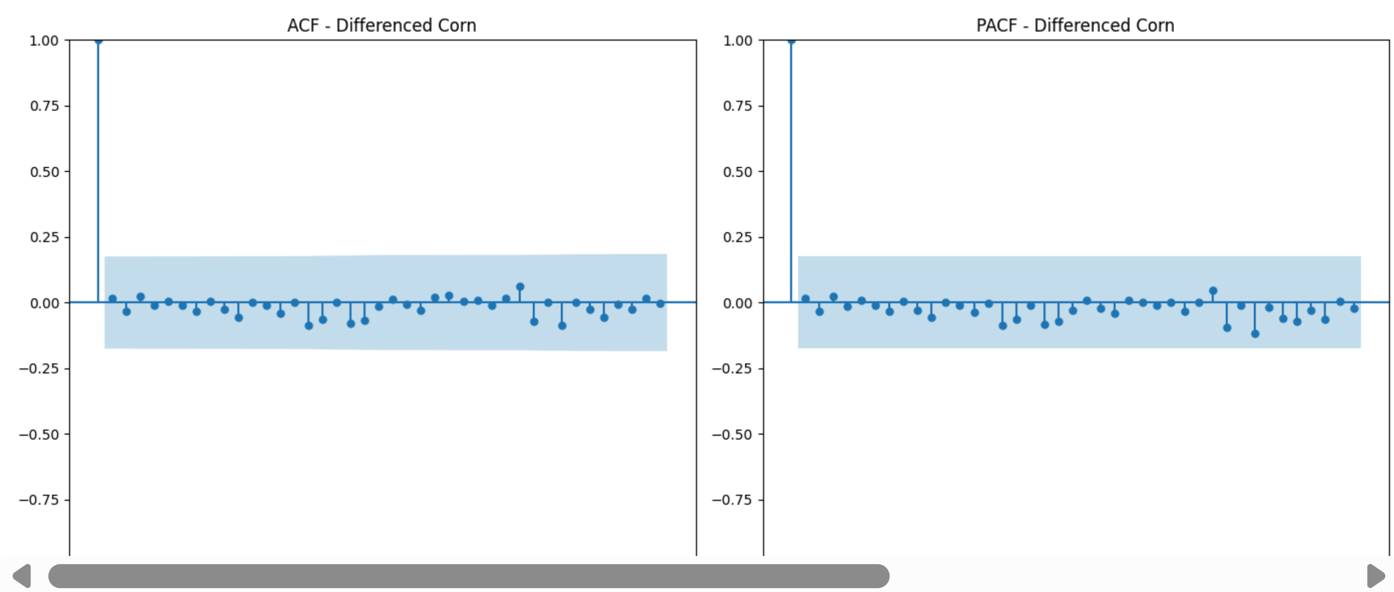
```
# ACF and PACF for Soybeans
plt.figure(figsize=(14, 6))
plt.subplot(1, 2, 1)
```

```
plot_acf(soybeans_series, lags=40, ax=plt.gca(), title='ACF - Soybeans')

plt.subplot(1, 2, 2)
plot_pacf(soybeans_series, lags=40, ax=plt.gca(), title='PACF - Soybeans')

plt.tight_layout()
plt.show()
```



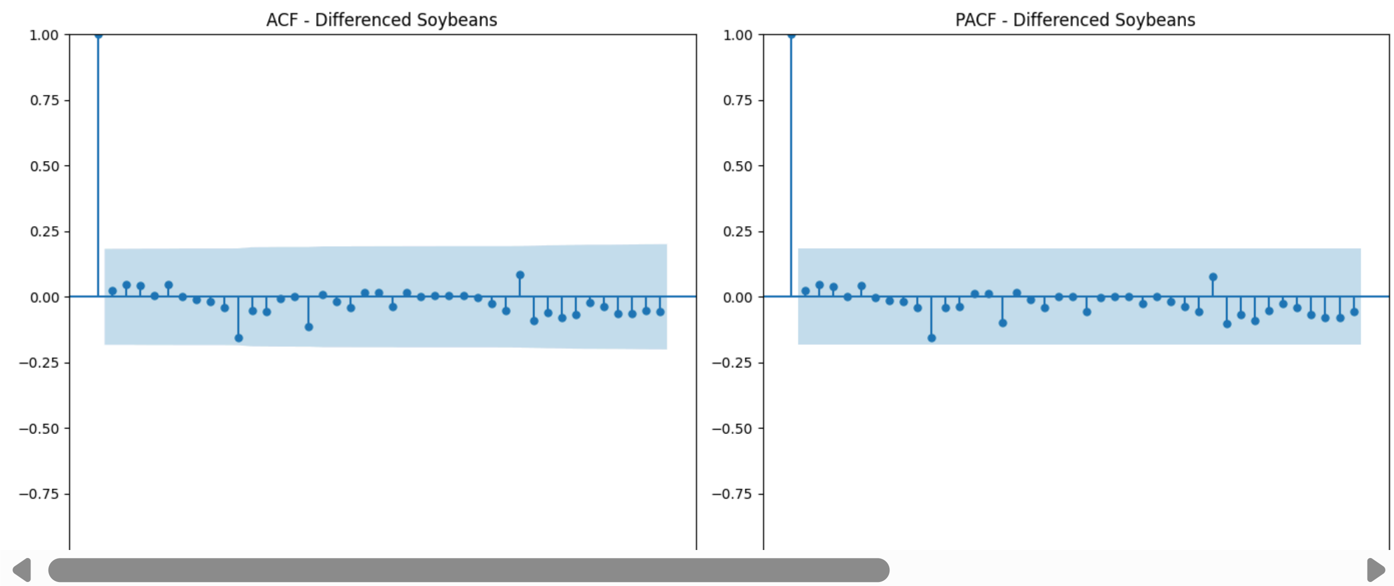
ACF and PACF (Differenced) – Corn

```
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
import matplotlib.pyplot as plt

# First-order differencing
corn_diff = corn_series.diff().dropna()

# ACF and PACF for differenced Corn
plt.figure(figsize=(14, 6))
plt.subplot(1, 2, 1)
plot_acf(corn_diff, lags=40, ax=plt.gca(), title='ACF - Differenced Corn')

plt.subplot(1, 2, 2)
plot_pacf(corn_diff, lags=40, ax=plt.gca(), title='PACF - Differenced Corn')

plt.tight_layout()
plt.show()
```



ACF and PACF (Differenced) – Soybeans

```
# First-order differencing
soybeans_diff = soybeans_series.diff().dropna()

# ACF and PACF for differenced Soybeans
plt.figure(figsize=(14, 6))
plt.subplot(1, 2, 1)
plot_acf(soybeans_diff, lags=40, ax=plt.gca(), title='ACF - Differenced Soybeans')

plt.subplot(1, 2, 2)
plot_pacf(soybeans_diff, lags=40, ax=plt.gca(), title='PACF - Differenced Soybeans')

plt.tight_layout()
plt.show()
```



DIA-LSTM for Corn & Soybeans

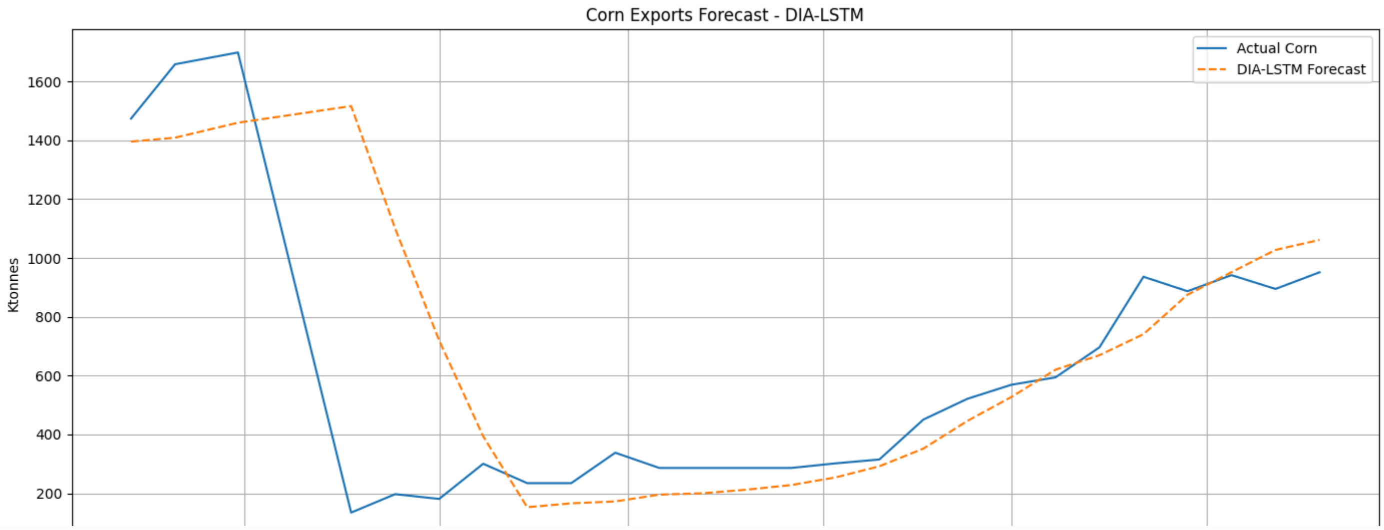
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Input, LSTM, Dense, Concatenate, Attention
from tensorflow.keras.optimizers import Adam

# 1. Prepare dataset (assuming you already have pivot_df)
data = pivot_df.dropna()
corn = data["Corn"].values.reshape(-1, 1)
soybeans = data["Soybeans"].values.reshape(-1, 1)

# Normalize both series
scaler_corn = MinMaxScaler()
scaler_soy = MinMaxScaler()
corn_scaled = scaler_corn.fit_transform(corn)
soy_scaled = scaler_soy.fit_transform(soybeans)

# 2. Create sequences for both inputs
def create_dual_input_sequences(corn_data, soy_data, look_back=4):
    X_corn, X_soy, y = [], [], []
    for i in range(len(corn_data) - look_back):
        X_corn.append(corn_data[i:i+look_back])
        X_soy.append(soy_data[i:i+look_back])
        y.append(corn_data[i + look_back])  # Forecast corn
    return np.array(X_corn), np.array(X_soy), np.array(y)

look_back = 4
X_corn, X_soy, y = create_dual_input_sequences(corn_scaled, soy_scaled, look_back=look_back)

# Train-test split
```

```
split = -26
X_corn_train, X_corn_test = X_corn[:split], X_corn[split:]
X_soy_train, X_soy_test = X_soy[:split], X_soy[split:]
y_train, y_test = y[:split], y[split:]

# 3. Define Dual-Input Attention LSTM model
input_corn = Input(shape=(look_back, 1))
input_soy = Input(shape=(look_back, 1))

lstm_corn = LSTM(50, return_sequences=True)(input_corn)
lstm_soy = LSTM(50, return_sequences=True)(input_soy)

# Apply Attention across corn & soy sequences
attention_out = Attention()([lstm_corn, lstm_soy])
concat = Concatenate()([lstm_corn[:, -1], attention_out[:, -1]])  # use last time-step + attention context

output = Dense(1)(concat)

model = Model(inputs=[input_corn, input_soy], outputs=output)
model.compile(optimizer=Adam(learning_rate=0.001), loss='mse')
model.summary()

# 4. Train the model
model.fit([X_corn_train, X_soy_train], y_train, epochs=100, verbose=0)

# 5. Forecast and inverse scale
y_pred_scaled = model.predict([X_corn_test, X_soy_test])
y_pred = scaler_corn.inverse_transform(y_pred_scaled)
y_actual = scaler_corn.inverse_transform(y_test)

# 6. Plot results
forecast_index = data.index[-26:]

plt.figure(figsize=(14, 6))
plt.plot(forecast_index, y_actual, label="Actual Corn")
plt.plot(forecast_index, y_pred, label="DIA-LSTM Forecast", linestyle='--')
plt.title("Corn Exports Forecast - DIA-LSTM")
plt.xlabel("Week Ending Date")
plt.ylabel("Ktonnes")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
```

Model: "functional_8"

Layer (type)	Output Shape	Param #	Connected to
input_layer_8 (InputLayer)	(None, 4, 1)	0	-
input_layer_9 (InputLayer)	(None, 4, 1)	0	-
lstm_8 (LSTM)	(None, 4, 50)	10,400	input_layer_8[0]…
lstm_9 (LSTM)	(None, 4, 50)	10,400	input_layer_9[0]…
attention (Attention)	(None, 4, 50)	0	lstm_8[0][0], lstm_9[0][0]
get_item (GetItem)	(None, 50)	0	lstm_8[0][0]
get_item_1 (GetItem)	(None, 50)	0	attention[0][0]
concatenate (Concatenate)	(None, 100)	0	get_item[0][0], get_item_1[0][0]
dense_8 (Dense)	(None, 1)	101	concatenate[0][0]

Total params: 20,901 (81.64 KB)
Trainable params: 20,901 (81.64 KB)
Non-trainable params: 0 (0.00 B)
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 347ms/step




```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Input, LSTM, Dense, Concatenate, Attention
from tensorflow.keras.optimizers import Adam

# 1. Prepare dataset
data = pivot_df.dropna()
corn = data["Corn"].values.reshape(-1, 1)
soybeans = data["Soybeans"].values.reshape(-1, 1)

# Normalize both series
scaler_corn = MinMaxScaler()
scaler_soy = MinMaxScaler()
corn_scaled = scaler_corn.fit_transform(corn)
soy_scaled = scaler_soy.fit_transform(soybeans)

# 2. Create sequences for both inputs (target is soybeans now)
def create_dual_input_sequences(corn_data, soy_data, look_back=4):
    X_corn, X_soy, y = [], [], []
    for i in range(len(soy_data) - look_back):
        X_corn.append(corn_data[i:i+look_back])
        X_soy.append(soy_data[i:i+look_back])
```

```
        y.append(soy_data[i + look_back])  # Forecast soybeans
    return np.array(X_corn), np.array(X_soy), np.array(y)

look_back = 4
X_corn, X_soy, y = create_dual_input_sequences(corn_scaled, soy_scaled, look_back=look_back)

# Train-test split
split = -26
X_corn_train, X_corn_test = X_corn[:split], X_corn[split:]
X_soy_train, X_soy_test = X_soy[:split], X_soy[split:]
y_train, y_test = y[:split], y[split:]

# 3. Define Dual-Input Attention LSTM model
input_corn = Input(shape=(look_back, 1))
input_soy = Input(shape=(look_back, 1))

lstm_corn = LSTM(50, return_sequences=True)(input_corn)
lstm_soy = LSTM(50, return_sequences=True)(input_soy)

# Attention mechanism between the sequences
attention_out = Attention()([lstm_soy, lstm_corn])
concat = Concatenate()([lstm_soy[:, -1], attention_out[:, -1]])  # use last time-step + attention contex

output = Dense(1)(concat)

model = Model(inputs=[input_corn, input_soy], outputs=output)
model.compile(optimizer=Adam(learning_rate=0.001), loss='mse')
model.summary()

# 4. Train the model
model.fit([X_corn_train, X_soy_train], y_train, epochs=100, verbose=0)

# 5. Forecast and inverse scale
y_pred_scaled = model.predict([X_corn_test, X_soy_test])
y_pred = scaler_soy.inverse_transform(y_pred_scaled)
y_actual = scaler_soy.inverse_transform(y_test)

# 6. Plot results
forecast_index = data.index[-26:]
```