Homework 1 - Time Series

This notebook contains all code required for Homework 1. Use the markdown sections to add your written analysis and conclusions.

In [2]:

```
%pip install -q pandas matplotlib seaborn xlrd openpyxl
```

```
Note: you may need to restart the kernel to use updated packages.
```

In [3]:

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

sns.set_theme(style="whitegrid")
plt.rcParams["figure.figsize"] = (12, 4)
```

Part 1: Impact of September 11 on U.S. Travel

Questions from Homework1.txt

1. Plot each of the three series (Air, Rail, Car). See the three-series plot in the following code output.
2. What type of trends appear? Explain. It seems that car and airline ravels are moving upward while trains are on their way out already, there also seems to be a lot of seasonality with a consistent 2 spikes per year for all modes of transport. Thus, the data suggest there the use of cars and plans are increasing while trains are being used less each year. However, train travel seems to sightly increase after 1998. There is also a sharp decline in plane travel between 2000 and 2002. This is likely due to 9/11.
3. Change the scale of the series and add trendlines. Do you notice any new trends? If so, explain. car travel was completly unaffected. and the trends i noteced eariler were confirmed. there is a huge drop in the airlines that isnt reflected in the railroads and cars data,

In [4]:

```
travel_path = "../resources/Sept11Travel.xls"

try:
    travel = pd.read_excel(travel_path)
except Exception:
    # Fallback in case file extension/engine differs on another machine
    travel = pd.read_excel(travel_path, engine="xlrd")

travel.columns = [str(col).strip() for col in travel.columns]
travel.head()
```

Out[4]:

	Month	Air RPM (000s)	Rail PM	Car (billions)
0	1990-01-01	35153577	454115779	163.275384
1	1990-02-01	32965187	435086002	153.254409
2	1990-03-01	39993913	568289732	178.417577
3	1990-04-01	37981886	568101697	178.680686
4	1990-05-01	38419672	539628385	188.876171

In [5]:

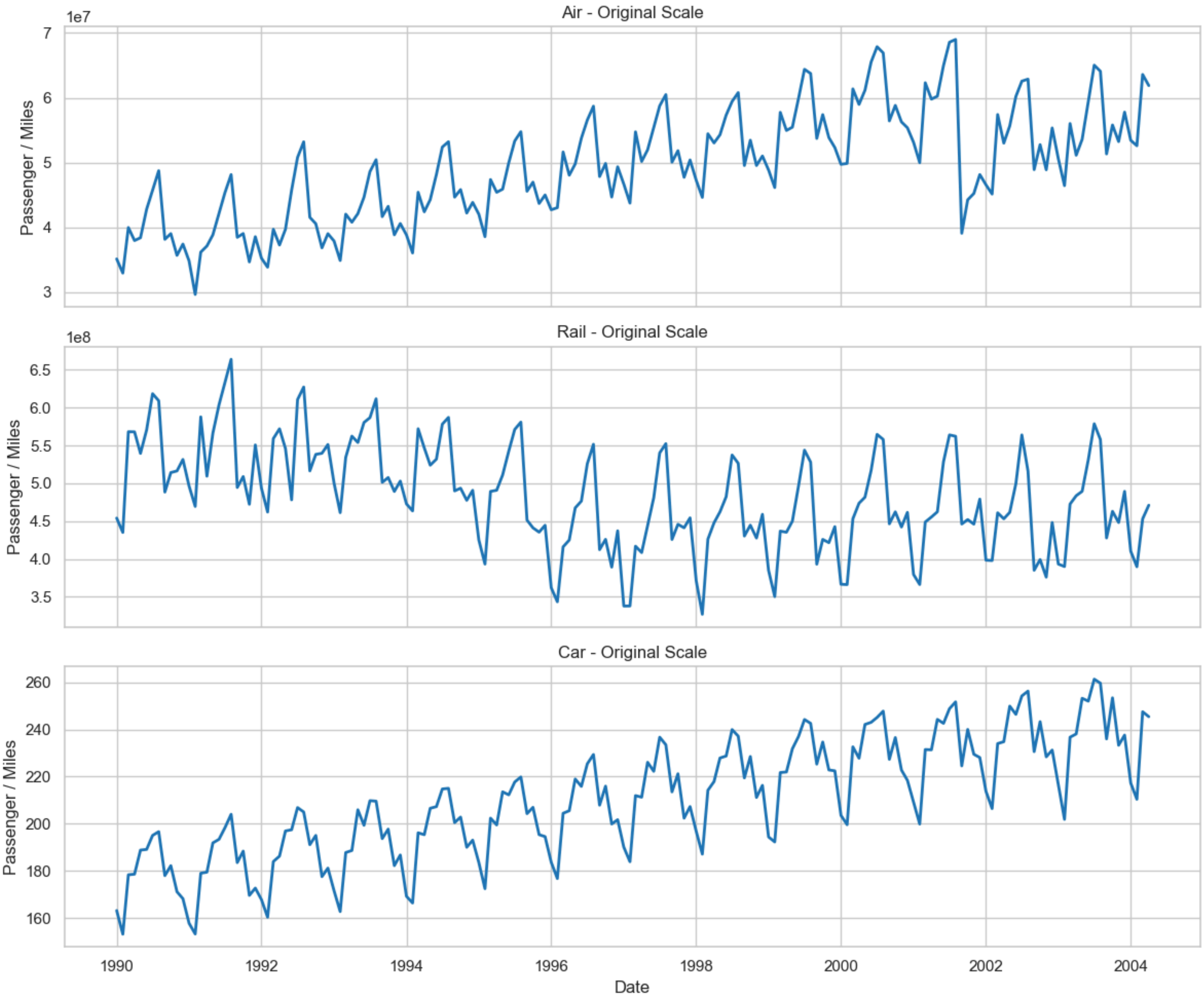
```python
# Build a monthly date index if one is not already present
if "Month" in travel.columns:
    travel["Month"] = pd.to_datetime(travel["Month"])
    travel = travel.set_index("Month")
elif "Date" in travel.columns:
    travel["Date"] = pd.to_datetime(travel["Date"])
    travel = travel.set_index("Date")
else:
    travel.index = pd.date_range(start="1990-01-01", periods=len(travel), freq="MS")

# Normalize expected column names
rename_map = {}
for col in travel.columns:
    lower = col.lower()
    if "air" in lower:
        rename_map[col] = "Air"
    elif "rail" in lower:
        rename_map[col] = "Rail"
    elif "car" in lower or "vehicle" in lower:
        rename_map[col] = "Car"

travel = travel.rename(columns=rename_map)
series_cols = [c for c in ["Air", "Rail", "Car"] if c in travel.columns]
travel = travel[series_cols].dropna()
travel.head()
```

Out[5]:

	Air	Rail	Car
Month			
1990-01-01	35153577	454115779	163.275384
1990-02-01	32965187	435086002	153.254409
1990-03-01	39993913	568289732	178.417577
1990-04-01	37981886	568101697	178.680686
1990-05-01	38419672	539628385	188.876171

In [6]:

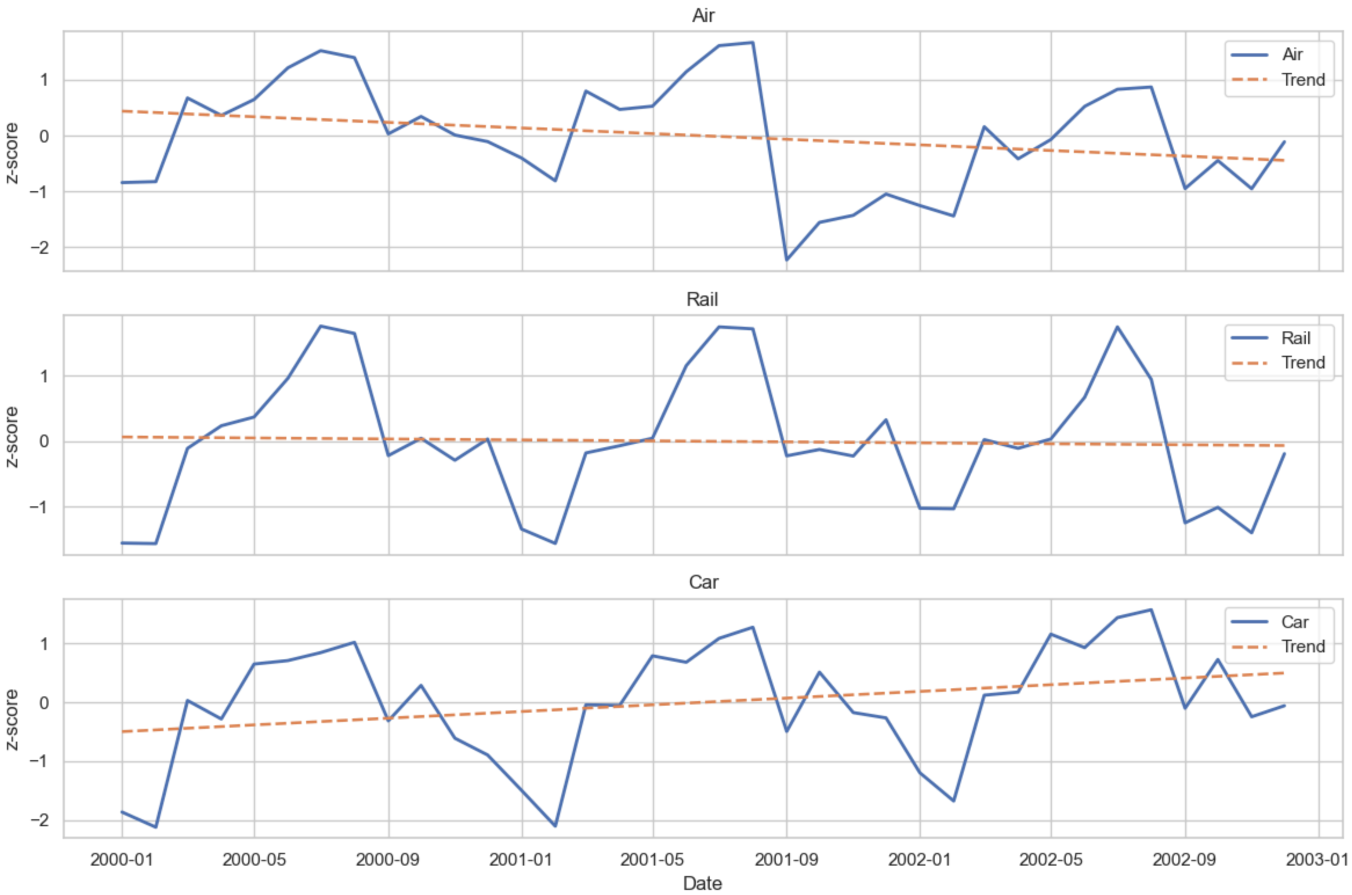
```python
# Plot each of the three original series
fig, axes = plt.subplots(nrows=3, ncols=1, sharex=True, figsize=(12, 10))
for ax, col in zip(axes, series_cols):
    ax.plot(travel.index, travel[col], color="#1f77b4", linewidth=2)
    ax.set_title(f"{col} - Original Scale")
    ax.set_ylabel("Passenger / Miles")

axes[-1].set_xlabel("Date")
plt.tight_layout()
plt.show()
```



In [17]:

```
# FILTER
travel = travel.loc["1998-01-01":"2004-12-31"].copy()


# Z-score scaling
scaled = (travel - travel.mean()) / travel.std()

# ensure numeric numpy arrays for polyfit (type-checkers require ArrayLike[complex])
x = np.arange(len(scaled)).astype(float)

fig, axes = plt.subplots(
    nrows=len(scaled.columns),
    ncols=1,
    figsize=(12, 8),
    sharex=True
)

for ax, col in zip(axes, scaled.columns):
    y = scaled[col].to_numpy(dtype=float)

    # Linear trend
    coeffs = np.polyfit(x, y, 1)
    trend = np.poly1d(coeffs)(x)

    ax.plot(scaled.index, y, linewidth=2, label=col)
    ax.plot(scaled.index, trend, linestyle="--", linewidth=1.8, label="Trend")

    ax.set_title(col)
    ax.set_ylabel("z-score")
    ax.legend()
    ax.grid(True)
```

```
axes[-1].set_xlabel("Date")

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



Part 2: Forecasting Department Store Sales

Questions from Homework1.txt

1. Create a well-formatted time plot of the data. done!

2. Which of the following components – trend, seasonality, and noise – seem to be present in this series? Explain. Its trending upwards, its seasonalality is shown by its repeating patten of large uniform spikes, whos uniformity tells me there isnt much noise

In [21]:

```
sales_path = "../resources/DepartmentStoreSales.csv"
sales = pd.read_csv(sales_path)
sales.columns = [str(c).strip() for c in sales.columns]
sales.head()
```

Out[21]:

	Quarter	Sales
0	1	50147
1	2	49325
2	3	57048
3	4	76781
4	5	48617

In [25]:

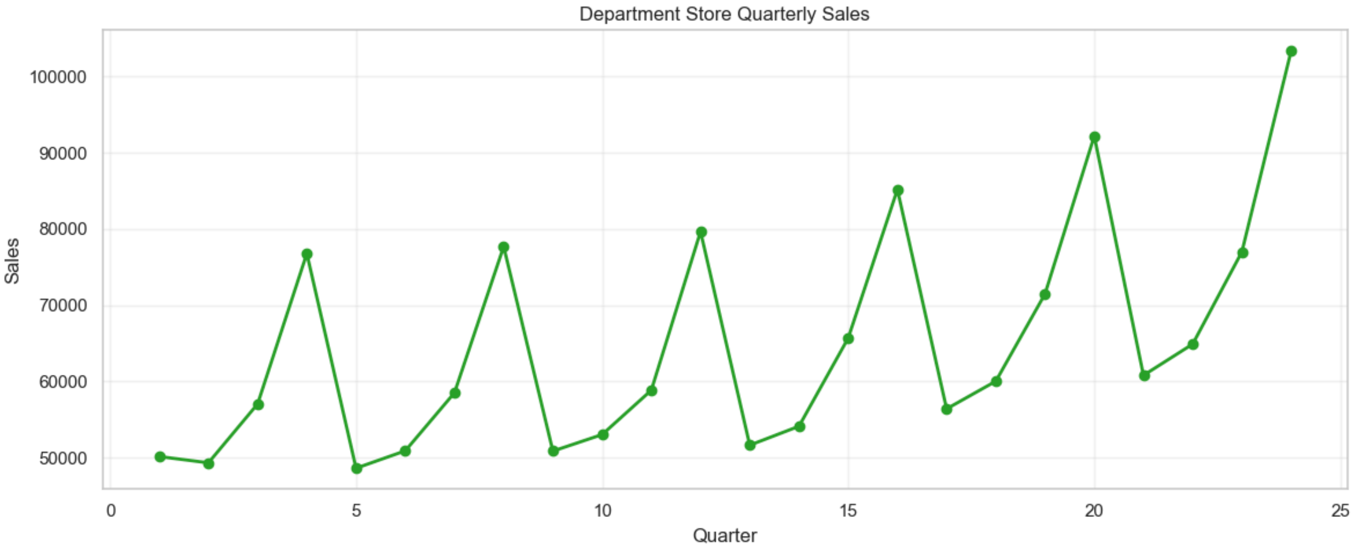
```
# Build a usable time/sequence index for plotting
if "Quarter" in sales.columns:
    quarter_raw = sales["Quarter"].astype(str).str.strip()

    # Case 1: simple quarter counter values (1, 2, ..., 24)
    quarter_num = pd.to_numeric(quarter_raw, errors="coerce")
    if quarter_num.notna().all():
        sales = sales.assign(Quarter=quarter_num.astype(int)).set_index("Quarter")

    # Case 2: values that contain explicit quarter-year info (e.g., Q1-2018, 2018 Q1)
    else:
        normalized = quarter_raw.str.replace(" ", "", regex=False)
        q = normalized.str.extract(r"(?:(Q[1-4]).*?(\d{4})|(\d{4}).*?(Q[1-4]))")
        q_label = q[0].fillna(q[3])
        year = q[1].fillna(q[2])
        valid = year.notna() & q_label.notna()

        if valid.all():
            sales_index = pd.PeriodIndex(year + q_label, freq="Q").to_timestamp()
            sales = sales.set_index(sales_index)
        else:
            # Fallback: preserve row order when quarter strings are irregular
            sales = sales.set_index(pd.RangeIndex(start=1, stop=len(sales) + 1, name=

elif "Date" in sales.columns:
    sales["Date"] = pd.to_datetime(sales["Date"])
    sales = sales.set_index("Date")

else:
    sales.index = pd.RangeIndex(start=1, stop=len(sales) + 1, name="Quarter")

# Identify sales column
sales_col = None
for c in sales.columns:
    if "sale" in c.lower():
        sales_col = c
        break
if sales_col is None:
    sales_col = sales.columns[-1]

sales_series = sales[sales_col].astype(float)
sales_series.head()
```

Out[25]:

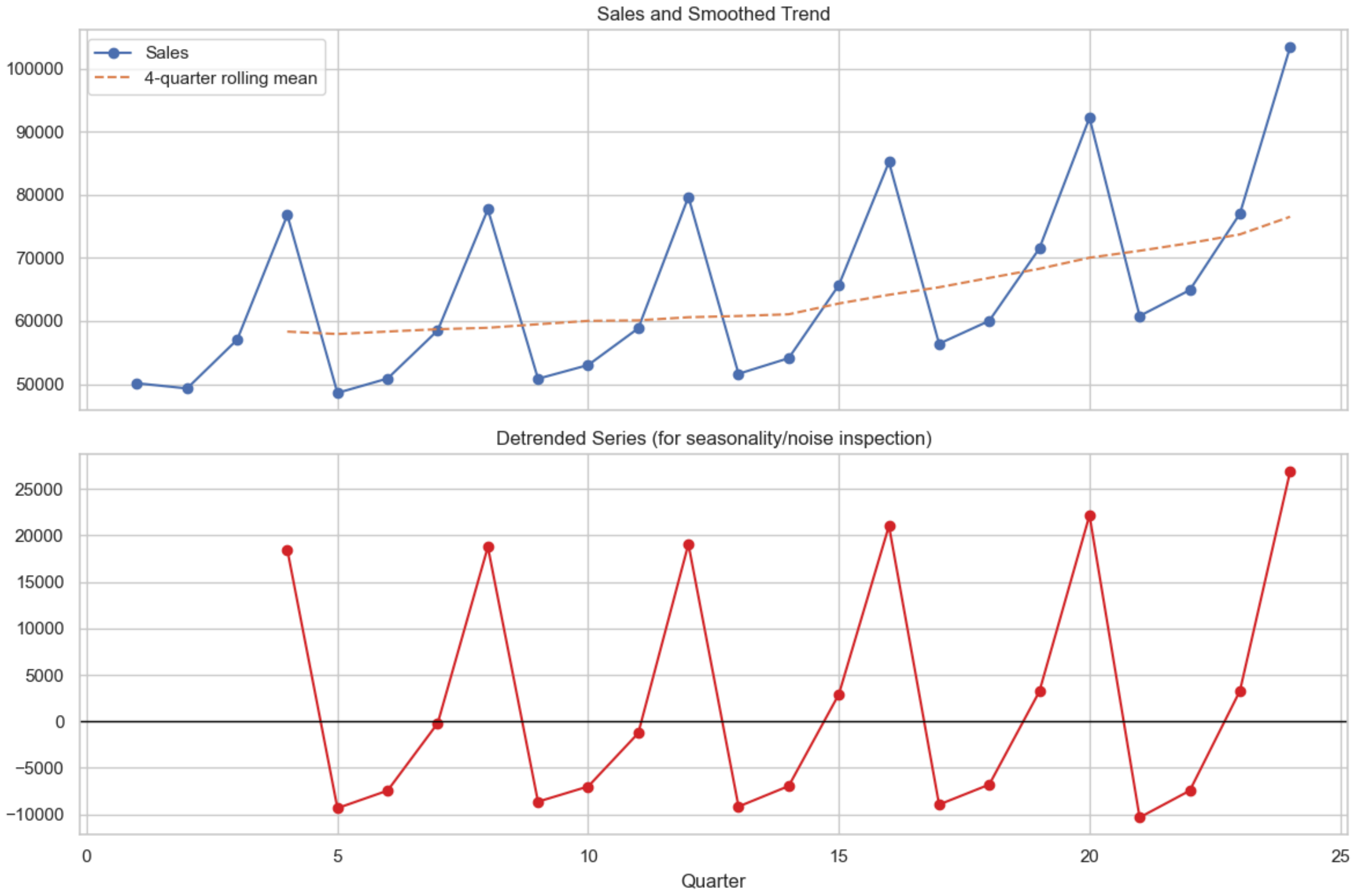
```
Quarter
1    50147.0
2    49325.0
3    57048.0
4    76781.0
5    48617.0
Name: Sales, dtype: float64
```

In [26]:

```
# Well-formatted quarterly sales plot
fig, ax = plt.subplots(figsize=(12, 5))
x = sales_series.index.to_numpy()
y = sales_series.to_numpy(dtype=float)
ax.plot(x, y, marker="o", linewidth=2, color="#2ca02c")
ax.set_title("Department Store Quarterly Sales")
ax.set_xlabel("Quarter")
ax.set_ylabel("Sales")
ax.grid(alpha=0.25)
plt.tight_layout()
plt.show()
```



```
In [27]: # Quick decomposition-style helpers for trend/seasonality discussion
sales_df = sales_series.to_frame(name="sales")
sales_df["rolling_mean_4"] = sales_df["sales"].rolling(window=4).mean()
sales_df["detrended"] = sales_df["sales"] - sales_df["rolling_mean_4"]

fig, axes = plt.subplots(2, 1, figsize=(12, 8), sharex=True)
axes[0].plot(sales_df.index, sales_df["sales"], marker="o", label="Sales")
axes[0].plot(sales_df.index, sales_df["rolling_mean_4"], linestyle="--", label="4-qua
axes[0].set_title("Sales and Smoothed Trend")
axes[0].legend()

axes[1].plot(sales_df.index, sales_df["detrended"], marker="o", color="#d62728")
axes[1].axhline(0, color="black", linewidth=1)
axes[1].set_title("Detrended Series (for seasonality/noise inspection)")
axes[1].set_xlabel("Quarter")

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


Sales and Smoothed Trend
Sales
4-quarter rolling mean
Detrended Series (for seasonality/noise inspection)
Quarter