In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

In [2]:
```
df = pd.read_csv("supply_chain_data.csv")
```

In [3]:
```
print(df.head())
print(df.info())
print(df.describe())
```

```
  Product type   SKU      Price  Availability  Number of products sold  \
0     haircare  SKU0  69.808006            55                      802
1     skincare  SKU1  14.843523            95                      736
2     haircare  SKU2  11.319683            34                        8
3     skincare  SKU3  61.163343            68                       83
4     skincare  SKU4   4.805496            26                      871

   Revenue generated Customer demographics  Stock levels  Lead times  \
0        8661.996792            Non-binary            58           7
1        7460.900065                Female            53          30
2        9577.749626               Unknown             1          10
3        7766.836426            Non-binary            23          13
4        2686.505152            Non-binary             5           3

   Order quantities  ...  Location Lead time  Production volumes  \
0                96  ...    Mumbai        29                 215
1                37  ...    Mumbai        23                 517
2                88  ...    Mumbai        12                 971
3                59  ...   Kolkata        24                 937
4                56  ...     Delhi         5                 414

  Manufacturing lead time Manufacturing costs  Inspection results  \
0                      29           46.279879             Pending
1                      30           33.616769             Pending
2                      27           30.688019             Pending
3                      18           35.624741                Fail
4                       3           92.065161                Fail

   Defect rates  Transportation modes   Routes       Costs
0      0.226410                  Road  Route B  187.752075
1      4.854068                  Road  Route B  503.065579
2      4.580593                   Air  Route C  141.920282
3      4.746649                  Rail  Route A  254.776159
4      3.145580                   Air  Route A  923.440632

[5 rows x 24 columns]
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 100 entries, 0 to 99
Data columns (total 24 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   Product type             100 non-null    object
 1   SKU                      100 non-null    object
 2   Price                    100 non-null    float64
 3   Availability             100 non-null    int64
 4   Number of products sold  100 non-null    int64
 5   Revenue generated        100 non-null    float64
 6   Customer demographics    100 non-null    object
 7   Stock levels             100 non-null    int64
 8   Lead times               100 non-null    int64
 9   Order quantities         100 non-null    int64
 10  Shipping times           100 non-null    int64
 11  Shipping carriers        100 non-null    object
 12  Shipping costs           100 non-null    float64
 13  Supplier name            100 non-null    object
 14  Location                 100 non-null    object
 15  Lead time                100 non-null    int64
 16  Production volumes       100 non-null    int64
 17  Manufacturing lead time  100 non-null    int64
 18  Manufacturing costs      100 non-null    float64
```

```
 19  Inspection results       100 non-null    object
 20  Defect rates             100 non-null    float64
 21  Transportation modes     100 non-null    object
 22  Routes                   100 non-null    object
 23  Costs                    100 non-null    float64
dtypes: float64(6), int64(9), object(9)
memory usage: 18.9+ KB
None
            Price  Availability  Number of products sold  Revenue generated  \
count  100.000000    100.000000               100.000000         100.000000
mean    49.462461     48.400000               460.990000        5776.048187
std     31.168193     30.743317               303.780074        2732.841744
min      1.699976      1.000000                 8.000000        1061.618523
25%     19.597823     22.750000               184.250000        2812.847151
50%     51.239831     43.500000               392.500000        6006.352023
75%     77.198228     75.000000               704.250000        8253.976921
max     99.171329    100.000000               996.000000        9866.465458

       Stock levels  Lead times  Order quantities  Shipping times  \
count    100.000000  100.000000        100.000000      100.000000
mean      47.770000   15.960000         49.220000        5.750000
std       31.369372    8.785801         26.784429        2.724283
min        0.000000    1.000000          1.000000        1.000000
25%       16.750000    8.000000         26.000000        3.750000
50%       47.500000   17.000000         52.000000        6.000000
75%       73.000000   24.000000         71.250000        8.000000
max      100.000000   30.000000         96.000000       10.000000

       Shipping costs   Lead time  Production volumes  \
count      100.000000  100.000000          100.000000
mean         5.548149   17.080000          567.840000
std          2.651376    8.846251          263.046861
min          1.013487    1.000000          104.000000
25%          3.540248   10.000000          352.000000
50%          5.320534   18.000000          568.500000
75%          7.601695   25.000000          797.000000
max          9.929816   30.000000          985.000000

       Manufacturing lead time  Manufacturing costs  Defect rates       Costs
count                100.00000           100.000000    100.000000  100.000000
mean                  14.77000            47.266693      2.277158  529.245782
std                    8.91243            28.982841      1.461366  258.301696
min                    1.00000             1.085069      0.018608  103.916248
25%                    7.00000            22.983299      1.009650  318.778455
50%                   14.00000            45.905622      2.141863  520.430444
75%                   23.00000            68.621026      3.563995  763.078231
max                   30.00000            99.466109      4.939255  997.413450
```

In [4]:
```
print(df.isnull().sum())
```

```
Product type                0
SKU                         0
Price                       0
Availability                0
Number of products sold     0
Revenue generated           0
Customer demographics       0
Stock levels                0
Lead times                  0
Order quantities            0
Shipping times              0
Shipping carriers           0
Shipping costs              0
Supplier name               0
Location                    0
Lead time                   0
Production volumes          0
Manufacturing lead time     0
Manufacturing costs         0
Inspection results          0
Defect rates                0
Transportation modes        0
Routes                      0
Costs                       0
dtype: int64
```

In [5]:
```
print("Shape:", df.shape)
```

```
Shape: (100, 24)
```

In [6]:
```
df.duplicated().sum()
```

Out[6]:
```
np.int64(0)
```

In [7]:
```
df = df.drop_duplicates()
```

In [8]:
```
df.columns
```

Out[8]:
```
Index(['Product type', 'SKU', 'Price', 'Availability',
       'Number of products sold', 'Revenue generated', 'Customer demographics',
       'Stock levels', 'Lead times', 'Order quantities', 'Shipping times',
       'Shipping carriers', 'Shipping costs', 'Supplier name', 'Location',
       'Lead time', 'Production volumes', 'Manufacturing lead time',
       'Manufacturing costs', 'Inspection results', 'Defect rates',
       'Transportation modes', 'Routes', 'Costs'],
      dtype='object')
```

In [9]:
```
df.nunique()
```

Out[9]:
```
Product type                 3
SKU                        100
Price                      100
Availability                63
Number of products sold     96
Revenue generated          100
Customer demographics        4
Stock levels                65
Lead times                  29
Order quantities            61
Shipping times              10
Shipping carriers            3
Shipping costs             100
Supplier name                5
Location                     5
Lead time                   29
Production volumes          96
Manufacturing lead time     30
Manufacturing costs        100
Inspection results           3
Defect rates               100
Transportation modes         4
Routes                       3
Costs                      100
dtype: int64
```

In [10]:
```
cols = ["Price", "Shipping costs", "Manufacturing costs", "Costs", "Stock levels
summary = df[cols].agg(["min", "max"]).T
print(summary)
```

```
                           min         max
Price                 1.699976   99.171329
Shipping costs        1.013487    9.929816
Manufacturing costs   1.085069   99.466109
Costs               103.916248  997.413450
Stock levels          0.000000  100.000000
Defect rates          0.018608    4.939255
```

In [11]:
```
# Price > 0
df = df[df["Price"] > 0]

# Costs >= 0
cost_cols = ["Shipping costs", "Manufacturing costs", "Costs"]
for col in cost_cols:
    df = df[df[col] >= 0]

# Stock >= 0
df = df[df["Stock levels"] >= 0]

# Defect rates
df = df[(df["Defect rates"] >= 0) & (df["Defect rates"] <= 5)]
```

In [12]:
```
# Convert columns to float
numeric_cols = ["Price", "Revenue generated", "Shipping costs",
                "Manufacturing costs", "Costs","Lead times", "Shipping times", "

for col in numeric_cols:
    df[col] = pd.to_numeric(df[col], errors="coerce")
```

In [13]:
```
# Convert columns to int
int_cols = ["Number of products sold", "Stock levels", "Order quantities", "Prod

for col in int_cols:
    df[col] = pd.to_numeric(df[col], errors="coerce").astype("Int64")
```

In [14]:
```
text_cols = ["Supplier name", "Location", "Transportation modes",
             "Routes", "Shipping carriers", "Customer demographics"]

for col in text_cols:
    df[col] = df[col].astype(str).str.strip()
```

In [15]:
```
print(df.head(5))
```

```
  Product type    SKU      Price  Availability  Number of products sold  \
0     haircare   SKU0  69.808006            55                      802
1     skincare   SKU1  14.843523            95                      736
2     haircare   SKU2  11.319683            34                        8
3     skincare   SKU3  61.163343            68                       83
4     skincare   SKU4   4.805496            26                      871

   Revenue generated Customer demographics  Stock levels  Lead times  \
0        8661.996792            Non-binary            58           7
1        7460.900065                Female            53          30
2        9577.749626               Unknown             1          10
3        7766.836426            Non-binary            23          13
4        2686.505152            Non-binary             5           3

   Order quantities  ...  Location Lead time  Production volumes  \
0                96  ...    Mumbai        29                 215
1                37  ...    Mumbai        23                 517
2                88  ...    Mumbai        12                 971
3                59  ...   Kolkata        24                 937
4                56  ...     Delhi         5                 414

  Manufacturing lead time Manufacturing costs  Inspection results  \
0                      29           46.279879             Pending
1                      30           33.616769             Pending
2                      27           30.688019             Pending
3                      18           35.624741                Fail
4                       3           92.065161                Fail

   Defect rates  Transportation modes   Routes       Costs
0      0.226410                  Road  Route B  187.752075
1      4.854068                  Road  Route B  503.065579
2      4.580593                   Air  Route C  141.920282
3      4.746649                  Rail  Route A  254.776159
4      3.145580                   Air  Route A  923.440632

[5 rows x 24 columns]
```

In [16]:
```
# two decimal digits
two_decimal_cols = ["Price", "Revenue generated", "Shipping costs",
                    "Manufacturing costs", "Costs"]

for col in two_decimal_cols:
    df[col] = df[col].round(2)
```

```
# one decimal number
df["Defect rates"] = df["Defect rates"].round(1)
```

In [17]:
```
#text_cols = ["Supplier name", "Location", "Transportation modes",
              #"Routes", "Shipping carriers", "Customer demographics"]
```

In [18]:
```
for col in text_cols:
    print(f"\n--- Values in column: {col} ---")
    print(df[col].value_counts(dropna=False).head(10))
```

```
--- Values in column: Supplier name ---
Supplier name
Supplier 1    27
Supplier 2    22
Supplier 5    18
Supplier 4    18
Supplier 3    15
Name: count, dtype: int64

--- Values in column: Location ---
Location
Kolkata      25
Mumbai       22
Chennai      20
Bangalore    18
Delhi        15
Name: count, dtype: int64

--- Values in column: Transportation modes ---
Transportation modes
Road    29
Rail    28
Air     26
Sea     17
Name: count, dtype: int64

--- Values in column: Routes ---
Routes
Route A    43
Route B    37
Route C    20
Name: count, dtype: int64

--- Values in column: Shipping carriers ---
Shipping carriers
Carrier B    43
Carrier C    29
Carrier A    28
Name: count, dtype: int64

--- Values in column: Customer demographics ---
Customer demographics
Unknown       31
Female        25
Non-binary    23
Male          21
Name: count, dtype: int64
```

In [19]:
```
txt_cols = ["Supplier name", "Location", "Transportation modes",
            "Routes", "Shipping carriers", "Customer demographics","Product typ
```

```
for col in txt_cols:
  # Remove spaces and unify capitalize letters
    df[col] = df[col].astype(str).str.strip().str.capitalize()
```

In [20]:
```
import re

for col in text_cols:
    df[col] = df[col].apply(lambda x: re.sub(r"[^a-zA-Z0-9\s]", "", x))
```

In [21]:
```
df.columns = df.columns.str.title()
```

In [22]:
```
for col in df.select_dtypes(include='object').columns:
    df[col] = df[col].fillna("Unknown")
```

In [23]:
```
print(df.head())
```

```
  Product Type   Sku  Price  Availability  Number Of Products Sold  \
0     Haircare  SKU0  69.81            55                      802
1     Skincare  SKU1  14.84            95                      736
2     Haircare  SKU2  11.32            34                        8
3     Skincare  SKU3  61.16            68                       83
4     Skincare  SKU4   4.81            26                      871

   Revenue Generated Customer Demographics  Stock Levels  Lead Times  \
0            8662.00              Nonbinary            58           7
1            7460.90                 Female            53          30
2            9577.75                Unknown             1          10
3            7766.84              Nonbinary            23          13
4            2686.51              Nonbinary             5           3

   Order Quantities  ...  Location Lead Time  Production Volumes  \
0                96  ...     Mumbai        29                 215
1                37  ...     Mumbai        23                 517
2                88  ...     Mumbai        12                 971
3                59  ...    Kolkata        24                 937
4                56  ...      Delhi         5                 414

  Manufacturing Lead Time Manufacturing Costs  Inspection Results  \
0                      29               46.28             Pending
1                      30               33.62             Pending
2                      27               30.69             Pending
3                      18               35.62                Fail
4                       3               92.07                Fail

   Defect Rates  Transportation Modes   Routes   Costs
0           0.2                  Road  Route b  187.75
1           4.9                  Road  Route b  503.07
2           4.6                   Air  Route c  141.92
3           4.7                  Rail  Route a  254.78
4           3.1                   Air  Route a  923.44

[5 rows x 24 columns]
```

In [24]:
```
df.columns
```

Out[24]:
```
Index(['Product Type', 'Sku', 'Price', 'Availability',
       'Number Of Products Sold', 'Revenue Generated', 'Customer Demographics',
       'Stock Levels', 'Lead Times', 'Order Quantities', 'Shipping Times',
       'Shipping Carriers', 'Shipping Costs', 'Supplier Name', 'Location',
       'Lead Time', 'Production Volumes', 'Manufacturing Lead Time',
       'Manufacturing Costs', 'Inspection Results', 'Defect Rates',
       'Transportation Modes', 'Routes', 'Costs'],
      dtype='object')
```

In [25]:
```
df['Profit']=(df['Revenue Generated']-df['Costs']).round (2)
```

In [26]:
```
df['Stock out Risk']=((df['Stock Levels']/df['Order Quantities'])*100).round(0)
df['Stock out Risk']=pd.to_numeric(df['Stock out Risk'],errors='coerce').astype(
```

In [27]:
```
df['Warehousing Costs']=(df['Costs']-(df['Manufacturing Costs']+df['Shipping Cos
```

In [28]:
```
df["Defective Units"] = df["Production Volumes"] * (df["Defect Rates"] / 100)
```

In [29]:
```
df["Accepted Units"] = df["Production Volumes"] - df["Defective Units"]
```

In [30]:
```
df[["Accepted Units", "Defective Units"]] = df[["Accepted Units", "Defective Uni
```

In [31]:
```
df.rename(columns={"Lead Times":"Customer Lead Time",'Lead Time':'Supplier Lead
                   'Customer Demographics':'Customer Gender','Availability':'Avai
                   'Costs':'Total Cost'}
          , inplace=True)
```

In [32]:
```
df.columns
```

Out[32]:
```
Index(['Product Type', 'Sku', 'Price', 'Availabile for Sale',
       'Number Of Products Sold', 'Revenue Generated', 'Customer Gender',
       'Stock Levels', 'Customer Lead Time', 'Order Quantities',
       'Shipping Times', 'Shipping Carriers', 'Shipping Costs',
       'Supplier Name', 'Location', 'Supplier Lead Time', 'Production Volumes',
       'Manufacturing Lead Time', 'Manufacturing Costs', 'Inspection Results',
       'Defect Rates', 'Transportation Modes', 'Routes', 'Total Cost',
       'Profit', 'Stock out Risk', 'Warehousing Costs', 'Defective Units',
       'Accepted Units'],
      dtype='object')
```

In [33]:
```
df
```

Out[33]:

	Product Type	Sku	Price	Availabile for Sale	Number Of Products Sold	Revenue Generated	Customer Gender	Stock Levels	Custo L T
0	Haircare	SKU0	69.81	55	802	8662.00	Nonbinary	58	
1	Skincare	SKU1	14.84	95	736	7460.90	Female	53	
2	Haircare	SKU2	11.32	34	8	9577.75	Unknown	1	
3	Skincare	SKU3	61.16	68	83	7766.84	Nonbinary	23	
4	Skincare	SKU4	4.81	26	871	2686.51	Nonbinary	5	
...	...	...	...	...	...	...	...	...	
95	Haircare	SKU95	77.90	65	672	7386.36	Unknown	15	
96	Cosmetics	SKU96	24.42	29	324	7698.42	Nonbinary	67	
97	Haircare	SKU97	3.53	56	62	4370.92	Male	46	
98	Skincare	SKU98	19.75	43	913	8525.95	Female	53	
99	Haircare	SKU99	68.52	17	627	9185.19	Unknown	55	

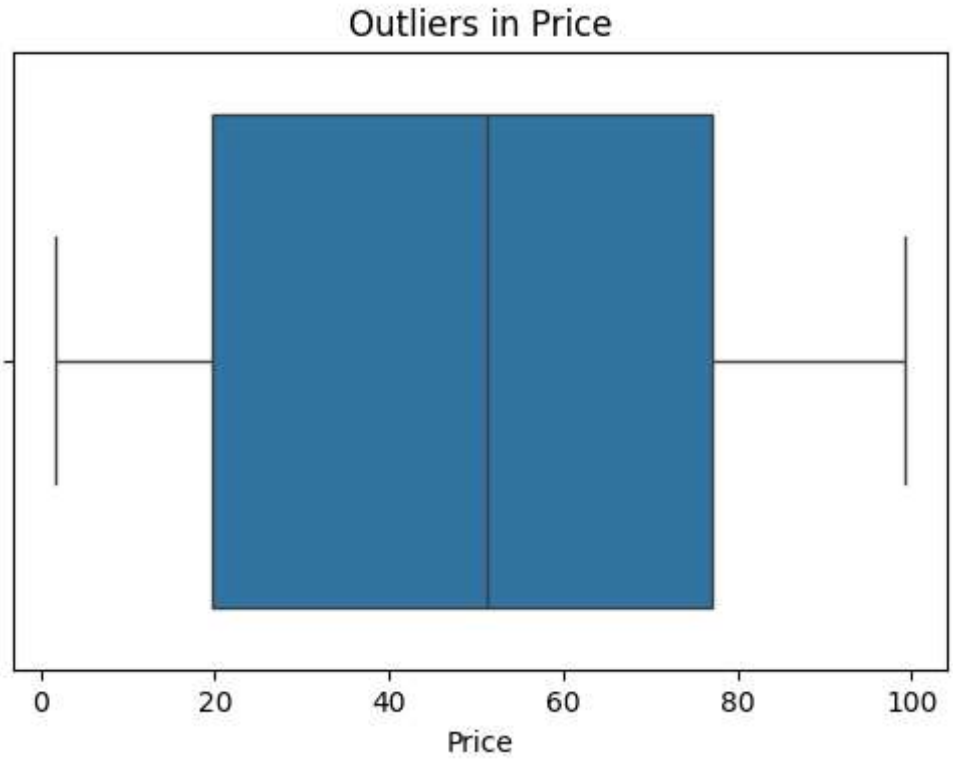
100 rows × 29 columns

In [34]:
```
df.loc[:,"Production Volumes"]
```

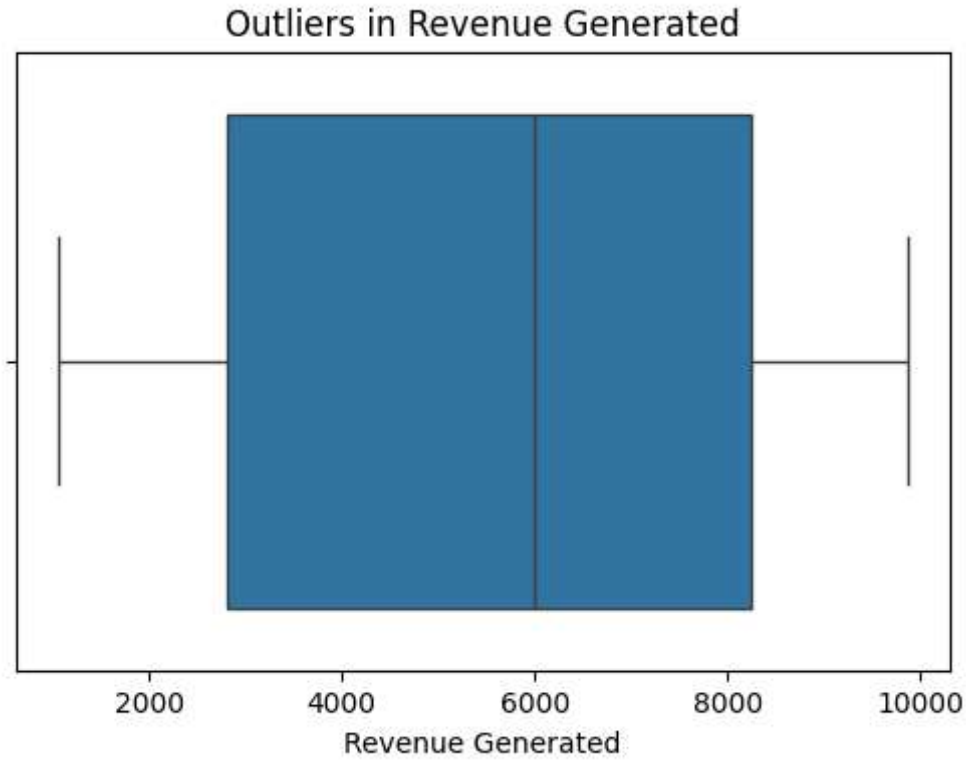
Out[34]:
```
0     215
1     517
2     971
3     937
4     414
     ...
95    450
96    648
97    535
98    581
99    921
Name: Production Volumes, Length: 100, dtype: Int64
```

In [38]:
```
# هنشيك علي الاعمده دي
num_cols = ['Price',
            'Revenue Generated',
            'Shipping Costs',
            'Manufacturing Costs',
            'Total Cost',
```

```
            'Defect Rates']


for col in num_cols:
    plt.figure(figsize=(6,4))
    sns.boxplot(x=df[col])
    plt.title(f"Outliers in {col}")
    plt.show()
# حساب IQR
    Q1 = df[col].quantile(0.25)
    Q3 = df[col].quantile(0.75)
    IQR = Q3 - Q1

    lower_bound = Q1 - 1.5 * IQR
    upper_bound = Q3 + 1.5 * IQR

    outliers = df[(df[col] < lower_bound) | (df[col] > upper_bound)]
    print(f"\nOutliers in {col}: {len(outliers)} rows")
    print(outliers[[col]].head(10))
```

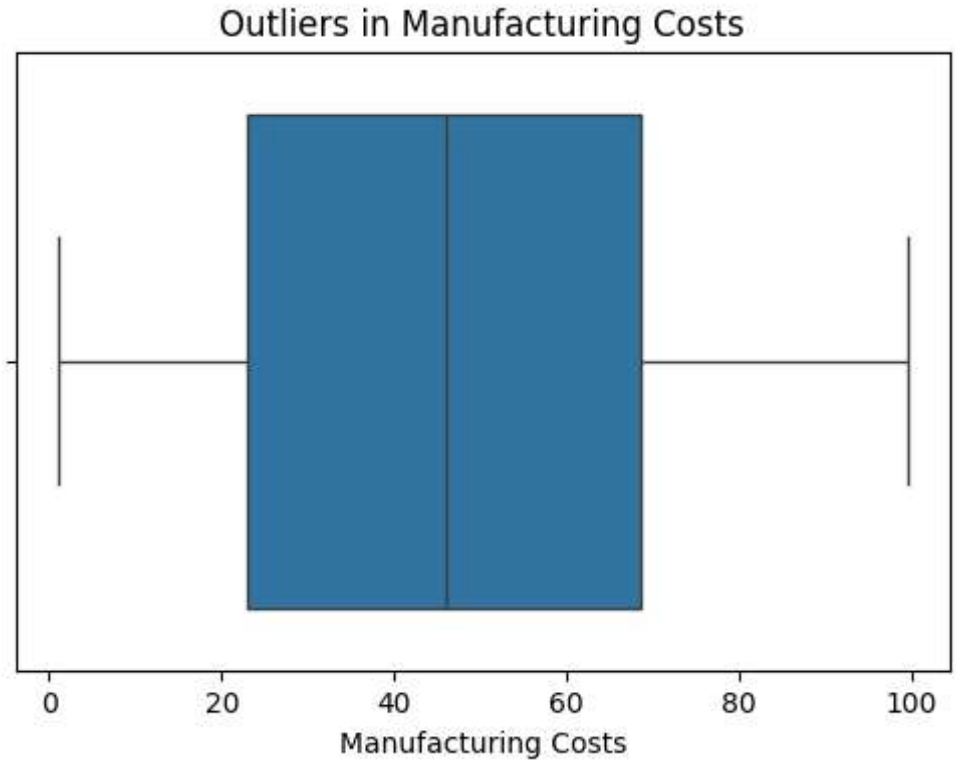



```
Outliers in Price: 0 rows
Empty DataFrame
Columns: [Price]
Index: []
```

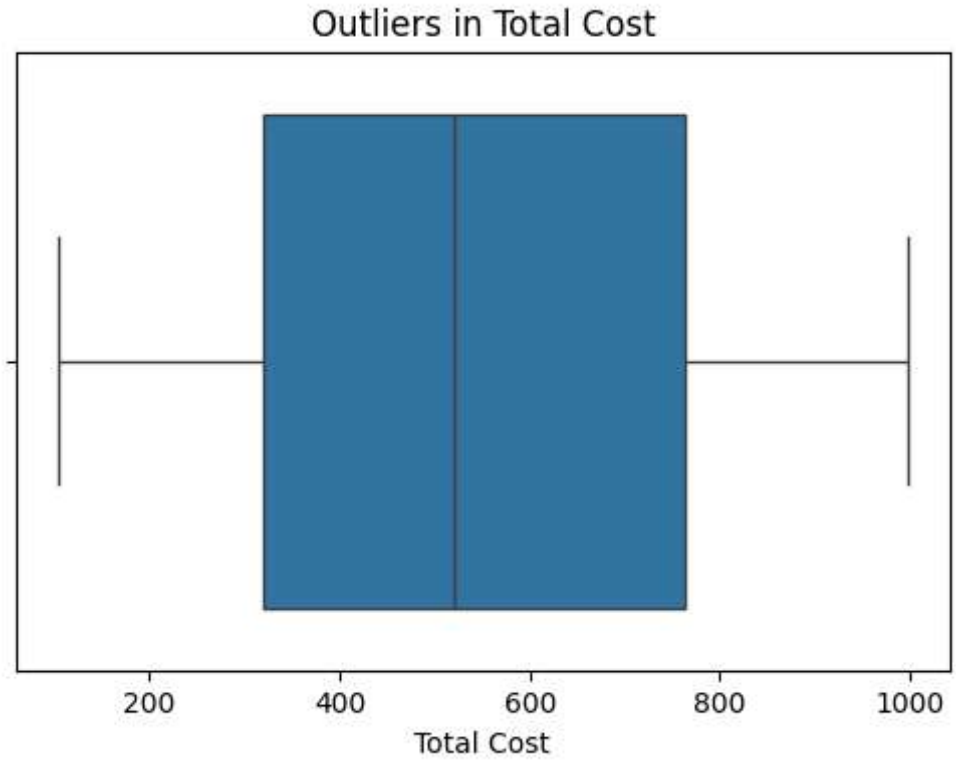



```
Outliers in Revenue Generated: 0 rows
Empty DataFrame
Columns: [Revenue Generated]
Index: []
```

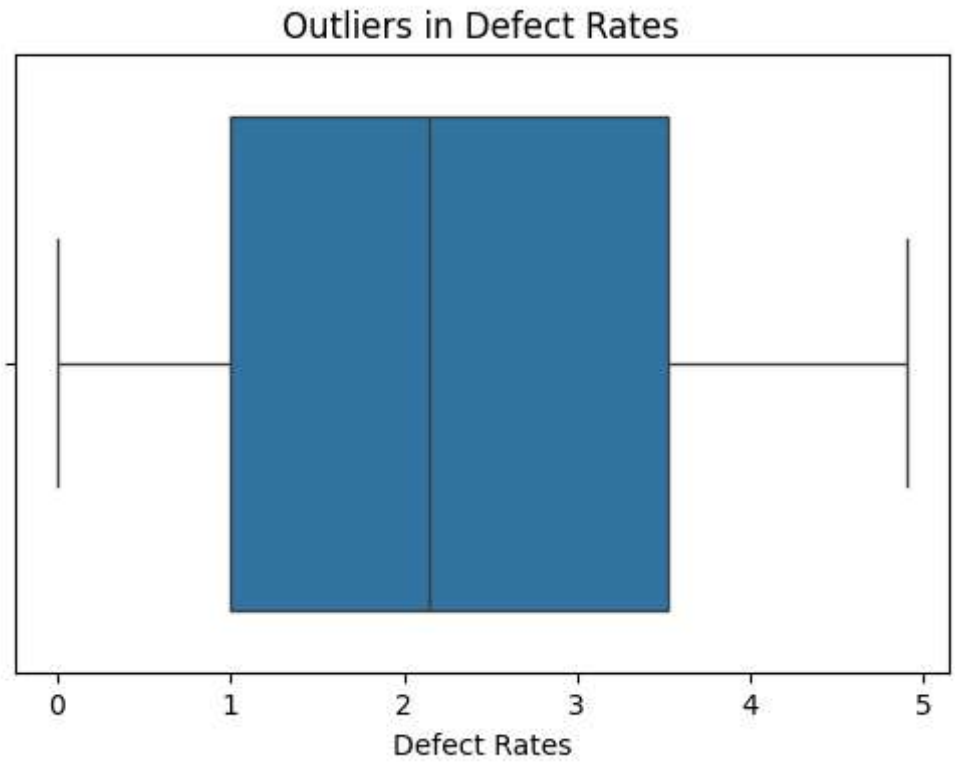

```
Outliers in Shipping Costs: 0 rows
Empty DataFrame
Columns: [Shipping Costs]
Index: []
```




```
Outliers in Manufacturing Costs: 0 rows
Empty DataFrame
Columns: [Manufacturing Costs]
Index: []
```




```
Outliers in Total Cost: 0 rows
Empty DataFrame
Columns: [Total Cost]
Index: []
```




```
Outliers in Defect Rates: 0 rows
Empty DataFrame
Columns: [Defect Rates]
Index: []
```

In [39]:
```
df.columns
```

Out[39]:
```
Index(['Product Type', 'Sku', 'Price', 'Availabile for Sale',
       'Number Of Products Sold', 'Revenue Generated', 'Customer Gender',
       'Stock Levels', 'Customer Lead Time', 'Order Quantities',
       'Shipping Times', 'Shipping Carriers', 'Shipping Costs',
       'Supplier Name', 'Location', 'Supplier Lead Time', 'Production Volumes',
       'Manufacturing Lead Time', 'Manufacturing Costs', 'Inspection Results',
       'Defect Rates', 'Transportation Modes', 'Routes', 'Total Cost',
       'Profit', 'Stock out Risk', 'Warehousing Costs', 'Defective Units',
       'Accepted Units'],
      dtype='object')
```

In [40]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 100 entries, 0 to 99
Data columns (total 29 columns):
 #   Column                   Non-Null Count  Dtype
---  ------                   --------------  -----
 0   Product Type             100 non-null    object
 1   Sku                      100 non-null    object
 2   Price                    100 non-null    float64
 3   Availabile for Sale      100 non-null    int64
 4   Number Of Products Sold  100 non-null    Int64
 5   Revenue Generated        100 non-null    float64
 6   Customer Gender          100 non-null    object
 7   Stock Levels             100 non-null    Int64
 8   Customer Lead Time       100 non-null    int64
 9   Order Quantities         100 non-null    Int64
 10  Shipping Times           100 non-null    int64
 11  Shipping Carriers        100 non-null    object
 12  Shipping Costs           100 non-null    float64
 13  Supplier Name            100 non-null    object
 14  Location                 100 non-null    object
 15  Supplier Lead Time       100 non-null    int64
 16  Production Volumes       100 non-null    Int64
 17  Manufacturing Lead Time  100 non-null    int64
 18  Manufacturing Costs      100 non-null    float64
 19  Inspection Results       100 non-null    object
 20  Defect Rates             100 non-null    float64
 21  Transportation Modes     100 non-null    object
 22  Routes                   100 non-null    object
 23  Total Cost               100 non-null    float64
 24  Profit                   100 non-null    float64
 25  Stock out Risk           100 non-null    int64
 26  Warehousing Costs        100 non-null    float64
 27  Defective Units          100 non-null    int64
 28  Accepted Units           100 non-null    int64
dtypes: Int64(4), float64(8), int64(8), object(9)
memory usage: 23.2+ KB
```

In [42]:
```
df.to_csv('Cleaning Supply Chain Project 12.11.csv')
```

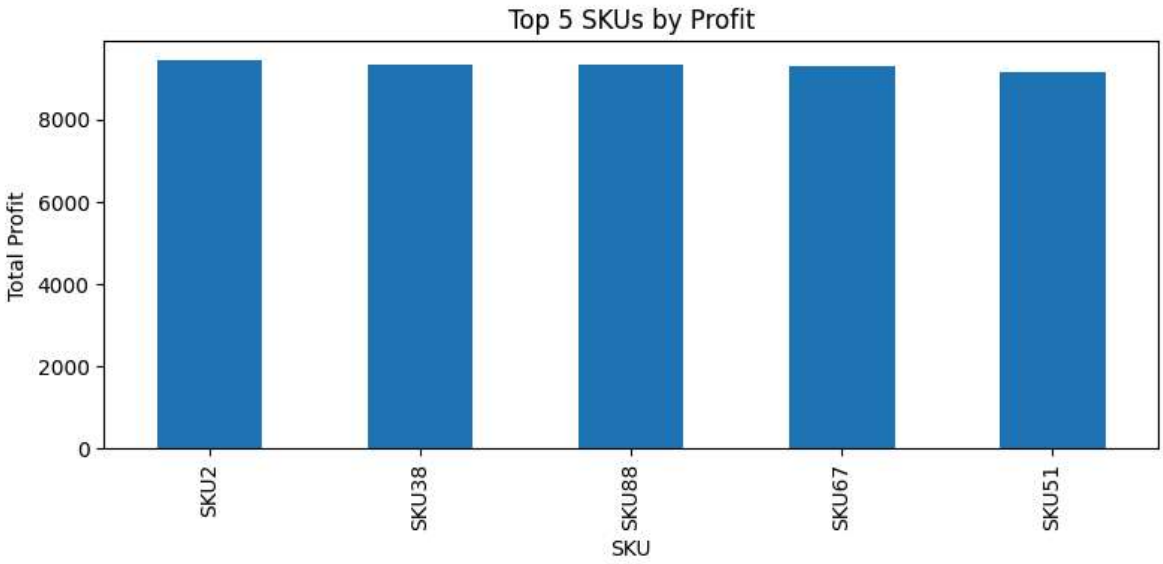
In [43]:
```
df.to_excel('Cleaning Supply Chain Project 12.11 .xlsx')
```

In [44]:
```
#Product Performance
```

In [45]:
```
#1.1 Top 5 SKUs by Profit
```

In [46]:
```
top5_skus = df.groupby('Sku')['Profit'].sum().sort_values(ascending=False).head(
print(top5_skus)

# Visualization
top5_skus.plot(kind='bar', title='Top 5 SKUs by Profit', ylabel='Total Profit',
plt.tight_layout()
plt.show()
```

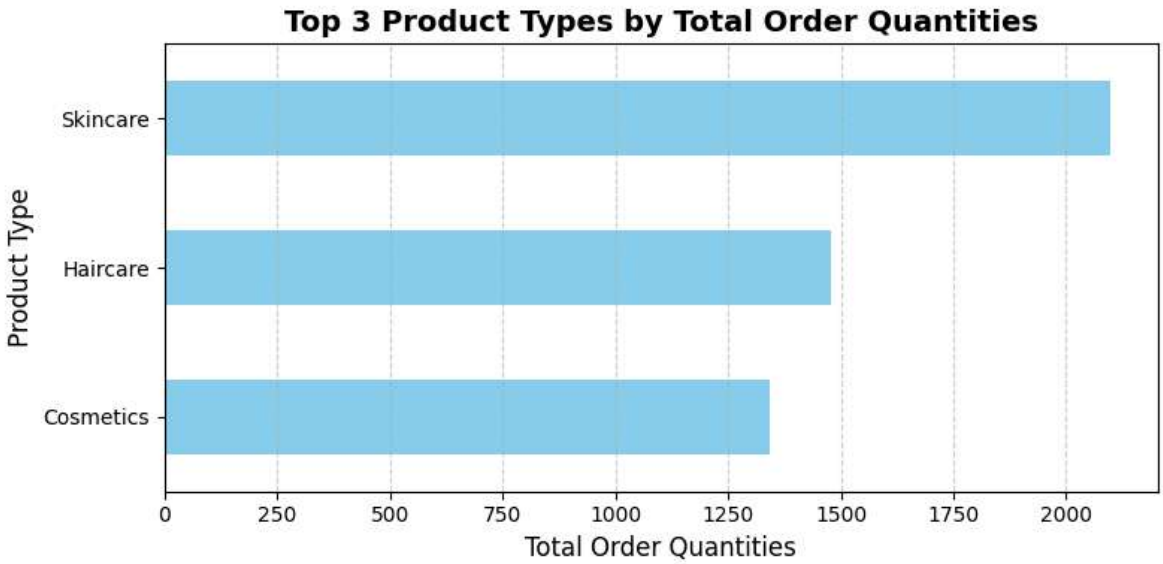
```
Sku
SKU2     9435.83
SKU38    9352.65
SKU88    9340.82
SKU67    9304.53
SKU51    9171.49
Name: Profit, dtype: float64
```



In [47]:
```
# Top 3 Product Types by Order Quantities
```

In [48]:
```
top3_types_qty = (
    df.groupby('Product Type')['Order Quantities']
    .sum()
    .sort_values(ascending=False)
    .head(3)
)

print(top3_types_qty)

# Visualization
plt.figure(figsize=(8, 4))
top3_types_qty.plot(
    kind='barh',
    color='skyblue',
)
plt.title('Top 3 Product Types by Total Order Quantities', fontsize=14, weight='
plt.xlabel('Total Order Quantities', fontsize=12)
plt.ylabel('Product Type', fontsize=12)
plt.gca().invert_yaxis()  # يخلي أعلى نوع في الأعلى
plt.grid(axis='x', linestyle='--', alpha=0.6)
plt.tight_layout()
plt.show()
```

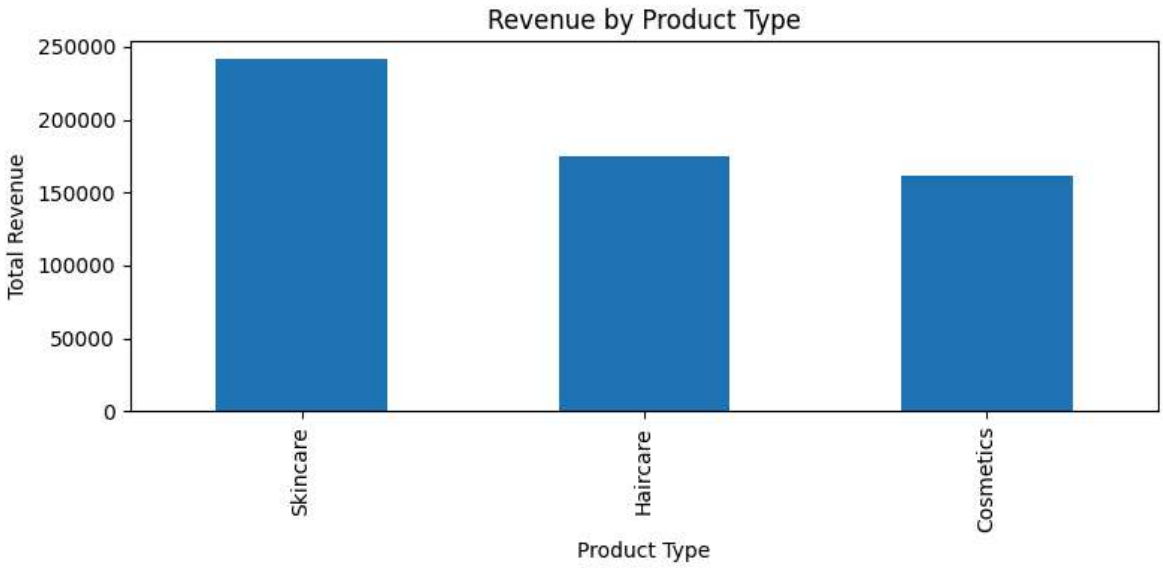
```
Product Type
Skincare     2099
Haircare     1480
Cosmetics    1343
Name: Order Quantities, dtype: Int64
```



In [49]:
```
#1.3 Revenue by Product Type
```

In [52]:
```
revenue_by_type = df.groupby('Product Type')['Revenue Generated'].sum().sort_val
print(revenue_by_type)

# Visualization
revenue_by_type.plot(kind='bar', title='Revenue by Product Type', ylabel='Total
plt.tight_layout()
plt.show()
```

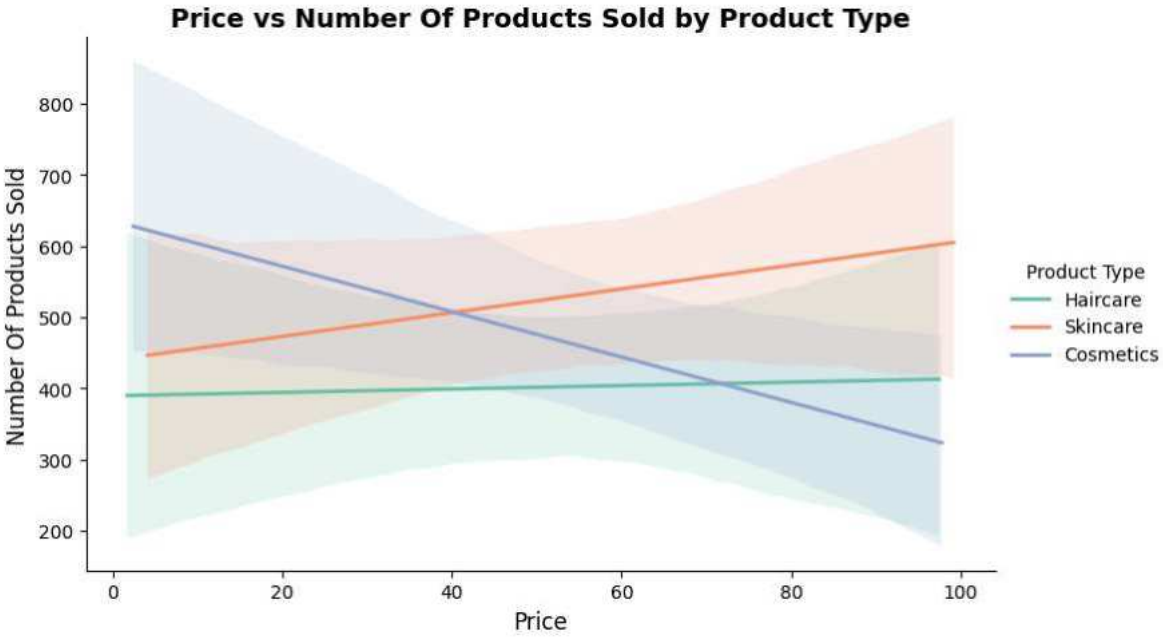
```
Product Type
Skincare     241628.17
Haircare     174455.42
Cosmetics    161521.27
Name: Revenue Generated, dtype: float64
```



In [53]:
```
#1.4 Price vs Number Of Products Sold
```

In [54]:
```
# Filter product types
types = ['Skincare', 'Haircare', 'Cosmetics']
data = df[df['Product Type'].isin(types)]

# Define consistent color palette
palette = sns.color_palette("Set2", n_colors=len(types))
```

```
# Draw trendlines
g = sns.lmplot(
    x='Price',
    y='Number Of Products Sold',
    data=data,
    hue='Product Type',
    height=5,
    aspect=1.3,
    scatter=False,
    palette=palette,
    line_kws={'lw': 2}
)

# Title & Labels
plt.title('Price vs Number Of Products Sold by Product Type', fontsize=14, weigh
plt.xlabel('Price', fontsize=12)
plt.ylabel('Number Of Products Sold', fontsize=12)

# Move single legend outside the plot
g._legend.set_bbox_to_anchor((1.15, 0.5))  # يحركها لليمين برا الرسم
g._legend.set_title('Product Type')         # العنوان
g._legend.set_frame_on(False)               # بدون إطار
g._legend.set_title('Product Type')
for text in g._legend.texts:
    text.set_fontsize(10)

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



In [55]:
```
#Supplier Performance
```

In [56]:
```
#2.1 Average Supplier Lead Time
```

In [57]:
```
avg_lead_time = df.groupby('Supplier Name')['Supplier Lead Time'].mean().sort_va
print(avg_lead_time)

# Visualization
avg_lead_time.plot(kind='bar', title='Average Supplier Lead Time', ylabel='Days'
```

```
plt.xticks(rotation=45, ha='right')
plt.tight_layout()
plt.show()
```

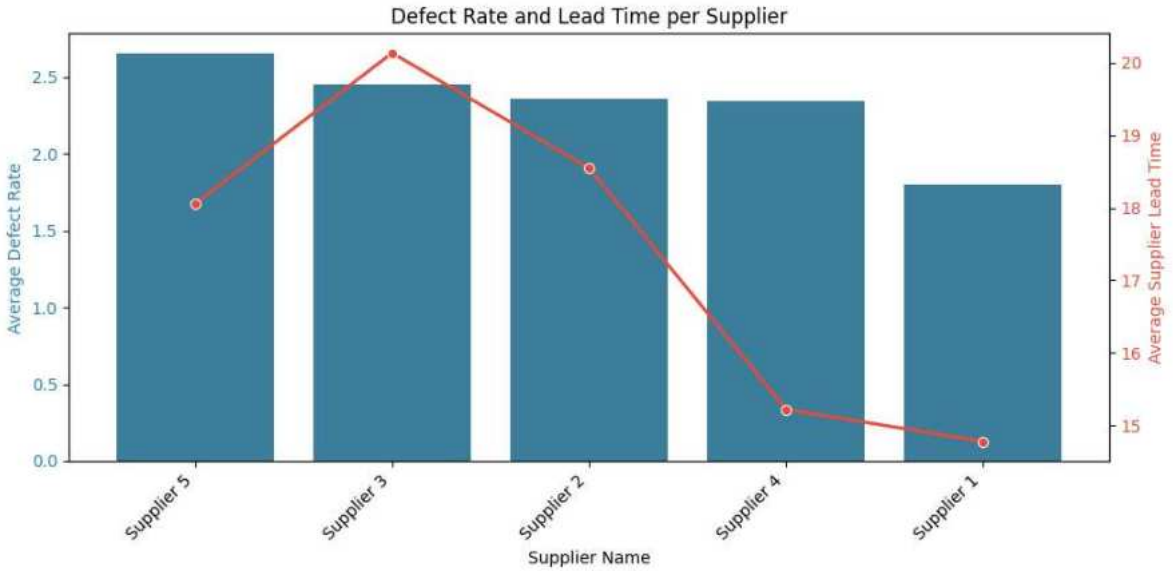
```
Supplier Name
Supplier 1    14.777778
Supplier 4    15.222222
Supplier 5    18.055556
Supplier 2    18.545455
Supplier 3    20.133333
Name: Supplier Lead Time, dtype: float64
```

In [58]:
```
# 2.2 Defect Rate vs Supplier Lead Time per Supplier
```

In [59]:
```
defect_vs_lead = df.groupby('Supplier Name')[['Defect Rates', 'Supplier Lead Tim

# ترتيب الموردين حسب معدل العيوب
defect_vs_lead = defect_vs_lead.sort_values('Defect Rates', ascending=False)

# إنشاء الشكل
fig, ax1 = plt.subplots(figsize=(10,5))

# العمود الأول: Defect Rate (Bar)
sns.barplot(
    data=defect_vs_lead,
    x='Supplier Name',
    y='Defect Rates',
    color='#2E86AB',
    ax=ax1
)
ax1.set_ylabel('Average Defect Rate', color='#2E86AB')
ax1.tick_params(axis='y', labelcolor='#2E86AB')
ax1.set_xticklabels(defect_vs_lead['Supplier Name'], rotation=45, ha='right')

# العمود الثاني: Supplier Lead Time (Line)
ax2 = ax1.twinx()
sns.lineplot(
    data=defect_vs_lead,
    x='Supplier Name',
    y='Supplier Lead Time',
    color='#E74C3C',
    marker='o',
    linewidth=2,
    ax=ax2
)
ax2.set_ylabel('Average Supplier Lead Time', color='#E74C3C')
```

```
ax2.tick_params(axis='y', labelcolor='#E74C3C')

plt.title('Defect Rate and Lead Time per Supplier')
plt.tight_layout()
plt.show()
print(defect_vs_lead)
```

```
C:\Users\dell\AppData\Local\Temp\ipykernel_10008\2377119272.py:19: UserWarning: s
et_ticklabels() should only be used with a fixed number of ticks, i.e. after set_
ticks() or using a FixedLocator.
  ax1.set_xticklabels(defect_vs_lead['Supplier Name'], rotation=45, ha='right')
```

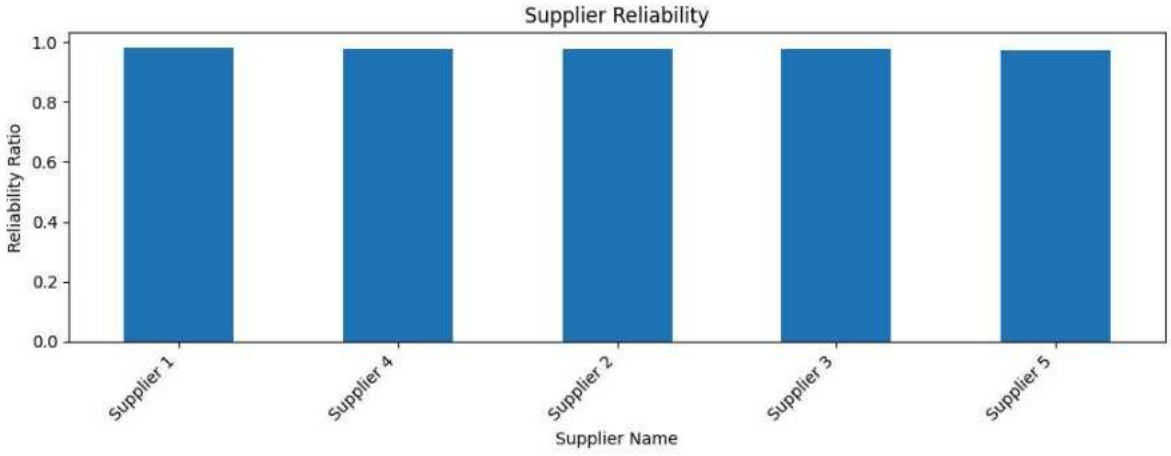


	Supplier Name	Defect Rates	Supplier Lead Time
4	Supplier 5	2.650000	18.055556
2	Supplier 3	2.453333	20.133333
1	Supplier 2	2.359091	18.545455
3	Supplier 4	2.344444	15.222222
0	Supplier 1	1.800000	14.777778

In [60]:
```
#2.4 Supplier Reliability (Accepted Units / Total Units) **********Panding******
```

In [61]:
```
df['Total Units'] = df['Accepted Units'] + df['Defective Units']
df['Supplier Reliability'] = df['Accepted Units'] / df['Total Units']
reliability = df.groupby('Supplier Name')['Supplier Reliability'].mean().sort_va
print(reliability)

# Visualization
reliability.plot(kind='bar', title='Supplier Reliability', ylabel='Reliability R
plt.xticks(rotation=45, ha='right')
plt.tight_layout()
plt.show()
```

```
Supplier Name
Supplier 1    0.981969
Supplier 4    0.976763
Supplier 2    0.976175
Supplier 3    0.975775
Supplier 5    0.973359
Name: Supplier Reliability, dtype: float64
```



In [62]:
```
#Logistics Analysis
```

In [63]:
```
#3.1 Avg Shipping Time per Carrier
```

In [64]:
```
avg_shipping_time = df.groupby('Shipping Carriers')['Shipping Times'].mean().sor
print(avg_shipping_time)

# Visualization
# Calculate average shipping time per carrier
avg_shipping_time = df.groupby('Shipping Carriers')['Shipping Times'].mean().sor

# Plot
plt.figure(figsize=(8,4))
sns.barplot(
    x=avg_shipping_time.values,
    y=avg_shipping_time.index,
    palette='crest'
)

# Add value labels
for i, v in enumerate(avg_shipping_time.values):
    plt.text(v + 0.1, i, f"{v:.1f} days", va='center', fontsize=9, weight='bold'

plt.title('Average Shipping Time per Carrier', fontsize=14, weight='bold')
plt.xlabel('Average Shipping Time (Days)', fontsize=12)
plt.ylabel('Shipping Carrier', fontsize=12)
plt.tight_layout()
plt.show()
```

```
Shipping Carriers
Carrier b    5.302326
Carrier c    6.034483
Carrier a    6.142857
Name: Shipping Times, dtype: float64
```

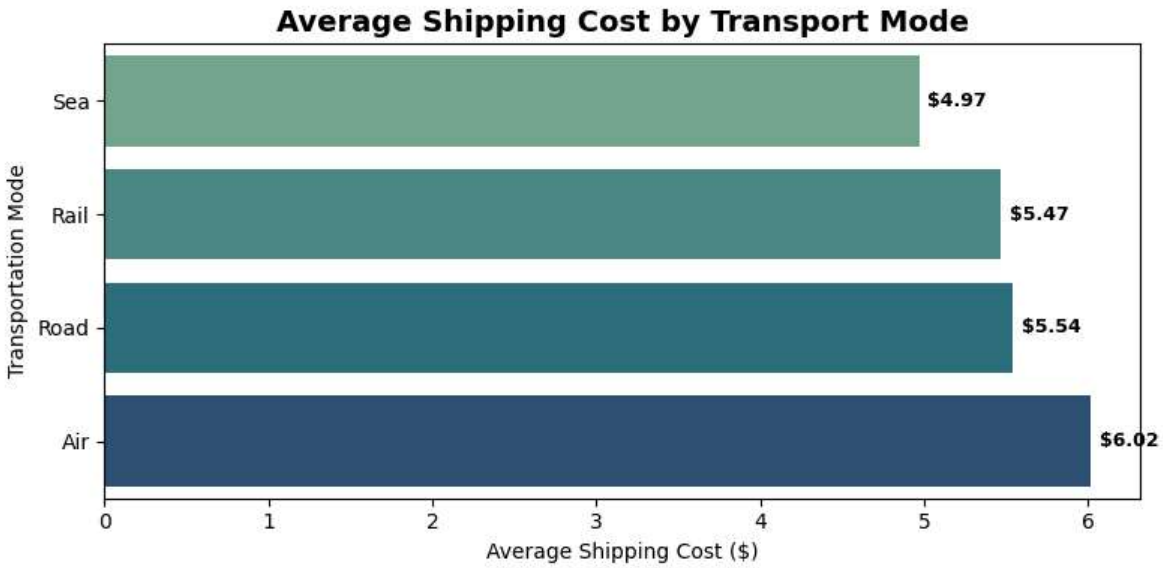
```
C:\Users\dell\AppData\Local\Temp\ipykernel_10008\220646903.py:10: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v
0.14.0. Assign the `y` variable to `hue` and set `legend=False` for the same effe
ct.

  sns.barplot(
```

In [65]:
```
#3.2 Avg Shipping Cost by Transport Mode
```

In [66]:
```
avg_shipping_cost = df.groupby('Transportation Modes')['Shipping Costs'].mean().
print(avg_shipping_cost)

# Visualization
plt.figure(figsize=(8,4))
sns.barplot(
    x=avg_shipping_cost.values,
    y=avg_shipping_cost.index,
    palette='crest'
)

# Add value labels
for i, v in enumerate(avg_shipping_cost.values):
    plt.text(v + 0.05, i, f"${v:.2f}", va='center', fontsize=9, fontweight='bold

plt.title('Average Shipping Cost by Transport Mode', fontsize=14, fontweight='bo
plt.xlabel('Average Shipping Cost ($)')
plt.ylabel('Transportation Mode')
plt.tight_layout()
plt.show()
```

```
Transportation Modes
Sea     4.970000
Rail    5.469286
Road    5.542414
Air     6.017692
Name: Shipping Costs, dtype: float64
```

```
C:\Users\dell\AppData\Local\Temp\ipykernel_10008\1227519717.py:6: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v
0.14.0. Assign the `y` variable to `hue` and set `legend=False` for the same effe
ct.

  sns.barplot(
```



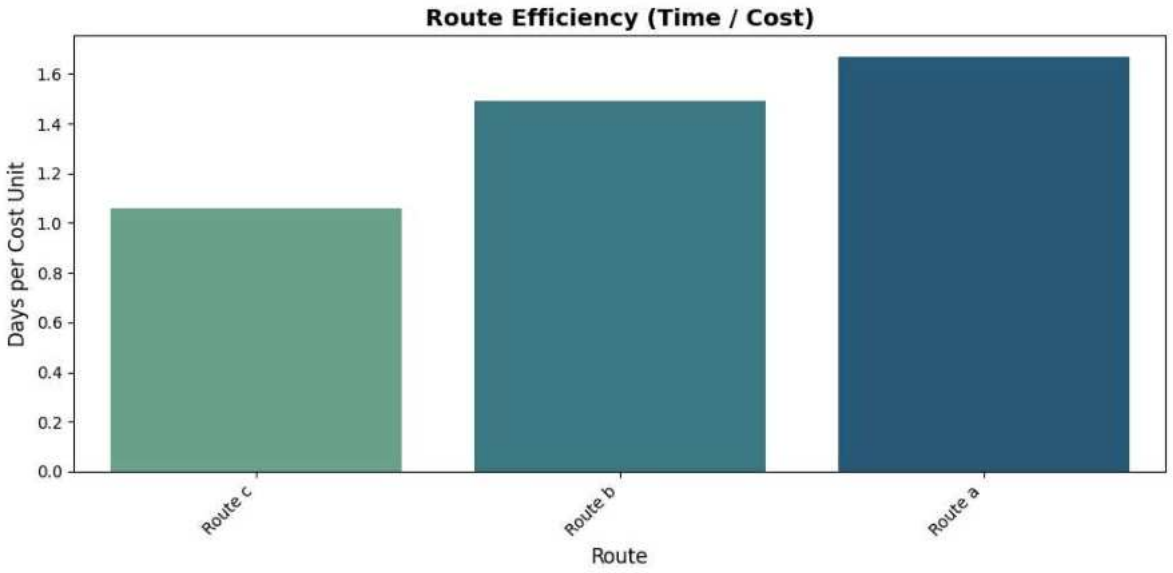
In [67]:
```
#3.3 Route Efficiency (Time / Cost)
```

In [68]:
```
df['Route Efficiency'] = df['Shipping Times'] / (df['Shipping Costs'] + 1e-6)

route_summary = df.groupby('Routes').agg({
    'Shipping Times': 'mean',
    'Shipping Costs': 'mean',
    'Route Efficiency': 'mean'
}).round(2)

route_summary = route_summary.sort_values('Route Efficiency')

route_summary = route_summary.rename(columns={
    'Shipping Times': 'Avg Shipping Time (Days)',
    'Shipping Costs': 'Avg Shipping Cost ($)',
    'Route Efficiency': 'Time per Cost Unit'
})

print("\n📊 Route Efficiency Summary:\n")
print(route_summary)

# Visualization
plt.figure(figsize=(10,5))
sns.barplot(
    x=route_summary.index,
    y='Time per Cost Unit',
    data=route_summary,
    palette="crest"
)
plt.title('Route Efficiency (Time / Cost)', fontsize=14, weight='bold')
plt.xlabel('Route', fontsize=12)
plt.ylabel('Days per Cost Unit', fontsize=12)
plt.xticks(rotation=45, ha='right')
plt.tight_layout()
plt.show()
```

📊 Route Efficiency Summary:

Routes	Avg Shipping Time (Days)	Avg Shipping Cost ($)	Time per Cost Unit
Route c	5.25	5.90	1.06
Route b	5.70	5.55	1.49
Route a	6.02	5.38	1.67

```
C:\Users\dell\AppData\Local\Temp\ipykernel_10008\4067178423.py:22: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v
0.14.0. Assign the `x` variable to `hue` and set `legend=False` for the same effe
ct.

  sns.barplot(
```



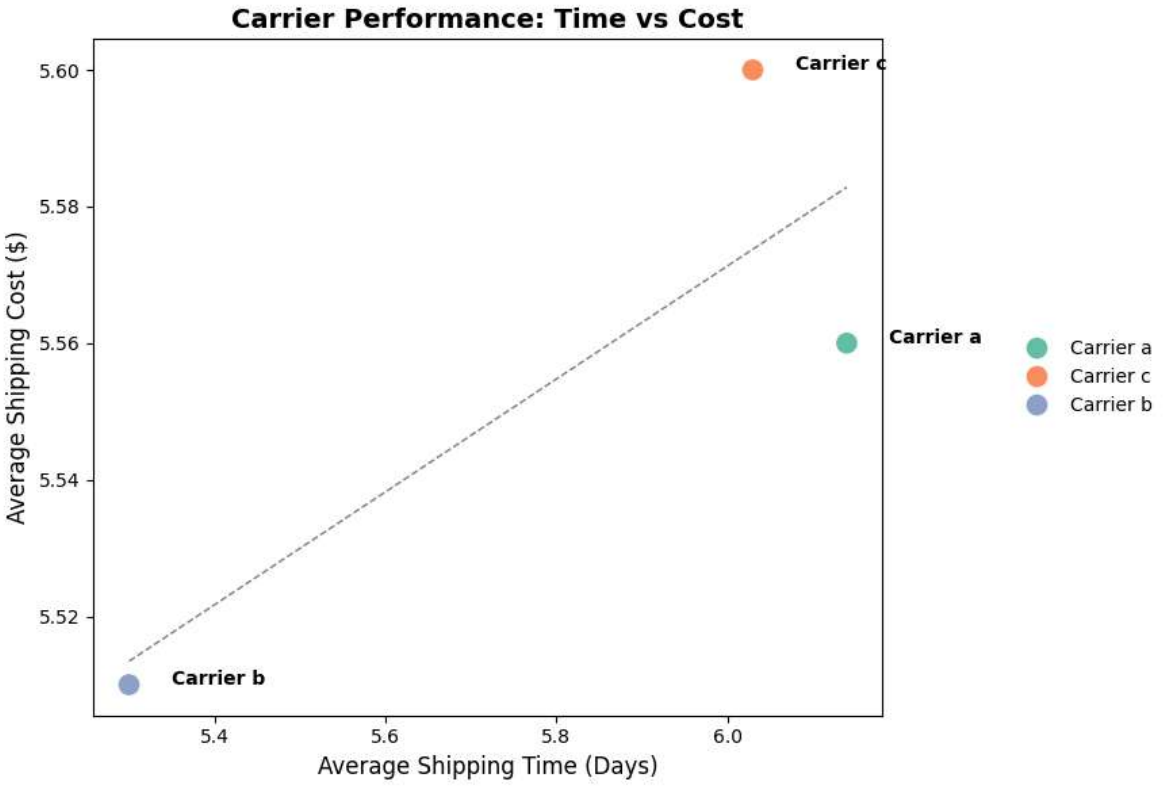
In [69]:
```
#3.4 Carrier Performance (Time vs Cost)
```

In [70]:
```
#  حساب المتوسط لكل Carrier
carrier_summary = df.groupby('Shipping Carriers').agg({
    'Shipping Times': 'mean',
    'Shipping Costs': 'mean'
}).round(2).reset_index()

#  Efficiency Score (كل ما يقل → Eff ++)
carrier_summary['Efficiency Score'] = (carrier_summary['Shipping Costs'] / carri
carrier_summary = carrier_summary.sort_values('Efficiency Score')

# عرض الجدول
print("📊 Average Carrier Performance (Time vs Cost):\n")
print(carrier_summary)

# Scatter Plot + Trendline + Labels
plt.figure(figsize=(9,6))
sns.regplot(
    data=carrier_summary,
    x='Shipping Times',
    y='Shipping Costs',
    scatter=False,
    ci=None,
    line_kws={'color':'gray', 'lw':1, 'ls':'--'}
)
```

```
sns.scatterplot(
    data=carrier_summary,
    x='Shipping Times',
    y='Shipping Costs',
    hue='Shipping Carriers',
    s=150,
    palette='Set2'
)

for i in range(len(carrier_summary)):
    plt.text(
        carrier_summary['Shipping Times'][i] + 0.05,
        carrier_summary['Shipping Costs'][i],
        carrier_summary['Shipping Carriers'][i],
        fontsize=10,
        weight='bold'
    )

plt.title('Carrier Performance: Time vs Cost', fontsize=14, weight='bold')
plt.xlabel('Average Shipping Time (Days)', fontsize=12)
plt.ylabel('Average Shipping Cost ($)', fontsize=12)
plt.legend(bbox_to_anchor=(1.15, 0.5), loc='center left', frameon=False)
plt.tight_layout()
plt.show()

# Heatmap
plt.figure(figsize=(6,4))
sns.heatmap(
    carrier_summary[['Shipping Times', 'Shipping Costs', 'Efficiency Score']].se
    annot=True,
    cmap='YlGnBu',
    fmt='.2f'
)
plt.title('Carrier Efficiency Overview', fontsize=13, weight='bold')
plt.ylabel('Shipping Carriers')
plt.tight_layout()
plt.show()
```

📊 Average Carrier Performance (Time vs Cost):

	Shipping Carriers	Shipping Times	Shipping Costs	Efficiency Score
0	Carrier a	6.14	5.56	0.91
2	Carrier c	6.03	5.60	0.93
1	Carrier b	5.30	5.51	1.04



In [71]:
```
#Manufacturing Analysis
```

In [72]:
```
#4.1 Manufacturing Lead Time vs Cost vs Production Volumes
```

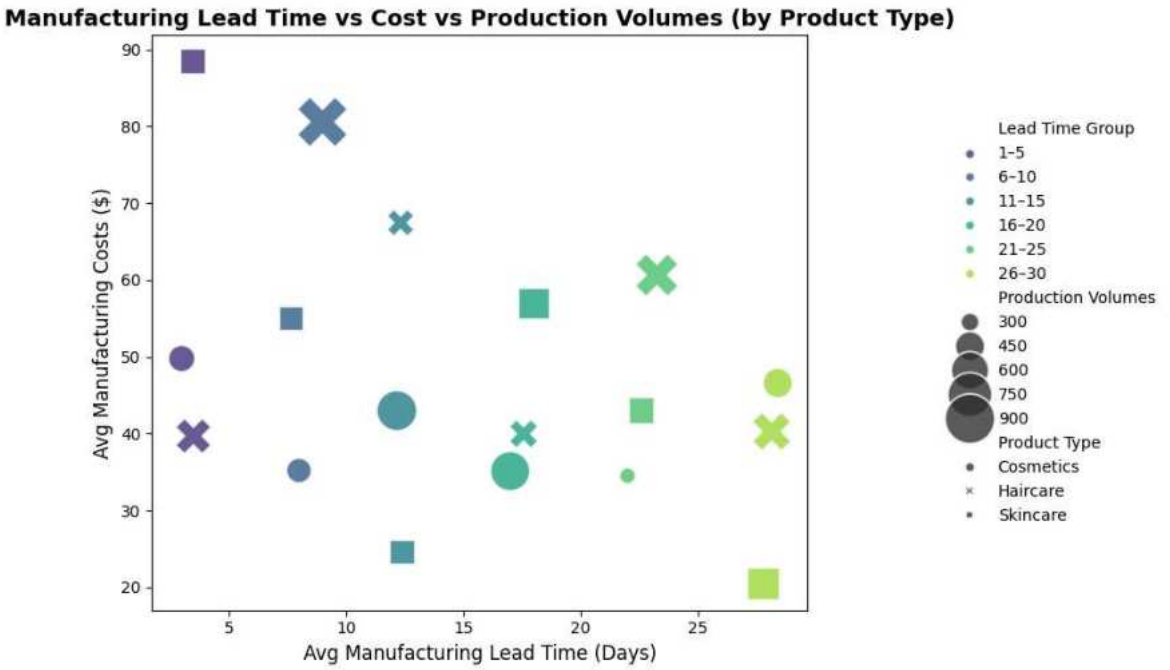
In [73]:
```
#  تقسيم Manufacturing Lead Time إلى فئات محددة
bins = [0, 5, 10, 15, 20, 25, 30]
labels = ['1-5', '6-10', '11-15', '16-20', '21-25', '26-30']
df['Lead Time Group'] = pd.cut(df['Manufacturing Lead Time'], bins=bins, labels=

#  حساب المتوسطات لكل نوع منتج
summary = df.groupby(['Product Type', 'Lead Time Group']).agg({
    'Manufacturing Lead Time': 'mean',
```

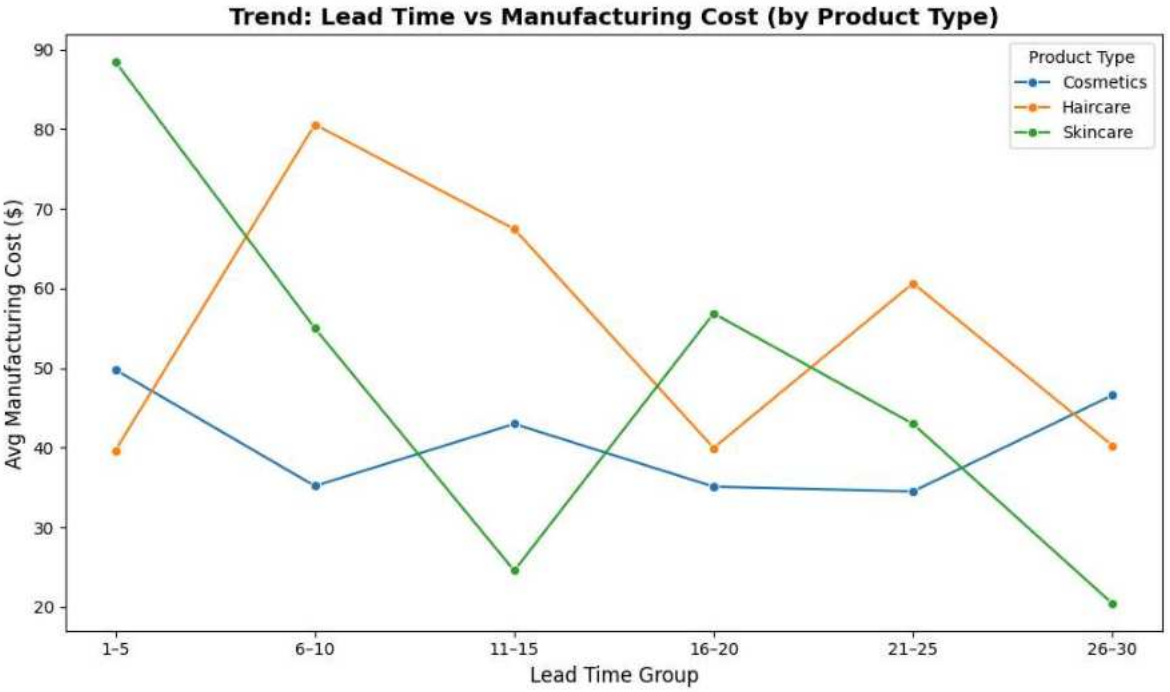
```
    'Manufacturing Costs': 'mean',
    'Production Volumes': 'mean'
}).round(2).reset_index()

summary['Production Volumes'] = summary['Production Volumes'].round().astype(int

print("📊 Manufacturing Summary by Product Type and Lead Time Group:\n")
print(summary)

# Visualization 1: Bubble Chart (لكل Product Type)
plt.figure(figsize=(10,6))
sns.scatterplot(
    data=summary,
    x='Manufacturing Lead Time',
    y='Manufacturing Costs',
    size='Production Volumes',
    sizes=(100, 1000),
    hue='Lead Time Group',
    style='Product Type',
    palette='viridis',
    alpha=0.8
)

plt.title('Manufacturing Lead Time vs Cost vs Production Volumes (by Product Typ
plt.xlabel('Avg Manufacturing Lead Time (Days)', fontsize=12)
plt.ylabel('Avg Manufacturing Costs ($)', fontsize=12)
plt.legend(bbox_to_anchor=(1.2, 0.5), loc='center left', frameon=False)
plt.tight_layout()
plt.show()

# Visualization 2: Line Chart توضح الاتجاه العام لكل نوع منتج
plt.figure(figsize=(10,6))
sns.lineplot(
    data=summary,
    x='Lead Time Group',
    y='Manufacturing Costs',
    hue='Product Type',
    marker='o'
)
plt.title('Trend: Lead Time vs Manufacturing Cost (by Product Type)', fontsize=1
plt.xlabel('Lead Time Group', fontsize=12)
plt.ylabel('Avg Manufacturing Cost ($)', fontsize=12)
plt.tight_layout()
plt.show()

# Correlation Analysis
corr_time_cost = df['Manufacturing Lead Time'].corr(df['Manufacturing Costs'])
corr_time_volume = df['Manufacturing Lead Time'].corr(df['Production Volumes'])
corr_cost_volume = df['Manufacturing Costs'].corr(df['Production Volumes'])

print("\n📈 Correlation Analysis (Overall):")
print(f"Lead Time ↔ Cost: {corr_time_cost:.3f}")
print(f"Lead Time ↔ Production Volume: {corr_time_volume:.3f}")
print(f"Cost ↔ Production Volume: {corr_cost_volume:.3f}")
```

```
C:\Users\dell\AppData\Local\Temp\ipykernel_10008\2375021959.py:7: FutureWarning:
The default of observed=False is deprecated and will be changed to True in a futu
re version of pandas. Pass observed=False to retain current behavior or observed=
True to adopt the future default and silence this warning.
  summary = df.groupby(['Product Type', 'Lead Time Group']).agg({
```

📊 Manufacturing Summary by Product Type and Lead Time Group:

	Product Type	Lead Time Group	Manufacturing Lead Time	Manufacturing Costs	Production Volumes
0	Cosmetics	1–5	3.00	49.78	406
1	Cosmetics	6–10	8.00	35.20	382
2	Cosmetics	11–15	12.17	42.99	662
3	Cosmetics	16–20	17.00	35.12	644
4	Cosmetics	21–25	22.00	34.52	278
5	Cosmetics	26–30	28.40	46.59	454
6	Haircare	1–5	3.50	39.69	562
7	Haircare	6–10	9.00	80.58	919
8	Haircare	11–15	12.33	67.45	414
9	Haircare	16–20	17.57	39.98	441
10	Haircare	21–25	23.25	60.65	728
11	Haircare	26–30	28.14	40.28	627
12	Skincare	1–5	3.50	88.44	560
13	Skincare	6–10	7.67	54.99	537
14	Skincare	11–15	12.40	24.57	549
15	Skincare	16–20	18.00	56.86	744
16	Skincare	21–25	22.60	42.99	593
17	Skincare	26–30	27.80	20.44	778





📈 Correlation Analysis (Overall):
Lead Time ↔ Cost: -0.158
Lead Time ↔ Production Volume: 0.184
Cost ↔ Production Volume: 0.051

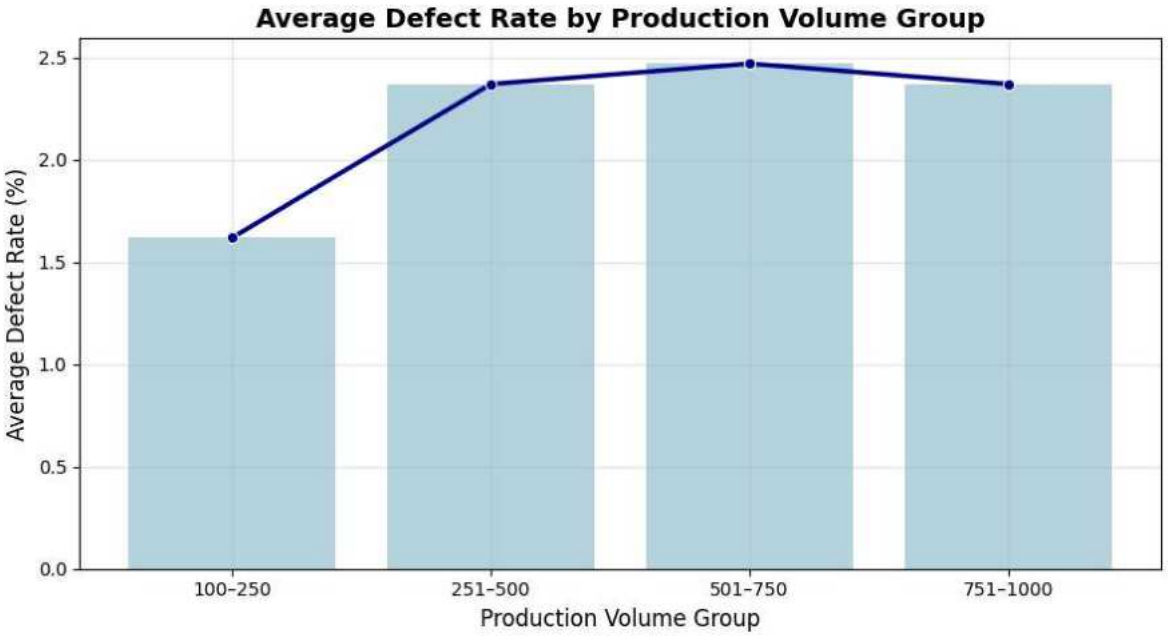
In [74]:
```
#4.2 Defect Rate vs Production Volume
```

In [75]:
```
#  تقسيم الـ Production Volumes
bins = [100, 250, 500, 750, 1000]
labels = ['100-250', '251-500', '501-750', '751-1000']
df['Production Volume Group'] = pd.cut(df['Production Volumes'], bins=bins, labe

# حساب المتوسط لكل جروب
summary = df.groupby('Production Volume Group').agg({
    'Defect Rates': 'mean'
}).round(2).reset_index()

print("📊 Summary Table:\n", summary)
```

```python
#  Visualization:
fig, ax1 = plt.subplots(figsize=(9,5))

# العمود الأساسي (Bar Chart)
sns.barplot(
    data=summary,
    x='Production Volume Group',
    y='Defect Rates',
    color='lightblue',
    ax=ax1
)

# الخط المتوسط (Line)
sns.lineplot(
    data=summary,
    x='Production Volume Group',
    y='Defect Rates',
    marker='o',
    linewidth=2.5,
    color='darkblue',
    ax=ax1
)

ax1.set_title('Average Defect Rate by Production Volume Group', fontsize=14, wei
ax1.set_xlabel('Production Volume Group', fontsize=12)
ax1.set_ylabel('Average Defect Rate (%)', fontsize=12)
ax1.grid(alpha=0.3)
plt.tight_layout()
plt.show()

# Correlation
corr = df['Production Volumes'].corr(df['Defect Rates'])
print(f"\n🔍 Correlation between Production Volumes and Defect Rates: {corr:.3f
```

```
📊 Summary Table:
  Production Volume Group  Defect Rates
0                 100-250          1.62
1                 251-500          2.37
2                 501-750          2.47
3                751-1000          2.37
```

```
C:\Users\dell\AppData\Local\Temp\ipykernel_10008\3399302648.py:7: FutureWarning:
The default of observed=False is deprecated and will be changed to True in a futu
re version of pandas. Pass observed=False to retain current behavior or observed=
True to adopt the future default and silence this warning.
  summary = df.groupby('Production Volume Group').agg({
```



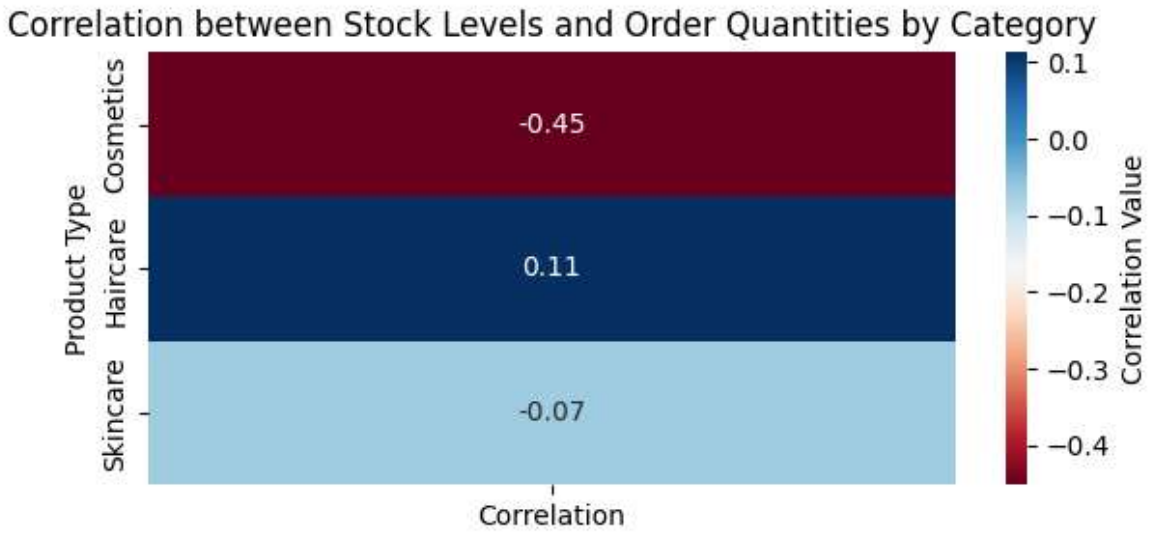
🔍 Correlation between Production Volumes and Defect Rates: 0.119

In [76]:
```
#Inventory & Warehouse Analysis
```

In [77]:
```
#5.1 Stock Levels vs Order Quantities
```

In [78]:
```
category_corr = df.groupby('Product Type').apply(
    lambda x: x['Stock Levels'].corr(x['Order Quantities'])
).reset_index(name='Correlation')

category_corr = category_corr.sort_values('Correlation', ascending=False)

plt.figure(figsize=(6,3))
sns.heatmap(
    category_corr.pivot_table(values='Correlation', index='Product Type'),
    annot=True, fmt='.2f', cmap='RdBu', cbar_kws={'label': 'Correlation Value'}
)
plt.title('Correlation between Stock Levels and Order Quantities by Category', f
plt.xlabel('')
plt.ylabel('Product Type')
plt.tight_layout()
plt.show()
```

```
C:\Users\dell\AppData\Local\Temp\ipykernel_10008\2095759728.py:1: FutureWarning:
DataFrameGroupBy.apply operated on the grouping columns. This behavior is depreca
ted, and in a future version of pandas the grouping columns will be excluded from
the operation. Either pass `include_groups=False` to exclude the groupings or exp
licitly select the grouping columns after groupby to silence this warning.
  category_corr = df.groupby('Product Type').apply(
```

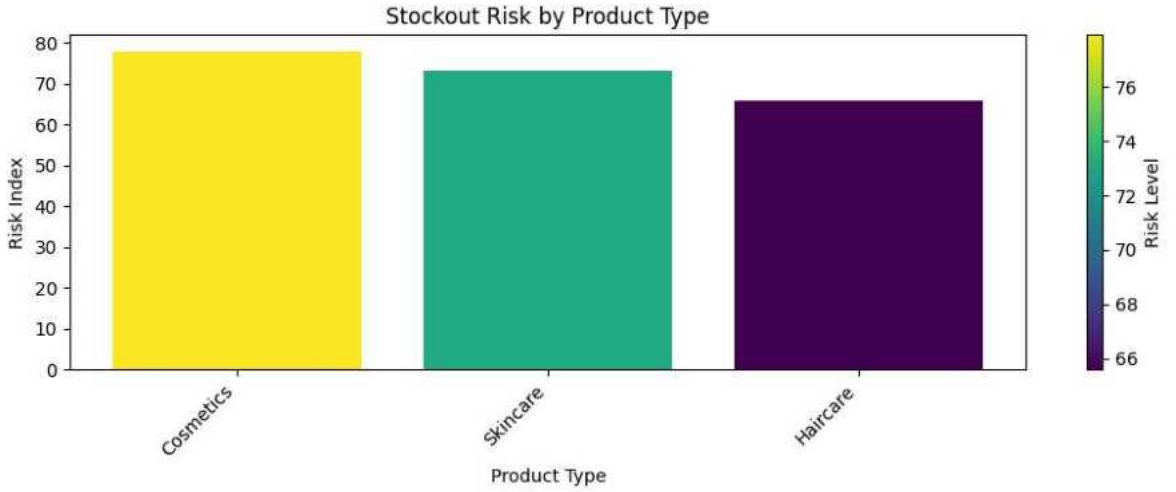


In [79]:
```
#5.2 Stockout Risk Index
```

In [80]:
```
df['Stockout Risk Index'] = df['Order Quantities'] * (df['Stock Levels'] / 100 +

# حساب المتوسط حسب نوع المنتج
stockout_risk = (
    df.groupby('Product Type')['Stockout Risk Index']
    .mean()
    .sort_values(ascending=False)
)
print(stockout_risk)

fig, ax = plt.subplots(figsize=(10, 4))

colors = plt.cm.viridis(
    (stockout_risk - stockout_risk.min()) / (stockout_risk.max() - stockout_risk
)

bars = ax.bar(stockout_risk.index, stockout_risk.values, color=colors)

ax.set_title('Stockout Risk by Product Type', fontsize=12)
ax.set_xlabel('Product Type', fontsize=10)
ax.set_ylabel('Risk Index', fontsize=10)
ax.set_xticklabels(stockout_risk.index, rotation=45, ha='right')

sm = plt.cm.ScalarMappable(
    cmap='viridis',
    norm=plt.Normalize(vmin=stockout_risk.min(), vmax=stockout_risk.max())
)
sm.set_array([])

fig.colorbar(sm, ax=ax, label='Risk Level')

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

```
Product Type
Cosmetics    77.908077
Skincare      73.11975
Haircare     65.592059
Name: Stockout Risk Index, dtype: Float64
```

```
C:\Users\dell\AppData\Local\Temp\ipykernel_10008\1169210866.py:22: UserWarning: s
et_ticklabels() should only be used with a fixed number of ticks, i.e. after set_
ticks() or using a FixedLocator.
  ax.set_xticklabels(stockout_risk.index, rotation=45, ha='right')
```

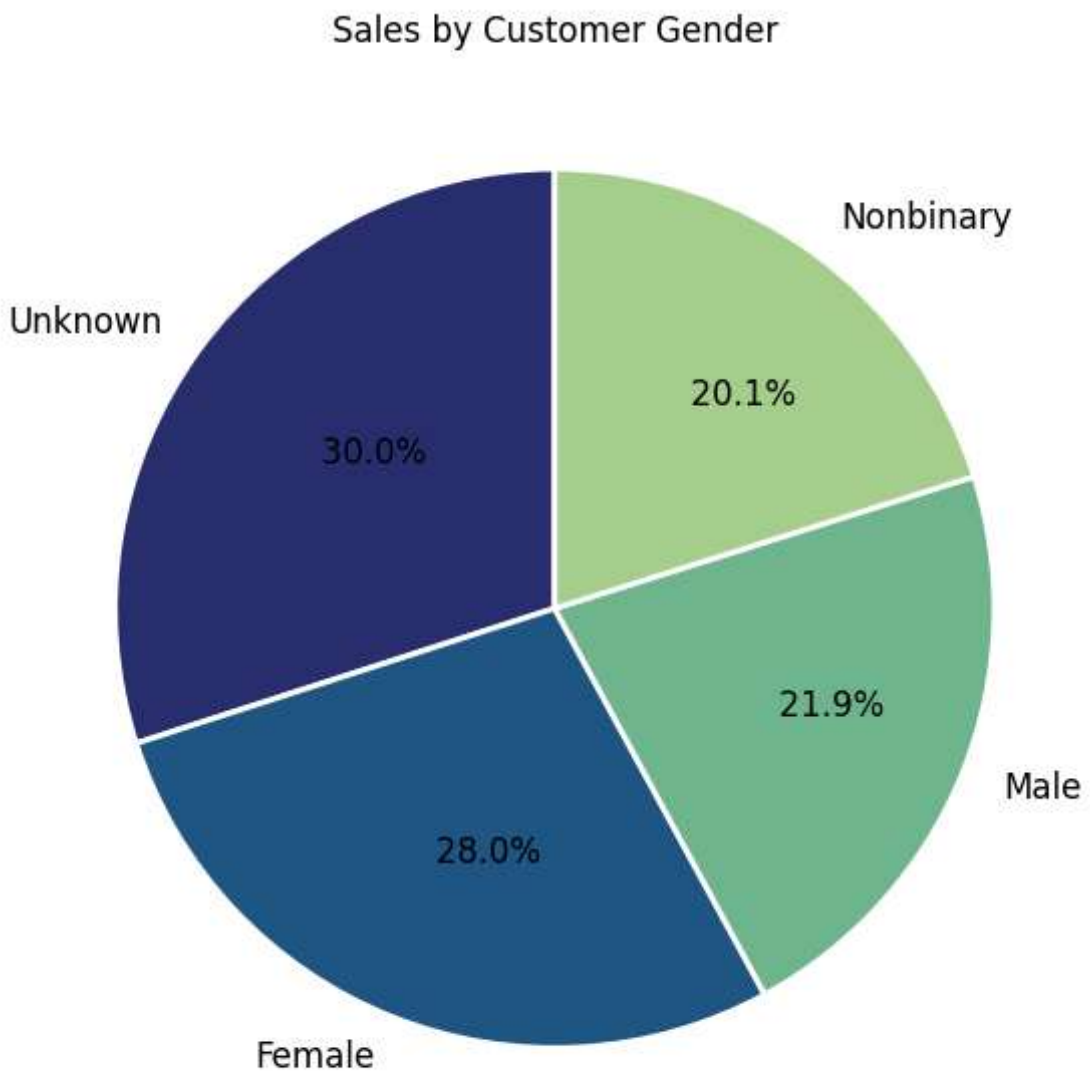


In [81]:
```
#Customer Insights
```

In [82]:
```
#6.1 Sales by Customer Gender
```

In [84]:
```
sales_by_gender = df.groupby('Customer Gender')['Revenue Generated'].sum().sort_
print(sales_by_gender)

cmap = plt.get_cmap('crest')

normalized_values = (sales_by_gender - sales_by_gender.min()) / (sales_by_gender
colors = cmap(normalized_values)

sales_by_gender.plot(
    kind='pie',
    title='Sales by Customer Gender',
    autopct='%10.1f%%',
    figsize=(6, 6),
    colors=colors,
    startangle=90,
    textprops={'fontsize': 12, 'color': 'black'},
    wedgeprops={'edgecolor': 'white', 'linewidth': 2}
)
plt.ylabel('')
plt.tight_layout()
plt.show()
```

```
Customer Gender
Unknown      173090.14
Female       161514.49
Male         126634.42
Nonbinary    116365.81
Name: Revenue Generated, dtype: float64
```



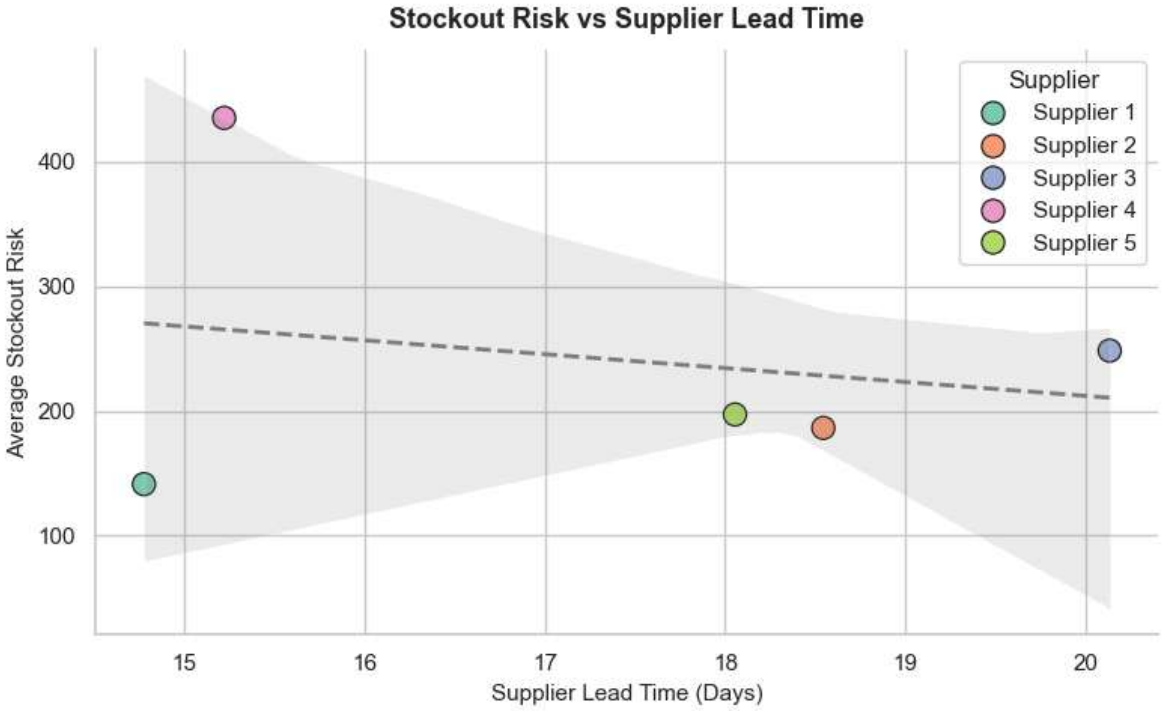
In [85]:
```
#Efficiency & Risk Analysis
```

In [86]:
```
#7.1 Stockout Risk vs Supplier Lead Time
```

In [87]:
```
stockout_vs_lead = df.groupby('Supplier Name')[['Stock out Risk', 'Supplier Lead
print(stockout_vs_lead)

# Visualization
plt.figure(figsize=(8,5))
sns.set(style='whitegrid')

sns.scatterplot(
    data=stockout_vs_lead,
    x='Supplier Lead Time',
    y='Stock out Risk',
    hue='Supplier Name',
    palette='Set2',
    s=120,
    edgecolor='black',
    alpha=0.85
)

sns.regplot(
```

```
    data=stockout_vs_lead,
    x='Supplier Lead Time',
    y='Stock out Risk',
    scatter=False,
    color='gray',
    line_kws={'linewidth':2, 'linestyle':'--'}
)

plt.title('Stockout Risk vs Supplier Lead Time', fontsize=13, fontweight='bold',
plt.xlabel('Supplier Lead Time (Days)', fontsize=11)
plt.ylabel('Average Stockout Risk', fontsize=11)

plt.legend(title='Supplier', loc='upper right', frameon=True)
sns.despine()
plt.tight_layout()
plt.show()
```

	Supplier Name	Stock out Risk	Supplier Lead Time
0	Supplier 1	141.259259	14.777778
1	Supplier 2	186.409091	18.545455
2	Supplier 3	248.466667	20.133333
3	Supplier 4	435.277778	15.222222
4	Supplier 5	197.166667	18.055556

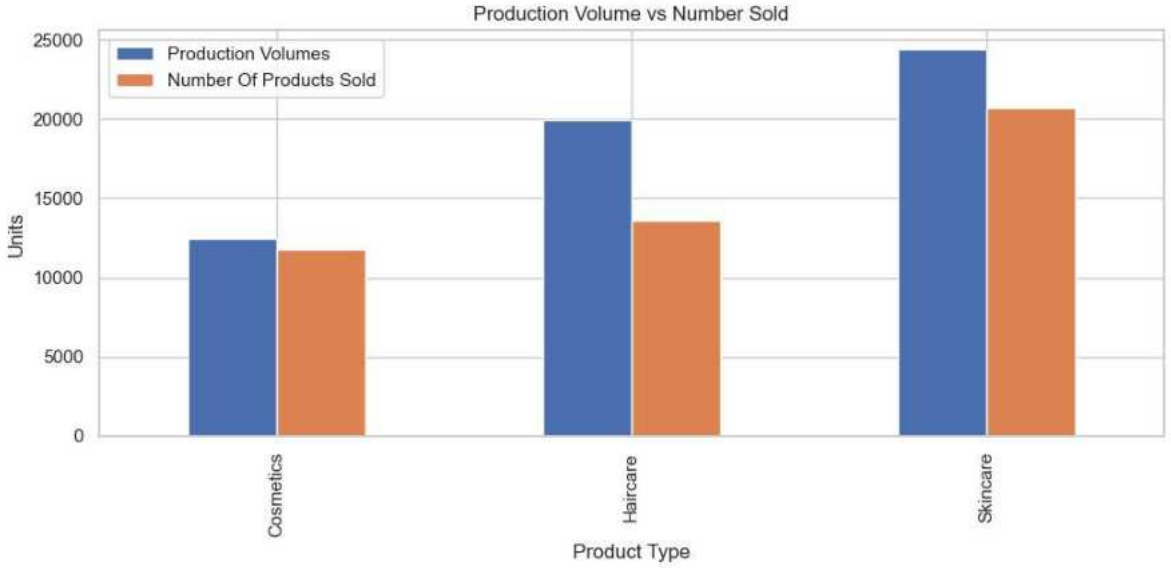


In [88]:
```
#Cross-Functional Analysis
```

In [89]:
```
#8.1 Production Volume vs Sales
```

In [90]:
```
prod_sales = df.groupby('Product Type')[['Production Volumes','Number Of Product
print(prod_sales)

# Visualization
prod_sales.set_index('Product Type').plot(kind='bar', title='Production Volume v
plt.ylabel('Units')
plt.tight_layout()
plt.show()
```

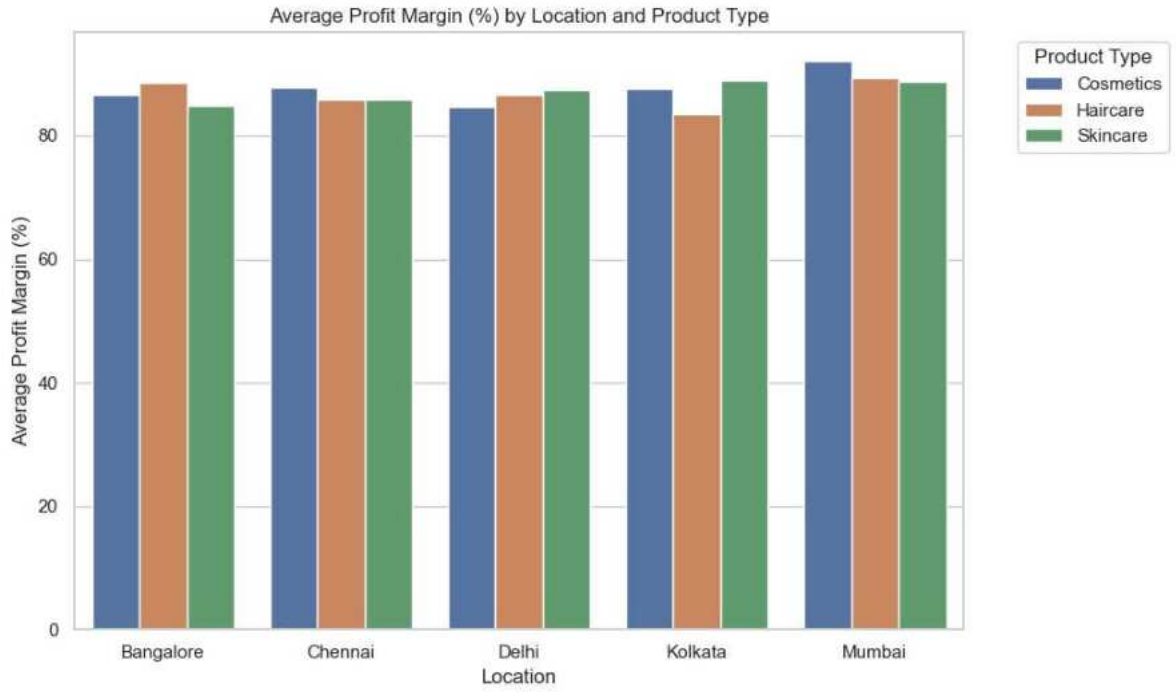
	Product Type	Production Volumes	Number Of Products Sold
0	Cosmetics	12461	11757
1	Haircare	19957	13611
2	Skincare	24366	20731



In [91]:
```
#8.2 Profit Margin vs Location
```

In [92]:
```
df['Profit Margin'] = (df['Profit'] / (df['Revenue Generated'] + 1e-6)) * 100

margin_loc = (
    df.groupby(['Product Type', 'Location'])['Profit Margin']
    .mean()
    .reset_index()
)

print(margin_loc)

# Visualization
plt.figure(figsize=(10,6))
sns.barplot(
    data=margin_loc,
    x='Location',
    y='Profit Margin',
    hue='Product Type',
    errorbar=None
)
plt.title('Average Profit Margin (%) by Location and Product Type')
plt.xlabel('Location')
plt.ylabel('Average Profit Margin (%)')
plt.legend(title='Product Type', bbox_to_anchor=(1.05, 1), loc='upper left')
plt.tight_layout()
plt.show()
```

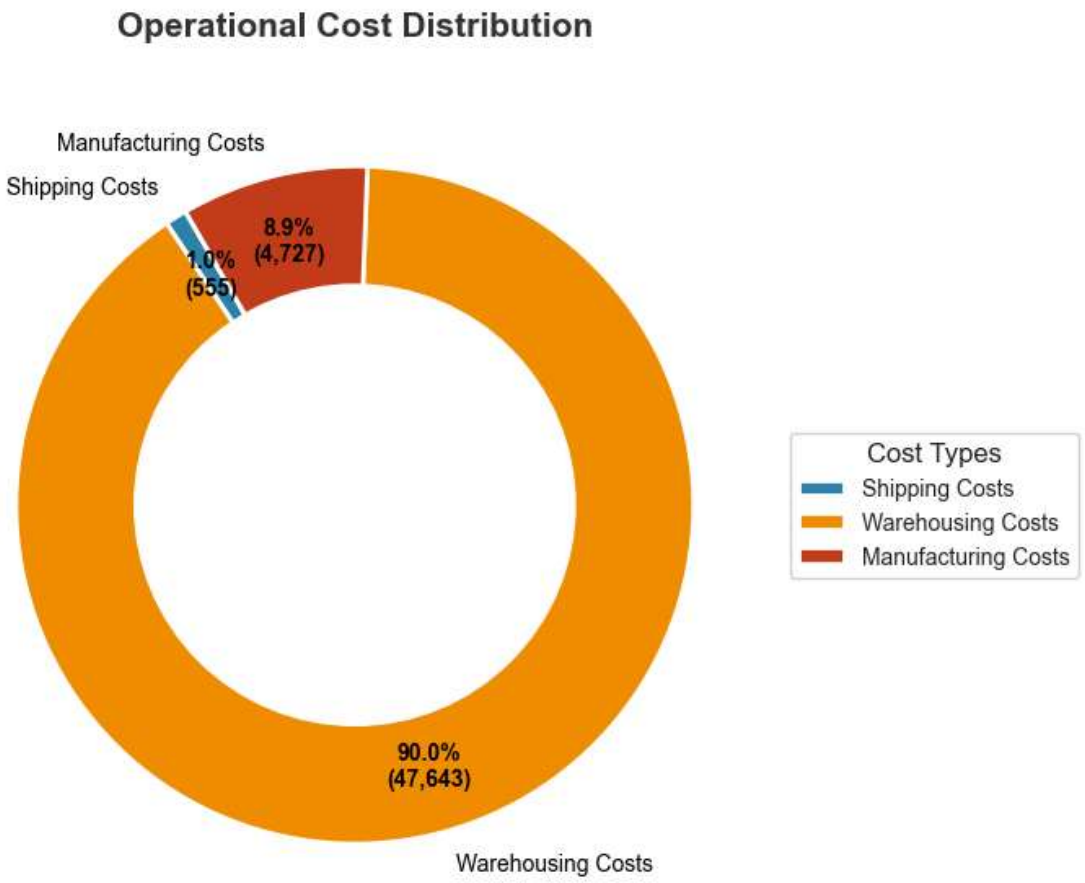
	Product Type	Location	Profit Margin
0	Cosmetics	Bangalore	86.620018
1	Cosmetics	Chennai	87.846746
2	Cosmetics	Delhi	84.693012
3	Cosmetics	Kolkata	87.602771
4	Cosmetics	Mumbai	92.079421
5	Haircare	Bangalore	88.563774
6	Haircare	Chennai	85.899502
7	Haircare	Delhi	86.659572
8	Haircare	Kolkata	83.507351
9	Haircare	Mumbai	89.362945
10	Skincare	Bangalore	84.952659
11	Skincare	Chennai	85.843412
12	Skincare	Delhi	87.319519
13	Skincare	Kolkata	89.020078
14	Skincare	Mumbai	88.747884



In [93]:
```
#8.3 Cost Breakdown (Operational Cost Distribution)
```

In [94]:
```
costs = {
    'Shipping Costs': df['Shipping Costs'].sum(),
    'Warehousing Costs': df['Warehousing Costs'].sum(),
    'Manufacturing Costs': df['Manufacturing Costs'].sum()
}

total_cost = sum(costs.values())

labels = list(costs.keys())
sizes = list(costs.values())
colors = ['#2E86AB', '#F18F01', '#C73E1D']

fig, ax = plt.subplots(figsize=(7,6))
wedges, texts, autotexts = ax.pie(
    sizes,
    labels=labels,
    autopct=lambda p: f'{p:.1f}%\n({p*total_cost/100:,.0f})',
    startangle=120,
    colors=colors,
    textprops={'fontsize':10, 'color':'black'},
```

```
    pctdistance=0.8,
    wedgeprops={'edgecolor':'white', 'linewidth':2}
)

for t in autotexts:
    t.set_fontweight('bold')
    t.set_fontsize(10)

centre_circle = plt.Circle((0,0), 0.65, fc='white')
fig.gca().add_artist(centre_circle)

plt.title('Operational Cost Distribution', fontsize=15, fontweight='bold', pad=2

plt.legend(
    wedges, labels,
    title="Cost Types",
    loc="center left",
    bbox_to_anchor=(1, 0, 0.5, 1),
    fontsize=10
)
plt.tight_layout()
plt.show()
```

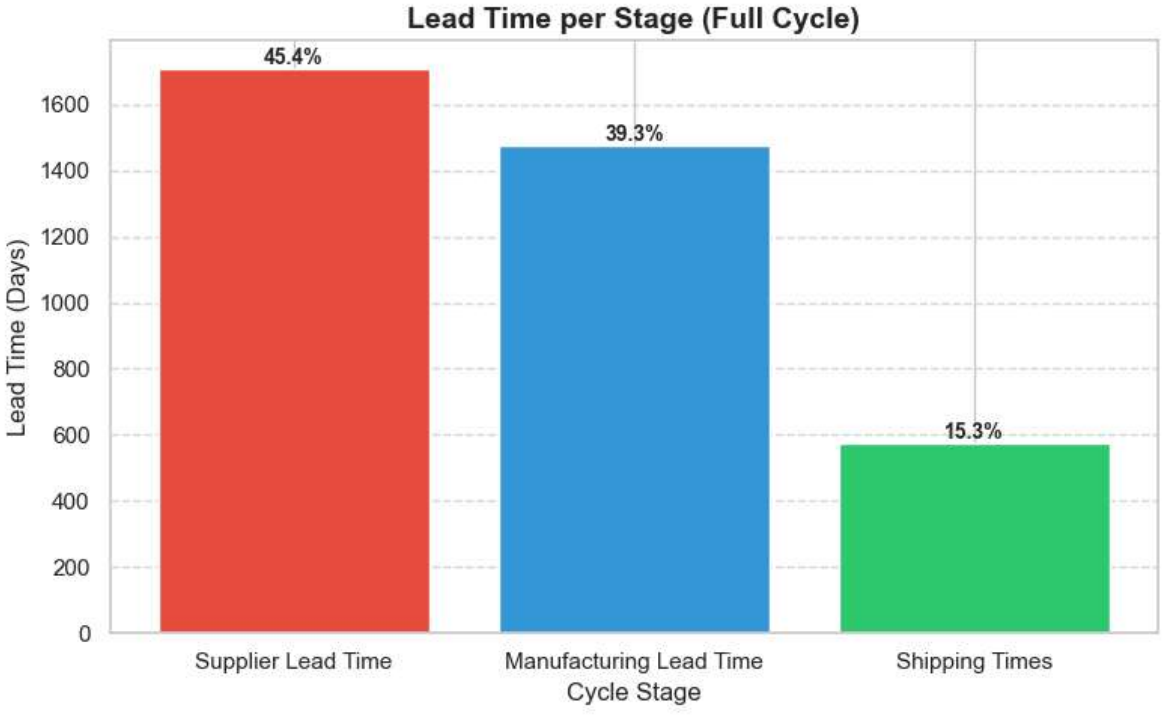


In [95]:
```
#8.4 Full Cycle Time (Supplier → Manufacturing → Shipping → Customer)
```

In [96]:
```
# حساب إجمالي الوقت لكل مرحلة
lead_times = {
    'Supplier Lead Time': df['Supplier Lead Time'].sum(),
    'Manufacturing Lead Time': df['Manufacturing Lead Time'].sum(),
    'Shipping Times': df['Shipping Times'].sum()
}
```

```
# تحويلها إلى DataFrame
lead_df = pd.DataFrame(list(lead_times.items()), columns=['Stage', 'Full Lead Ti

# حساب الإجمالي الكلي
total_lead_time = lead_df['Full Lead Time (Days)'].sum()

# حساب النسبة المئوية من الإجمالي
lead_df['% of Total Cycle Time'] = (lead_df['Full Lead Time (Days)'] / total_lea

# ترتيب تنازلي حسب القيمة
lead_df = lead_df.sort_values(by='Full Lead Time (Days)', ascending=False)

# عرض النتائج
print(lead_df)

#Visualization
plt.figure(figsize=(8,5))
bars = plt.bar(lead_df['Stage'], lead_df['Full Lead Time (Days)'], color=['#E74C
plt.title('Lead Time per Stage (Full Cycle)', fontsize=14, fontweight='bold')
plt.xlabel('Cycle Stage')
plt.ylabel('Lead Time (Days)')
plt.grid(axis='y', linestyle='--', alpha=0.7)

for bar, pct in zip(bars, lead_df['% of Total Cycle Time']):
    plt.text(bar.get_x() + bar.get_width()/2, bar.get_height(), f"{pct:.1f}%",
             ha='center', va='bottom', fontsize=10, fontweight='bold')

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

	Stage	Full Lead Time (Days)	% of Total Cycle Time
0	Supplier Lead Time	1708	45.425532
1	Manufacturing Lead Time	1477	39.281915
2	Shipping Times	575	15.292553



In [ ]: