In [19]:
```
import pandas as pd
import os
import glob
import logging
from pathlib import Path
import itertools
```

In [20]:
```
# import file
file="G:\\Projects\\DataAnalysis\\SalesDataAnalysis\\ProcessedData\\Consolidated2019Sales.csv"
df = pd.read_csv(file)
```

In [21]:
```
 # Create input and output directory
input_dir = Path('G:\\Projects\\DataAnalysis\\SalesDataAnalysis\\ProcessedData\\ProductCombinations')
output_dir = Path('G:\\Projects\\DataAnalysis\\SalesDataAnalysis\\ProcessedData\\ProductAnalysis')
output_dir.mkdir(parents=True, exist_ok=True)
```

In [22]:
```
# Calculate revenue for each transaction
df['Revenue'] = (df['Quantity'] * df['UnitPrice']).round(2)


# 1. Overall Product Performance
product_summary = df.groupby('Product').agg({
            'Order ID': 'nunique',  # Number of orders
            'Quantity': 'sum',      # Total units sold
            'Revenue': 'sum',       # Total revenue
            'City': 'nunique'       # Number of cities sold in
        }).reset_index()

# Rename columns
product_summary = product_summary.rename(columns={
            'Order ID': 'Number of Orders',
            'Quantity': 'Total Units Sold',
            'City': 'Cities Sold In'
        })

# Calculate average metrics
product_summary['Average Order Size'] = (product_summary['Total Units Sold'] /
                                               product_summary['Number of Orders']).round(2)
product_summary['Average Unit Revenue'] = (product_summary['Revenue'] /
                                                 product_summary['Total Units Sold']).round(2)
product_summary['Average Order Revenue'] = (product_summary['Revenue'] /
                                                  product_summary['Number of Orders']).round(2)

# Sort by revenue
product_summary = product_summary.sort_values('Revenue', ascending=False)

# Save detailed product summary
product_summary.to_csv(output_dir / 'product_performance_summary.csv', index=False)
```

In [23]:

```
# 2. Product Sales by City
city_product_summary = df.pivot_table(
            index='Product',
            columns='City',
            values='Quantity',
            aggfunc='sum',
            fill_value=0
        ).reset_index()

city_product_summary.to_csv(output_dir / 'product_sales_by_city.csv', index=False)

# 3. Monthly Product Performance
df['Month'] = pd.to_datetime(df['OrderDate']).dt.strftime('%Y-%m')
monthly_product = df.pivot_table(
            index='Product',
            columns='Month',
            values='Quantity',
            aggfunc='sum',
            fill_value=0
        ).reset_index()

monthly_product.to_csv(output_dir / 'monthly_product_sales.csv', index=False)

# 4. Product Correlations
product_correlations = df.pivot_table(
            index='Order ID',
            columns='Product',
            values='Quantity',
            aggfunc='sum',
            fill_value=0
        ).corr()
```

```
product_correlations.to_csv(output_dir / 'product_correlations.csv')
```

In [24]:

```
# Group orders to get product combinations
order_products = df.groupby('Order ID')['Product'].agg(list).reset_index()

# Function to get combinations and their frequencies
def get_combination_stats(combinations):
    combo_stats = []
    for combo in combinations:
        # Count orders containing this combination
        orders_with_combo = order_products['Product'].apply(
                    lambda x: all(item in x for item in combo)
                ).sum()

        if orders_with_combo > 0:
                    # Get all orders containing this combination
            combo_orders = df[df['Order ID'].isin(
                        order_products[order_products['Product'].apply(
                            lambda x: all(item in x for item in combo)
                        )]['Order ID']
                    )]

            # Calculate statistics
            total_revenue = combo_orders['Revenue'].sum()
            avg_order_value = total_revenue / orders_with_combo

            combo_stats.append({
                        'Combination': ' + '.join(combo),
                        'Number of Orders': orders_with_combo,
                        'Total Revenue': total_revenue,
                        'Average Order Value': avg_order_value,
                        'Products in Combination': len(combo)
                    })

    return pd.DataFrame(combo_stats)
```

In [25]:

```
 # Analyze 2-product combinations
product_pairs = list(itertools.combinations(df['Product'].unique(), 2))
```

```
pair_stats = get_combination_stats(product_pairs)

# Analyze 3-product combinations
product_triplets = list(itertools.combinations(df['Product'].unique(), 3))
triplet_stats = get_combination_stats(product_triplets)

# Sort by number of orders and filter for significant combinations
min_orders = 5  # Minimum number of orders to be considered significant

pair_stats = pair_stats[pair_stats['Number of Orders'] >= min_orders].sort_values('Number of Orders', ascending=Fals

triplet_stats = triplet_stats[triplet_stats['Number of Orders'] >= min_orders].sort_values('Number of Orders', ascend

# Save results
pair_stats.to_csv(output_dir / 'product_pairs_analysis.csv', index=False)
triplet_stats.to_csv(output_dir / 'product_triplets_analysis.csv', index=False)
```

In [26]:

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

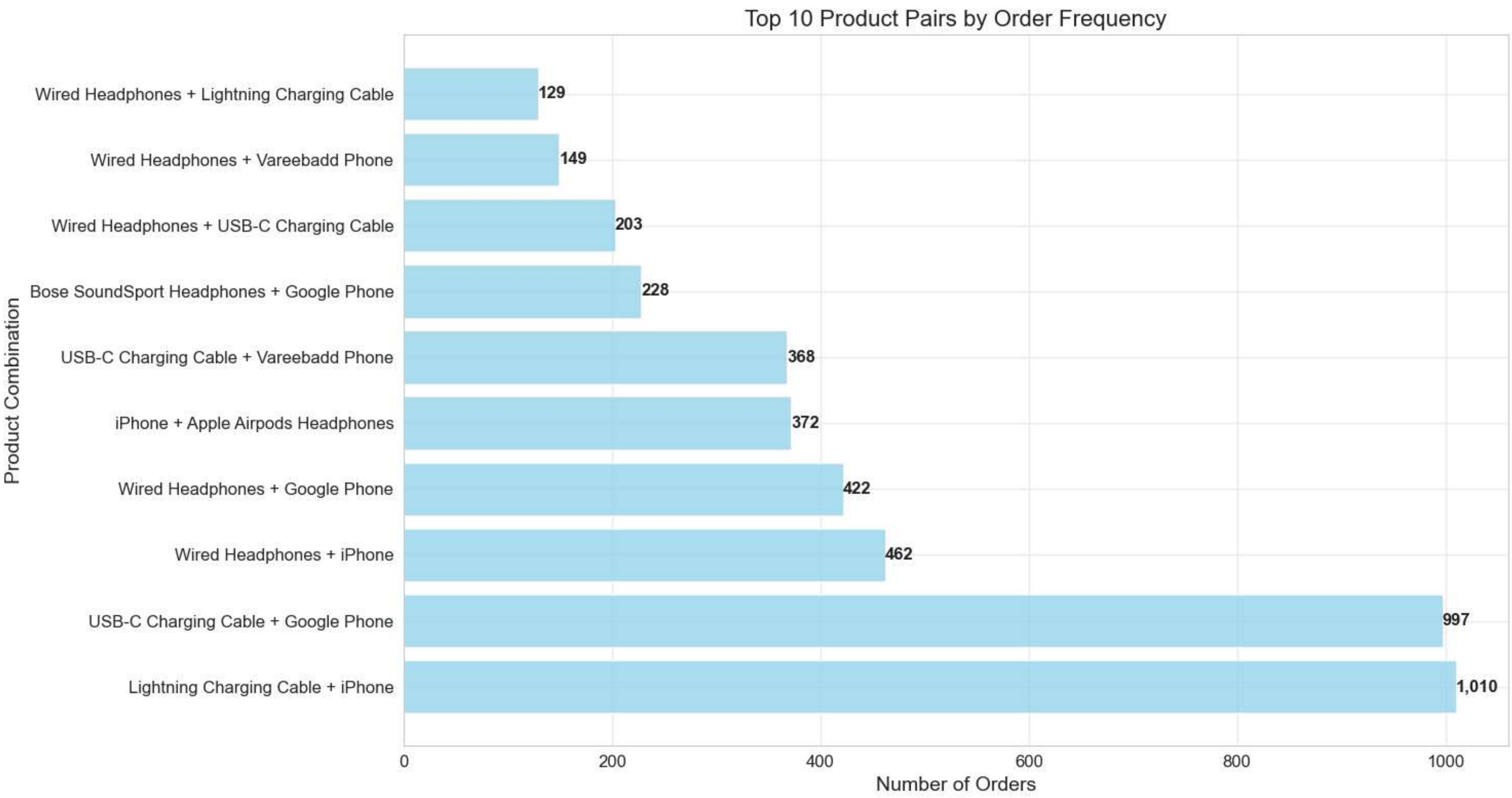
In [27]:

```
# Set style parameters
plt.style.use('default')
plt.rcParams.update({
            'figure.figsize': (15, 8),
            'figure.facecolor': 'white',
            'axes.facecolor': 'white',
            'axes.grid': True,
            'grid.alpha': 0.3,
            'font.family': 'sans-serif',
            'font.size': 12,
            'axes.labelsize': 14,
            'axes.titlesize': 16
        })
```

In [29]:

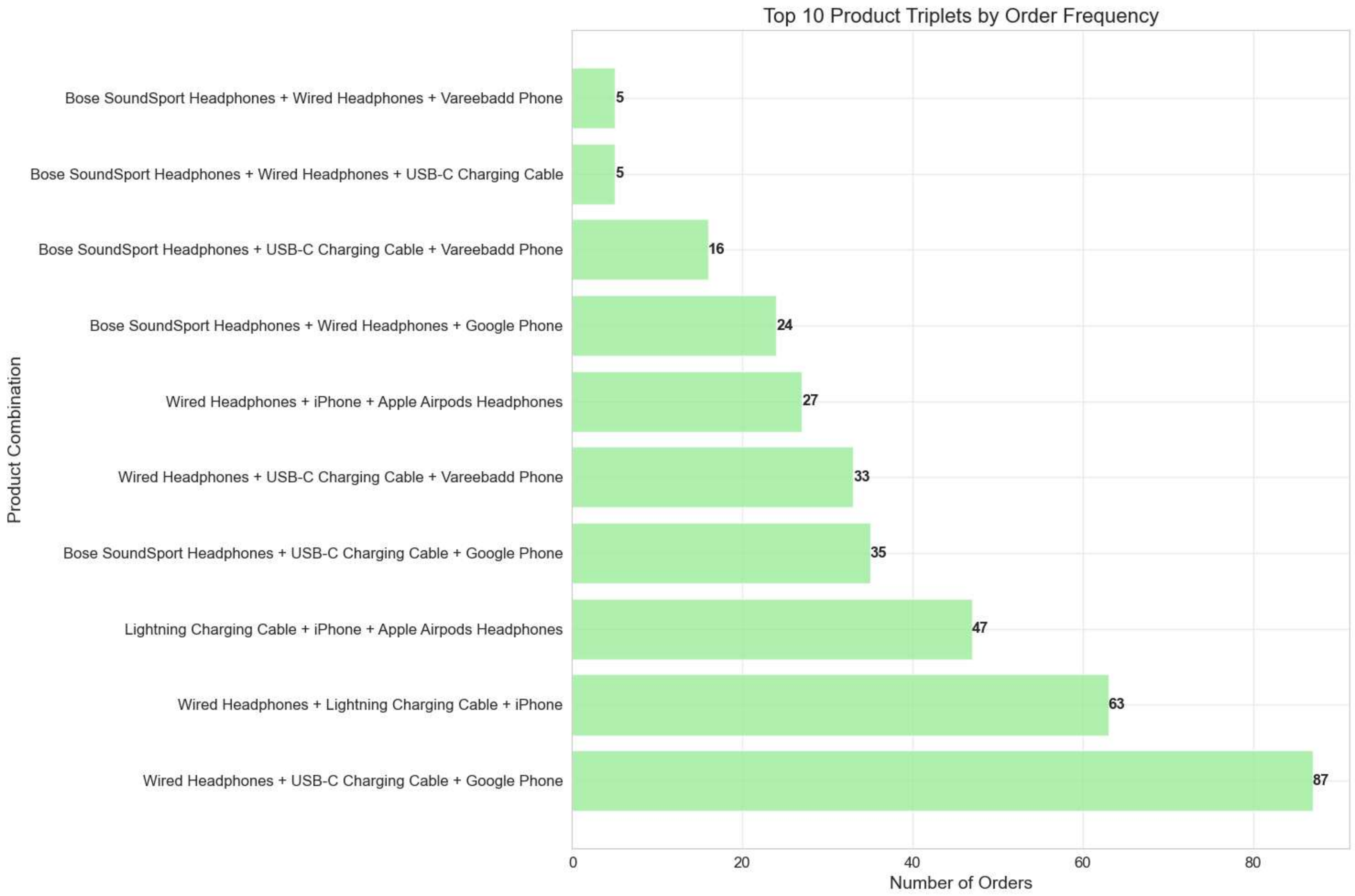
```
pair_stats = pd.read_csv(output_dir / 'product_pairs_analysis.csv')
triplet_stats = pd.read_csv(output_dir / 'product_triplets_analysis.csv')


# Set style parameters
plt.style.use('default')
plt.rcParams.update({
```

```
            'figure.figsize': (15, 8),
            'figure.facecolor': 'white',
            'axes.facecolor': 'white',
            'axes.grid': True,
            'grid.alpha': 0.3,
            'font.family': 'sans-serif',
            'font.size': 12,
            'axes.labelsize': 14,
            'axes.titlesize': 16
        })



# Set Seaborn style
sns.set_style("whitegrid")

# 1. Top 10 Product Pairs
plt.figure(figsize=(15, 8))
top_pairs = pair_stats.head(10)
bars = plt.barh(top_pairs['Combination'], top_pairs['Number of Orders'],
                       color='skyblue', alpha=0.7)
plt.title('Top 10 Product Pairs by Order Frequency')
plt.xlabel('Number of Orders')
plt.ylabel('Product Combination')

# Add value labels
for bar in bars:
    width = bar.get_width()
    plt.text(width, bar.get_y() + bar.get_height()/2,f'{int(width):,}',ha='left', va='center', fontweight='bold')

plt.tight_layout()
plt.savefig(output_dir / 'top_product_pairs.png', dpi=300, bbox_inches='tight')
plt.show()
plt.close()
```



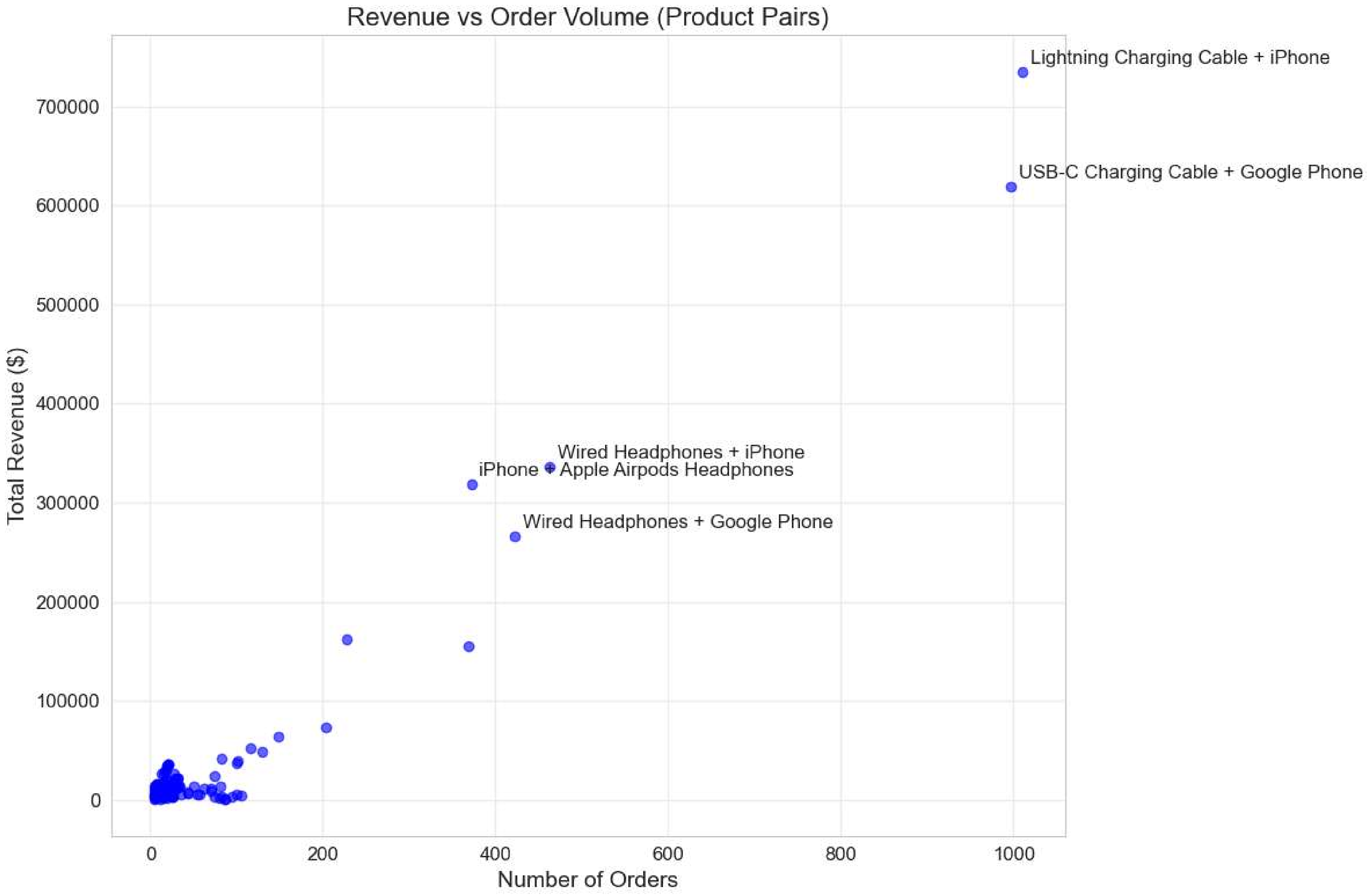
In [30]:

```python
# 2. Top 10 Product Triplets
plt.figure(figsize=(15, 10))
top_triplets = triplet_stats.head(10)
bars = plt.barh(top_triplets['Combination'], top_triplets['Number of Orders'],
                       color='lightgreen', alpha=0.7)
plt.title('Top 10 Product Triplets by Order Frequency')
plt.xlabel('Number of Orders')
plt.ylabel('Product Combination')

# Add value labels
for bar in bars:
    width = bar.get_width()
    plt.text(width, bar.get_y() + bar.get_height()/2,
                f'{int(width):,}',
                    ha='left', va='center', fontweight='bold')

plt.tight_layout()
plt.savefig(output_dir / 'top_product_triplets.png', dpi=300, bbox_inches='tight')
plt.show()
plt.close()
```



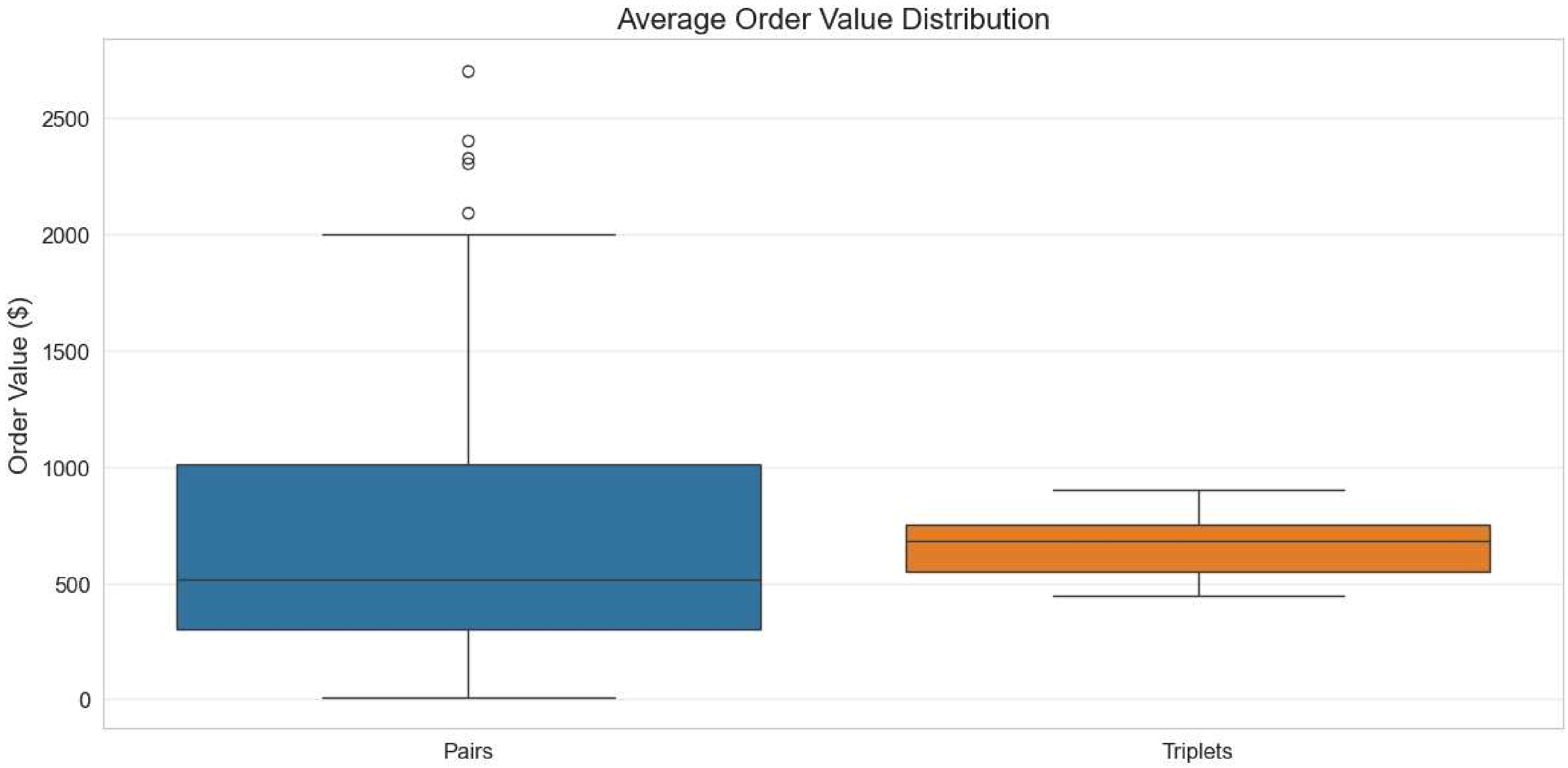
In [31]:

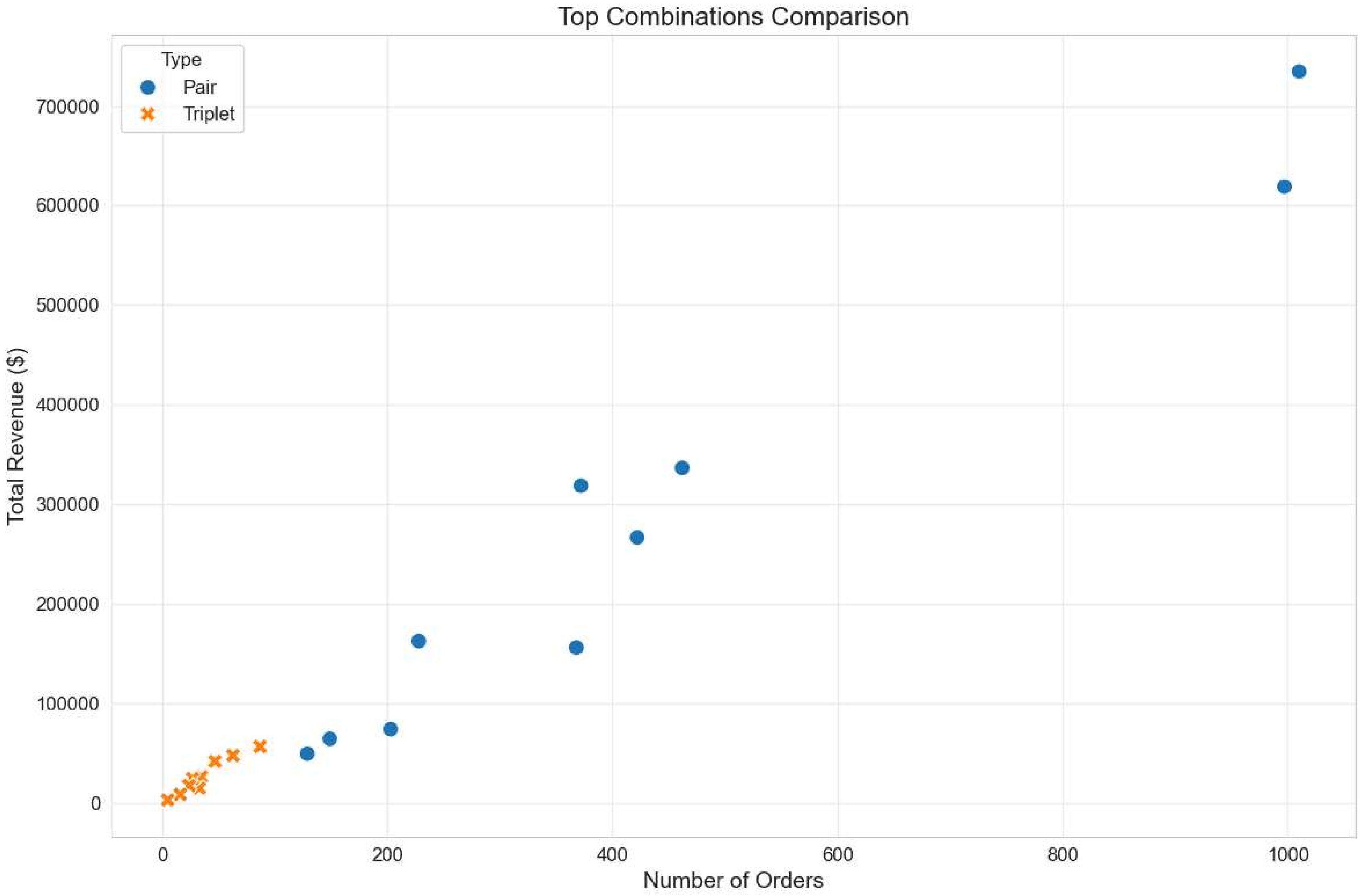
```python
# 3. Revenue vs Orders Scatter Plot (Pairs)
plt.figure(figsize=(12, 8))
plt.scatter(pair_stats['Number of Orders'], pair_stats['Total Revenue'],
                   alpha=0.6, c='blue')
plt.title('Revenue vs Order Volume (Product Pairs)')
plt.xlabel('Number of Orders')
plt.ylabel('Total Revenue ($)')

# Add annotations for top 5 points
top_5_pairs = pair_stats.nlargest(5, 'Total Revenue')
for _, row in top_5_pairs.iterrows():
    plt.annotate(row['Combination'],
                        (row['Number of Orders'], row['Total Revenue']),
                        xytext=(5, 5), textcoords='offset points')

plt.tight_layout()
plt.savefig(output_dir / 'pairs_revenue_scatter.png', dpi=300, bbox_inches='tight')
plt.show()
plt.close()
```



In [33]:

```
# 4. Average Order Value Comparison
plt.figure(figsize=(12, 6))
data = {
            'Pairs': pair_stats['Average Order Value'],
            'Triplets': triplet_stats['Average Order Value']
        }
sns.boxplot(data=data)
plt.title('Average Order Value Distribution')
plt.ylabel('Order Value ($)')

plt.tight_layout()
plt.savefig(output_dir / 'order_value_comparison.png', dpi=300, bbox_inches='tight')
plt.show()
plt.close()

# 6. Top Combinations Matrix
plt.figure(figsize=(12, 8))
top_10_matrix = pd.DataFrame({
            'Combination': pd.concat([top_pairs['Combination'], top_triplets['Combination']]),
            'Orders': pd.concat([top_pairs['Number of Orders'], top_triplets['Number of Orders']]),
            'Revenue': pd.concat([top_pairs['Total Revenue'], top_triplets['Total Revenue']]),
            'Type': ['Pair']*10 + ['Triplet']*10
        })

sns.scatterplot(data=top_10_matrix, x='Orders', y='Revenue',
                       hue='Type', style='Type', s=100)
plt.title('Top Combinations Comparison')
plt.xlabel('Number of Orders')
plt.ylabel('Total Revenue ($)')

plt.tight_layout()
plt.savefig(output_dir / 'top_combinations_matrix.png', dpi=300, bbox_inches='tight')
plt.show()
plt.close()
```

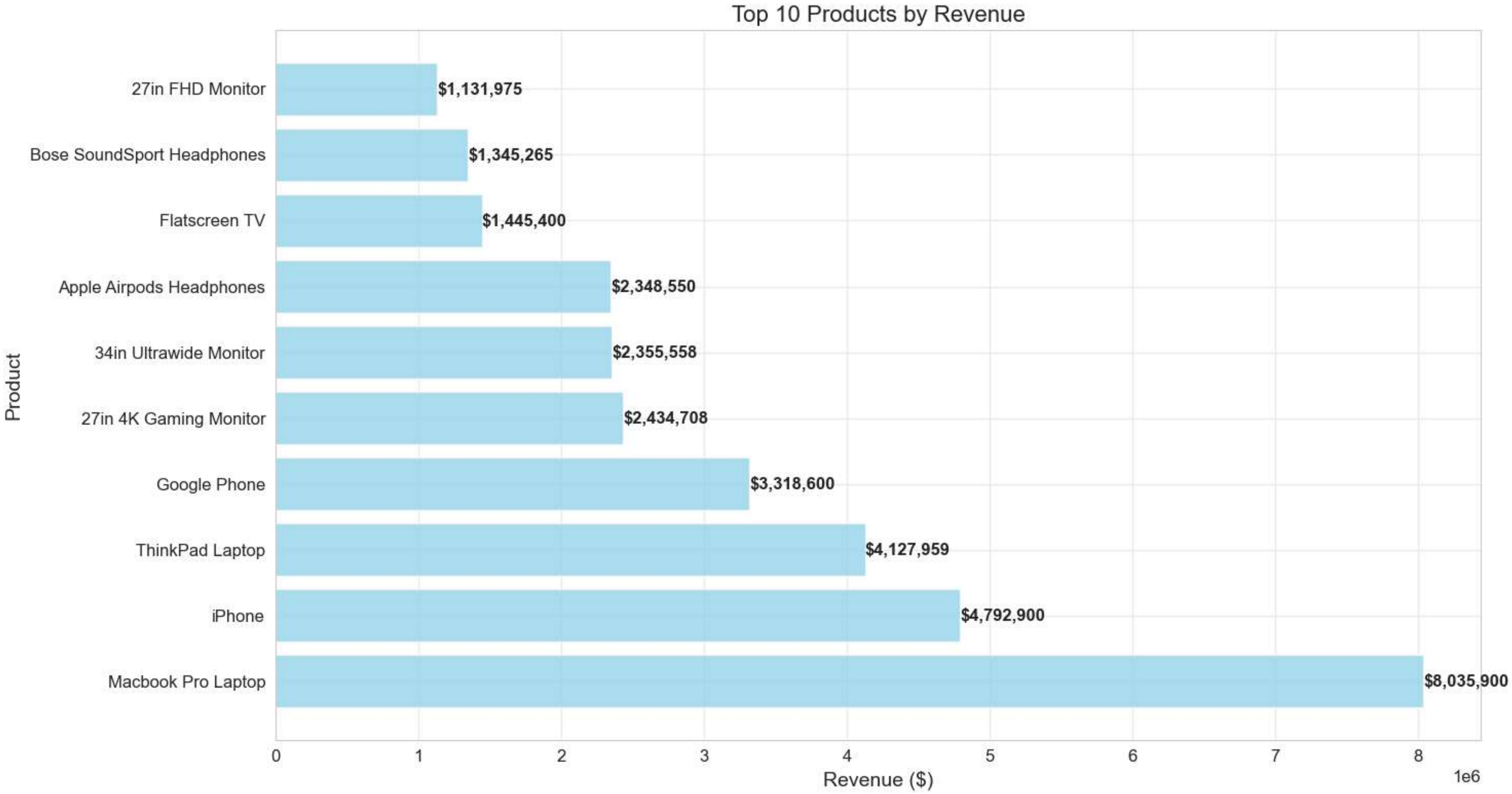

Average Order Value Distribution
Order Value ($)
0
500
1000
1500
2000
2500
Pairs
Triplets



In [34]:
```
input_dir = Path('G:\\Projects\\DataAnalysis\\SalesDataAnalysis\\ProcessedData\\ProductAnalysis')
product_summary = pd.read_csv(input_dir / 'product_performance_summary.csv')
city_product = pd.read_csv(input_dir / 'product_sales_by_city.csv')
monthly_sales = pd.read_csv(input_dir / 'monthly_product_sales.csv')



# Set style parameters
plt.style.use('default')
plt.rcParams.update({
            'figure.figsize': (15, 8),
            'figure.facecolor': 'white',
            'axes.facecolor': 'white',
            'axes.grid': True,
            'grid.alpha': 0.3,
            'font.family': 'sans-serif',
            'font.size': 12,
            'axes.labelsize': 14,
            'axes.titlesize': 16
        })

# Create output directory
output_dir = Path('G:\\Projects\\DataAnalysis\\SalesDataAnalysis\\Visualizations\\ProductPatterns')
output_dir.mkdir(parents=True, exist_ok=True)
```

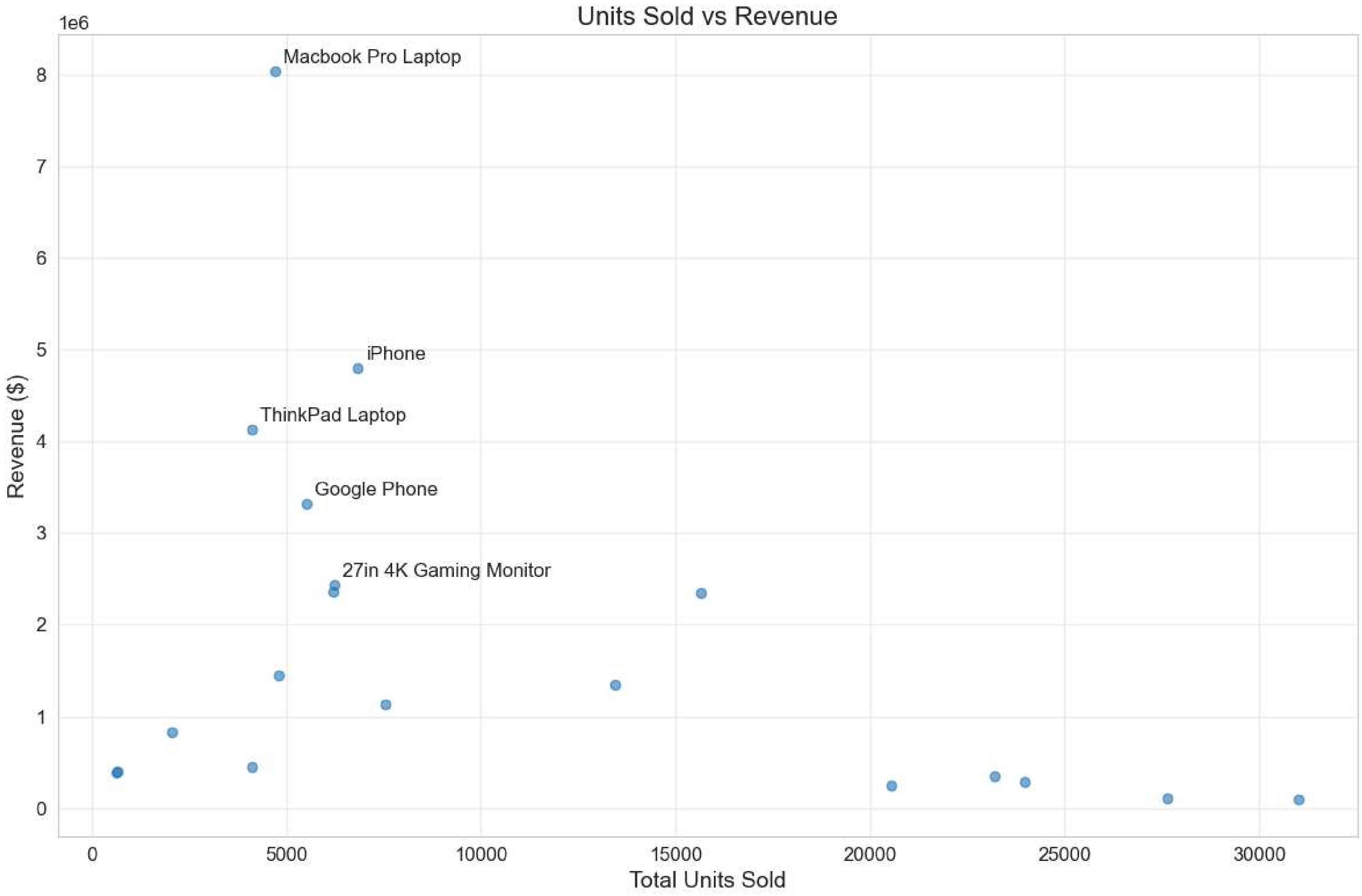
In [35]:

```
# Set Seaborn style
sns.set_style("whitegrid")

# 1. Top 10 Products by Revenue
plt.figure(figsize=(15, 8))
top_products = product_summary.nlargest(10, 'Revenue')
bars = plt.barh(top_products['Product'], top_products['Revenue'],
                       color='skyblue', alpha=0.7)
plt.title('Top 10 Products by Revenue')
plt.xlabel('Revenue ($)')
plt.ylabel('Product')

# Add value labels
for bar in bars:
    width = bar.get_width()
    plt.text(width, bar.get_y() + bar.get_height()/2,
                    f'${width:,.0f}',
                    ha='left', va='center', fontweight='bold')

plt.tight_layout()
plt.savefig(output_dir / 'top_products_revenue.png', dpi=300, bbox_inches='tight')
plt.show()
plt.close()
```



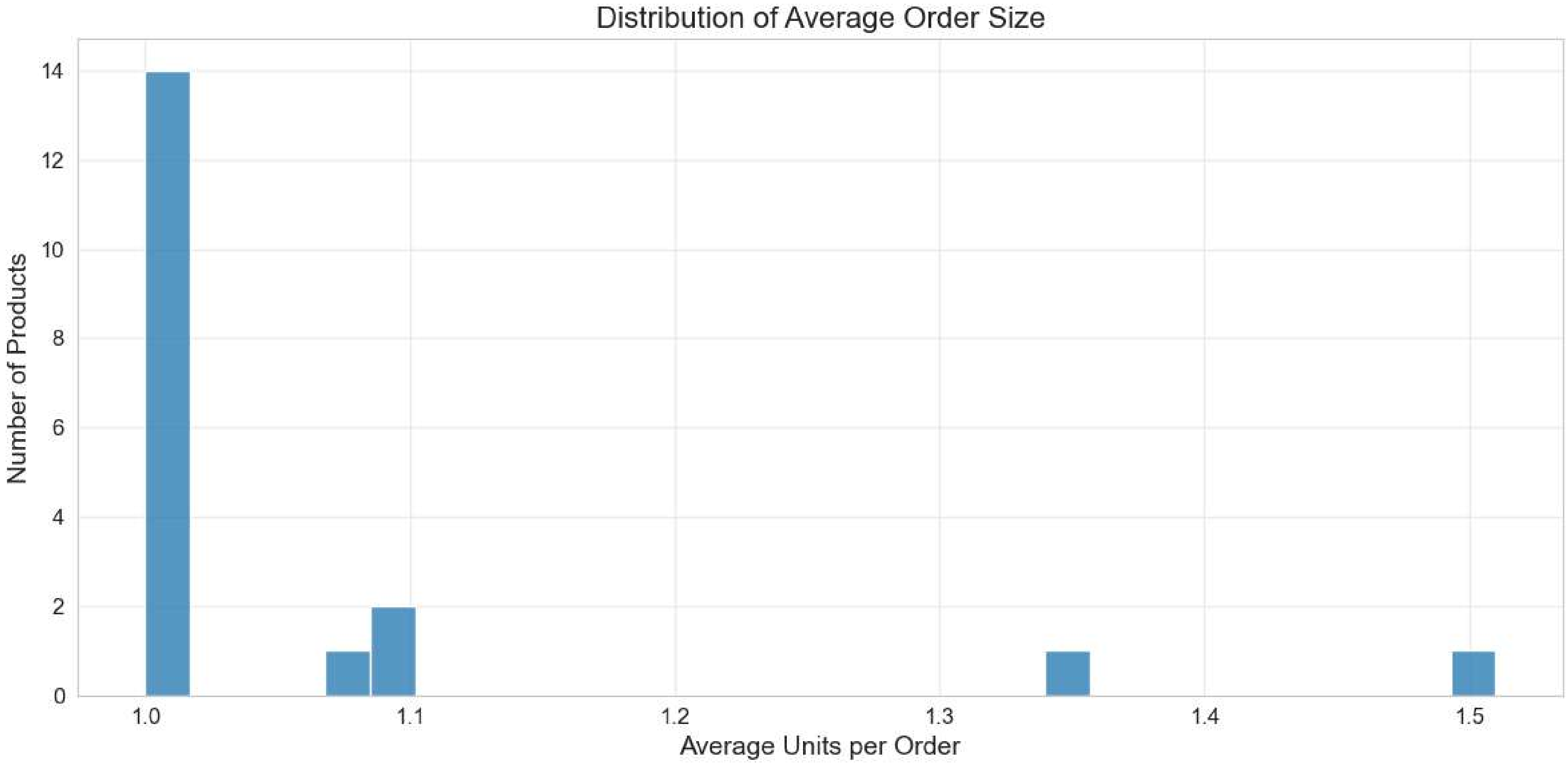
In [36]:

```
 # 2. Units Sold vs Revenue Scatter
plt.figure(figsize=(12, 8))
plt.scatter(product_summary['Total Units Sold'],
                   product_summary['Revenue'],
                   alpha=0.6)
plt.title('Units Sold vs Revenue')
plt.xlabel('Total Units Sold')
plt.ylabel('Revenue ($)')

# Add annotations for top 5 products
top_5_revenue = product_summary.nlargest(5, 'Revenue')
for _, row in top_5_revenue.iterrows():
    plt.annotate(row['Product'],
                        (row['Total Units Sold'], row['Revenue']),
                        xytext=(5, 5), textcoords='offset points')

plt.tight_layout()
plt.savefig(output_dir / 'units_vs_revenue.png', dpi=300, bbox_inches='tight')
plt.show()
plt.close()
```



In [37]:

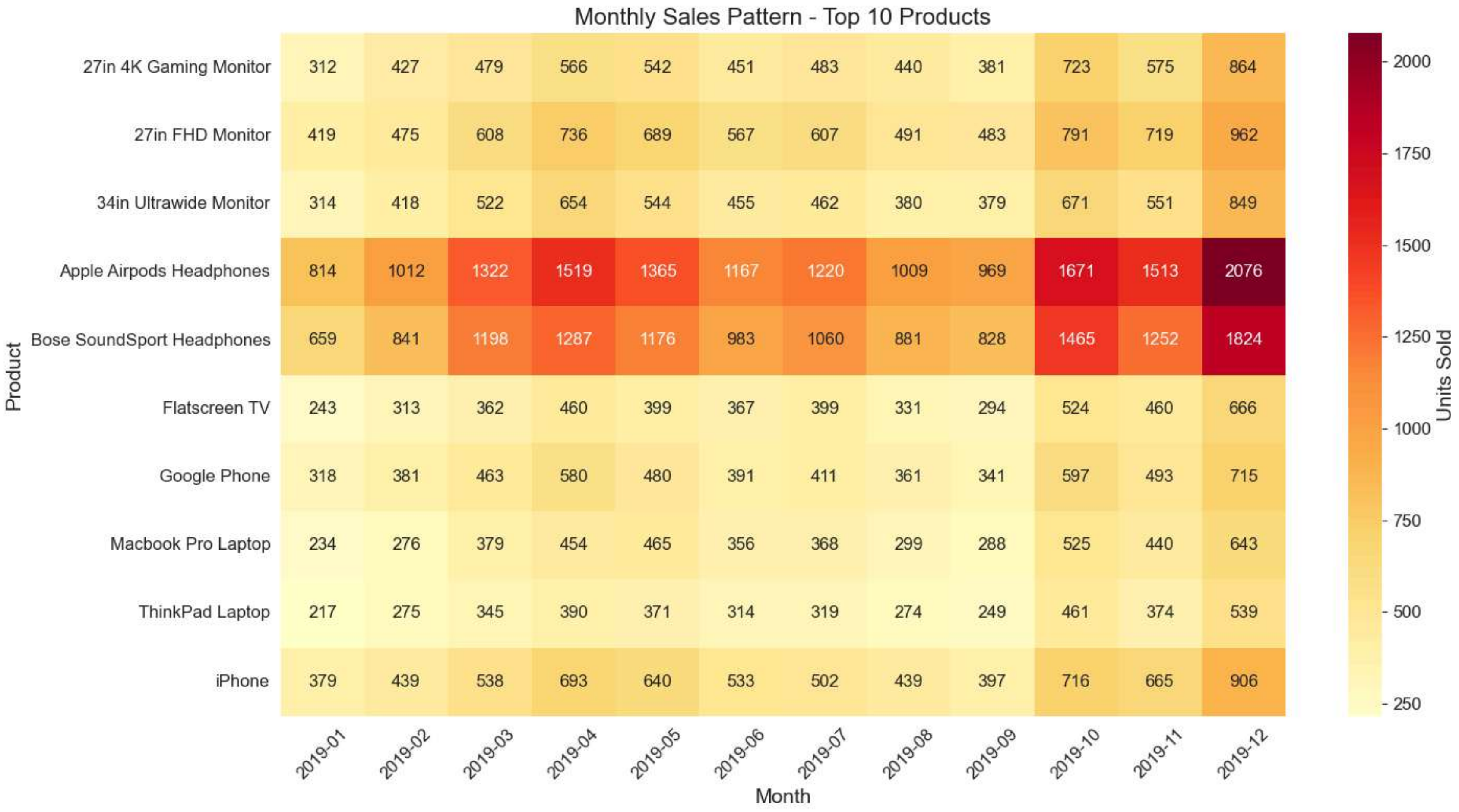
```
# 3. Average Order Size Distribution
plt.figure(figsize=(12, 6))
sns.histplot(data=product_summary, x='Average Order Size', bins=30)
plt.title('Distribution of Average Order Size')
plt.xlabel('Average Units per Order')
plt.ylabel('Number of Products')
plt.tight_layout()
plt.savefig(output_dir / 'order_size_distribution.png', dpi=300, bbox_inches='tight')
plt.show()
plt.close()
```



In [38]:

```
# 4. Monthly Sales Heatmap for Top Products
plt.figure(figsize=(15, 8))
top_10_products = product_summary.nlargest(10, 'Revenue')['Product']
monthly_heatmap = monthly_sales[monthly_sales['Product'].isin(top_10_products)]
monthly_heatmap = monthly_heatmap.set_index('Product')
```

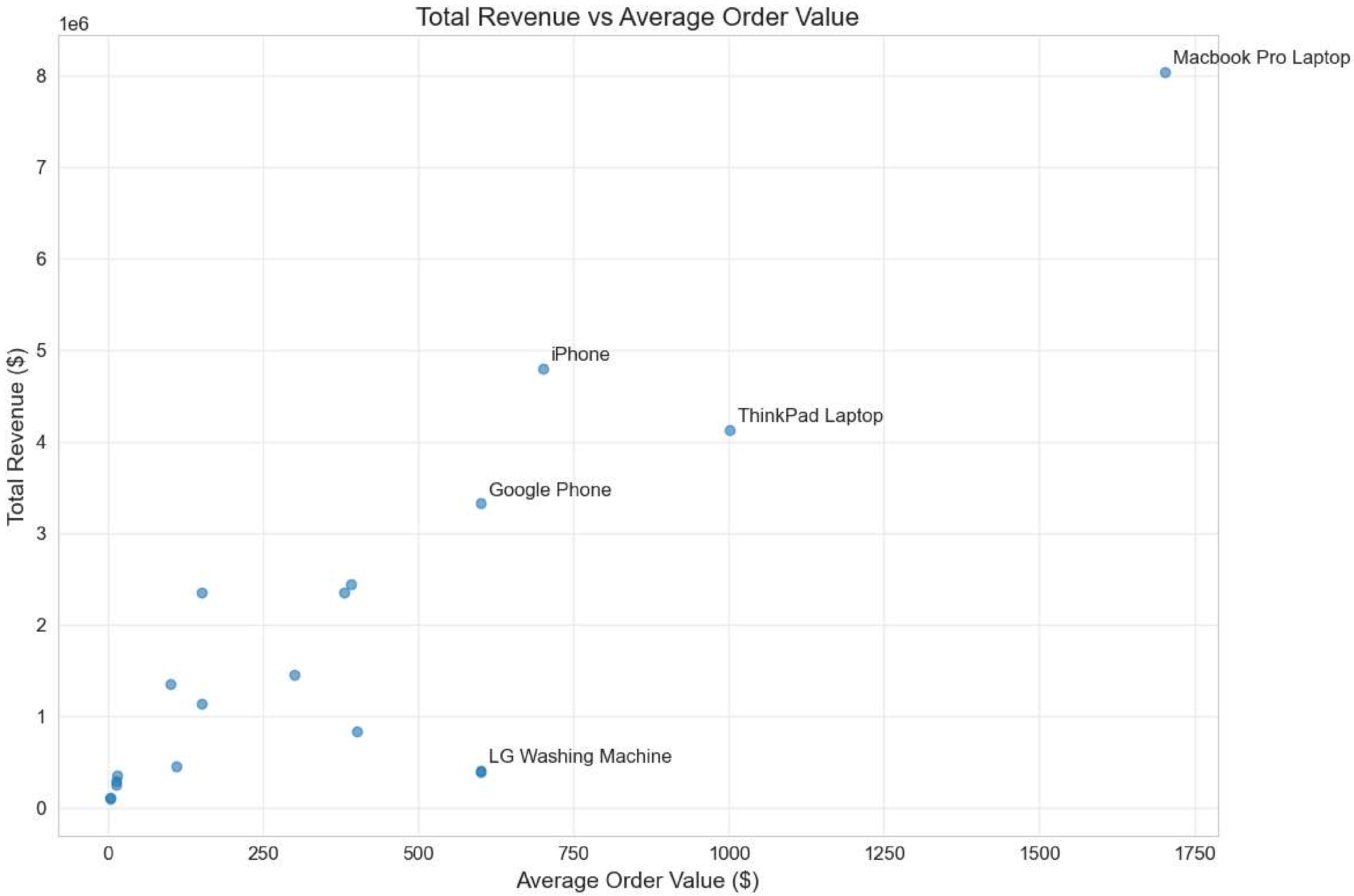
```
sns.heatmap(monthly_heatmap, cmap='YlOrRd',
                   annot=True, fmt='.0f',
                   cbar_kws={'label': 'Units Sold'})
plt.title('Monthly Sales Pattern - Top 10 Products')
plt.xlabel('Month')
plt.xticks(rotation=45)
plt.tight_layout()
plt.savefig(output_dir / 'monthly_sales_heatmap.png', dpi=300, bbox_inches='tight')
plt.show()
plt.close()
```



Product	2019-01	2019-02	2019-03	2019-04	2019-05	2019-06	2019-07	2019-08	2019-09	2019-10	2019-11	2019-12
27in 4K Gaming Monitor	312	427	479	566	542	451	483	440	381	723	575	864
27in FHD Monitor	419	475	608	736	689	567	607	491	483	791	719	962
34in Ultrawide Monitor	314	418	522	654	544	455	462	380	379	671	551	849
Apple Airpods Headphones	814	1012	1322	1519	1365	1167	1220	1009	969	1671	1513	2076
Bose SoundSport Headphones	659	841	1198	1287	1176	983	1060	881	828	1465	1252	1824
Flatscreen TV	243	313	362	460	399	367	399	331	294	524	460	666
Google Phone	318	381	463	580	480	391	411	361	341	597	493	715
Macbook Pro Laptop	234	276	379	454	465	356	368	299	288	525	440	643
ThinkPad Laptop	217	275	345	390	371	314	319	274	249	461	374	539
iPhone	379	439	538	693	640	533	502	439	397	716	665	906

In [39]:

```
# 6. Revenue vs Average Order Value
plt.figure(figsize=(12, 8))
plt.scatter(product_summary['Average Order Revenue'],
                   product_summary['Revenue'],
                   alpha=0.6)
plt.title('Total Revenue vs Average Order Value')
plt.xlabel('Average Order Value ($)')
plt.ylabel('Total Revenue ($)')

# Add annotations for interesting points
top_5_avg_order = product_summary.nlargest(5, 'Average Order Revenue')
for _, row in top_5_avg_order.iterrows():
    plt.annotate(row['Product'],
                        (row['Average Order Revenue'], row['Revenue']),
                        xytext=(5, 5), textcoords='offset points')

plt.tight_layout()
plt.savefig(output_dir / 'revenue_vs_order_value.png', dpi=300, bbox_inches='tight')
plt.show()
plt.close()
```


Total Revenue vs Average Order Value
1e6
Total Revenue ($)
0
1
2
3
4
5
6
7
8
Average Order Value ($)
0
250
500
750
1000
1250
1500
1750
Macbook Pro Laptop
iPhone
ThinkPad Laptop
Google Phone
LG Washing Machine

```
In [ ]:
```