

Competition 02 - The Christmas Predictor Challenge

Management Science - Retail Forecasting Competition

Client Briefing: MegaMart Retail Chain

Company Background

MegaMart is a major European retail chain with 250 stores across 8 countries. Founded in 1985, they've grown to €4.2B in annual revenue. Their motto: "Everything you need, when you need it."

Your Role: You've been hired as forecasting consultants for their critical Christmas season planning.

The Christmas Crisis

Last Year's Disaster:

- Gaming Console X: Sold out December 10th, missed €1.2M in sales
- Fitness Tracker Pro: 500 units unsold, €150K clearance loss
- Smart Speaker Mini: Perfect stock, but pure luck

Operations Director: "We can't afford another Christmas like last year. Every stockout means disappointed customers and lost revenue. Every overstock means clearance losses and tied-up capital. We need accurate forecasts!"

The Challenge

Your Mission

Forecast December 2025 sales (weeks 1-4) for three key products using 3 years of historical weekly data.

The Three Products

1. TechPod Pro (Wireless Earbuds)

- Category: Consumer Electronics
- Price: €199
- Margin: €80 per unit
- Storage cost: €2 per unit per week
- Lead time: 3 weeks from supplier
- Last year: Strong growth, some seasonality

2. FitBand Ultra (Fitness Tracker)

- Category: Health & Wellness

- Price: €149
- Margin: €55 per unit
- Storage cost: €1.50 per unit per week
- Lead time: 4 weeks from supplier
- Last year: Volatile, New Year resolution spike

3. CozyThrow Deluxe (Heated Blanket)

- Category: Home & Living
- Price: €79
- Margin: €30 per unit
- Storage cost: €3 per unit per week (bulky)
- Lead time: 6 weeks from supplier
- Last year: Highly seasonal, winter peak

Success Metrics

Your forecasts will be evaluated on:

1. Accuracy (60%): Mean Absolute Error (MAE) across all 12 forecasts
2. Business Logic (20%): Reasonable patterns, seasonality considered
3. Method Clarity (20%): Clear explanation of approach

Financial Impact

Cost of Errors:

- Underforecast: Lost profit margin + customer disappointment
- Overforecast: Storage costs + clearance losses (assume 30% markdown)

Example: If you forecast 1000 units but actual is 1200: - Lost profit: $200 \times €80 = €16,000$ (for TechPod Pro)

Data Access & Analysis

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from datetime import datetime, timedelta

# DON'T CHANGE ANYTHING BELOW!
# Random seed for consistency
np.random.seed(2025)

# Generate 3 years of realistic weekly sales data
weeks = pd.date_range(start='2023-01-03', end='2025-12-01', freq='W-MON')

def generate_product_sales(trend, seasonality_type, volatility, base=100):
    """Generate realistic sales patterns"""
    n_weeks = len(weeks)

    # Base trend
    if trend == 'growing':
```

```

        trend_component = np.linspace(base, base * 1.7, n_weeks)
    elif trend == 'stable':
        trend_component = np.ones(n_weeks) * base
    else: # declining
        trend_component = np.linspace(base, base * 0.6, n_weeks)

    # Seasonality
    if seasonality_type == 'christmas':
        # Peak in December, low in summer
        seasonal = 1 + 0.5 * np.sin(2 * np.pi * (np.arange(n_weeks) - 45) /
52)
    elif seasonality_type == 'newyear':
        # Peak in January and December
        seasonal = 1 + 0.25 * np.cos(2 * np.pi * np.arange(n_weeks) / 52)
    else: # moderate
        seasonal = 1 + 0.05 * np.sin(2 * np.pi * np.arange(n_weeks) / 52)

    # Combine with noise
    noise = np.random.normal(1, volatility, n_weeks)
    sales = trend_component * seasonal * noise

    # Ensure positive values
    sales = np.maximum(sales, base * 0.2)

    return sales.astype(int)

# Generate sales for each product
techpod_sales = generate_product_sales('growing', 'moderate', 0.1,
base=250)
fitband_sales = generate_product_sales('stable', 'newyear', 0.25, base=180)
cozythrow_sales = generate_product_sales('stable', 'christmas', 0.15,
base=120)

# Create the historical data DataFrame
historical_data = pd.DataFrame({
    'week': weeks,
    'techpod_pro': techpod_sales,
    'fitband_ultra': fitband_sales,
    'cozythrow_deluxe': cozythrow_sales
})

print("Historical sales data loaded!")
print(f"Data period: {historical_data['week'].min().date()} to
{historical_data['week'].max().date()}")
print(f"Total weeks: {len(historical_data)}")
print("\nFirst few weeks:")
print(historical_data.head())
print("\nLast few weeks (November 2023):")
print(historical_data.tail(6))
# DON'T CHANGE ANYTHING ABOVE!

```

```

Historical sales data loaded!
Data period: 2023-01-09 to 2025-12-01

```

Total weeks: 152

First few weeks:

| | week | techpod_pro | fitband_ultra | cozythrow_deluxe |
|---|------------|-------------|---------------|------------------|
| 0 | 2023-01-09 | 247 | 267 | 155 |
| 1 | 2023-01-16 | 271 | 215 | 150 |
| 2 | 2023-01-23 | 218 | 239 | 200 |
| 3 | 2023-01-30 | 240 | 194 | 168 |
| 4 | 2023-02-06 | 257 | 306 | 158 |

Last few weeks (November 2023):

| | week | techpod_pro | fitband_ultra | cozythrow_deluxe |
|-----|------------|-------------|---------------|------------------|
| 146 | 2025-10-27 | 380 | 131 | 82 |
| 147 | 2025-11-03 | 371 | 157 | 107 |
| 148 | 2025-11-10 | 394 | 173 | 136 |
| 149 | 2025-11-17 | 332 | 206 | 103 |
| 150 | 2025-11-24 | 448 | 217 | 116 |
| 151 | 2025-12-01 | 432 | 154 | 139 |

Data Exploration Tools

```
# Quick statistics
print("Product Statistics (weekly sales):")
print("-" * 40)
for product in ['techpod_pro', 'fitband_ultra', 'cozythrow_deluxe']:
    mean_sales = historical_data[product].mean()
    std_sales = historical_data[product].std()
    max_sales = historical_data[product].max()
    min_sales = historical_data[product].min()
    print(f"\n{product.upper()}:")
    print(f"  Average: {mean_sales:.0f} units/week")
    print(f"  Std Dev: {std_sales:.0f} units")
    print(f"  Range: {min_sales} - {max_sales} units")

# Visualize the full history
fig, axes = plt.subplots(3, 1, figsize=(14, 10))

products = ['techpod_pro', 'fitband_ultra', 'cozythrow_deluxe']
colors = ['#537E8F', '#F6B265', '#DB6B6B']

for idx, (product, color) in enumerate(zip(products, colors)):
    axes[idx].plot(historical_data['week'], historical_data[product],
                   color=color, linewidth=1.5, alpha=0.8)
    axes[idx].set_ylabel('Weekly Sales')
    axes[idx].set_title(f'{product.replace("_", " ").title()} - 3 Year
History')
    axes[idx].grid(True, alpha=0.2)
    axes[idx].axvline(x=pd.Timestamp('2023-12-01'), color='red',
                      linestyle='--', alpha=0.5, label='December Start')

    if idx == 0:
        axes[idx].legend()

axes[-1].set_xlabel('Week')
```

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

Product Statistics (weekly sales):

TECHPOD_PRO:

Average: 333 units/week

Std Dev: 58 units

Range: 218 - 489 units

FITBAND_ULTRA:

Average: 179 units/week

Std Dev: 54 units

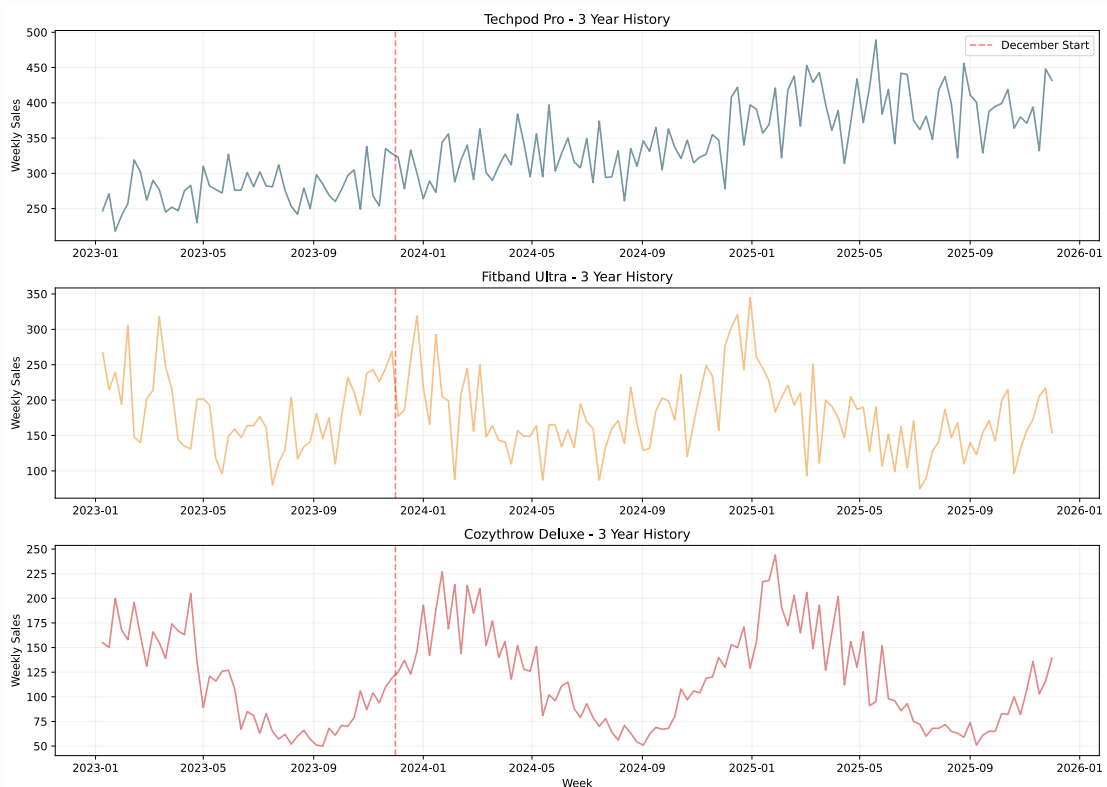
Range: 75 - 345 units

COZYTHROW_DELUXE:

Average: 118 units/week

Std Dev: 48 units

Range: 50 - 244 units



December Weeks to Forecast

```
# Define the December 2025 weeks we need to forecast (exactly 4 weeks)
december_weeks = pd.date_range(start='2025-12-01', periods=4, freq='W-MON')
print("December 2025 weeks to forecast:")
```

```

for i, week in enumerate(december_weeks, 1):
    print(f" Week {i}: {week.date()} (Monday start)")

# Create a template for your submission
forecast_template = pd.DataFrame({
    'week': december_weeks,
    'week_num': [1, 2, 3, 4],
    'techpod_pro': [0, 0, 0, 0],          # Your forecasts here
    'fitband_ultra': [0, 0, 0, 0],       # Your forecasts here
    'cozythrow_deluxe': [0, 0, 0, 0]     # Your forecasts here
})

print("\nForecast template (you'll fill this):")
print(forecast_template)

print("\nExample: How to fill your forecasts:")
print(" forecast_template.loc[0, 'techpod_pro'] = your_week1_forecast")
print(" forecast_template.loc[1, 'techpod_pro'] = your_week2_forecast")
print(" ... and so on for all products and weeks")

```

December 2025 weeks to forecast:

Week 1: 2025-12-01 (Monday start)
 Week 2: 2025-12-08 (Monday start)
 Week 3: 2025-12-15 (Monday start)
 Week 4: 2025-12-22 (Monday start)

Forecast template (you'll fill this):

| | week | week_num | techpod_pro | fitband_ultra | cozythrow_deluxe |
|---|------------|----------|-------------|---------------|------------------|
| 0 | 2025-12-01 | 1 | 0 | 0 | 0 |
| 1 | 2025-12-08 | 2 | 0 | 0 | 0 |
| 2 | 2025-12-15 | 3 | 0 | 0 | 0 |
| 3 | 2025-12-22 | 4 | 0 | 0 | 0 |

Example: How to fill your forecasts:

forecast_template.loc[0, 'techpod_pro'] = your_week1_forecast
 forecast_template.loc[1, 'techpod_pro'] = your_week2_forecast
 ... and so on for all products and weeks

Starter Code & Helper Functions

```

def calculate_mae(actual, forecast):
    """Calculate Mean Absolute Error"""
    return np.mean(np.abs(actual - forecast))

def calculate_mape(actual, forecast):
    """Calculate Mean Absolute Percentage Error"""
    return np.mean(np.abs((actual - forecast) / actual)) * 100

def simple_moving_average(data, window):
    """Calculate simple moving average forecast"""
    return data.iloc[-window:].mean()

```

```
def seasonal_naive(data, season_length=52):
    """Forecast based on same week last year"""
    if len(data) < season_length:
        return data.iloc[-1] # Fallback to last value
    return data.iloc[-season_length]

print("Helper functions loaded!")
print("\nAvailable functions:")
print(" - calculate_mae(actual, forecast)")
print(" - simple_moving_average(data, window)")
print(" - seasonal_naive(data, season_length)")
```

Helper functions loaded!

Available functions:

- calculate_mae(actual, forecast)
- simple_moving_average(data, window)
- seasonal_naive(data, season_length)

Example: Basic Forecast Implementation

```
# Example forecast for TechPod Pro using simple moving average
print("Example Forecast: TechPod Pro")
print("-" * 40)

# Method 1: Simple 4-week moving average
techpod_ma4 = simple_moving_average(historical_data['techpod_pro'],
window=4)
print(f"4-week MA forecast: {techpod_ma4:.0f} units/week")

# Method 2: Same week last year
techpod_seasonal = seasonal_naive(historical_data['techpod_pro'],
season_length=52)
print(f"Last year same week: {techpod_seasonal:.0f} units/week")

print("\nYou can use any of these methods or create your own!")
```

Example Forecast: TechPod Pro

4-week MA forecast: 402 units/week
Last year same week: 408 units/week

You can use any of these methods or create your own!

Your Task

Step 1: Analyze Each Product

Study the patterns, trends, and seasonality for each product. Consider:

- Is there a clear trend (growing/declining)?
- Is there seasonality? When are the peaks?
- How volatile is the demand?
- What happened last December?

Step 2: Choose Your Methods

Select appropriate forecasting methods for each product. You might use:

- Different methods for different products
- Combination of methods
- Adjusted forecasts based on December patterns
- Your own creative approach

Step 3: Generate Forecasts

Create your forecasts for the 4 December weeks for each product.

```
# YOUR SOLUTION HERE
# This is where you'll implement your forecasting approach

# Step 1: Analyze patterns (add your analysis code)

# Step 2: Choose and implement methods

# Step 3: Generate December forecasts

# Step 4: Validate your forecasts are reasonable
```

Step 4: Create Your Submission

Prepare a one-slide presentation (PDF) containing:

1. Your Forecasts: Clear visualization of all 12 predictions
2. Method Summary: 2-3 sentences explaining your approach
3. Key Insights: What patterns did you find?
4. Confidence Level: How confident are you in these forecasts?

Tips for Success

Strategy Suggestions

1. Start Simple: Get a baseline forecast working first
2. Look for Patterns: December might be special for some products
3. Consider Product Types: Electronics vs. seasonal items behave differently
4. Validate Reasonableness: Do your forecasts make business sense?

Common Pitfalls

- Using the same method for all products without considering their differences
- Ignoring obvious seasonality

- Forecasts way outside historical ranges without justification
- Overly complex methods when simple ones work better

Final Checklist

- [?] All 12 forecasts completed (3 products × 4 weeks)
- [?] Forecasts seem reasonable given history
- [?] One-slide PDF ready for presentation

Bonus Analysis (Optional)

For extra insights, consider:

```
# Calculate potential financial impact
def calculate_financial_impact(forecast, actual, margin, storage_cost):
    """Calculate the cost of forecast error"""
    error = actual - forecast
    if error > 0: # Underforecast
        lost_profit = error * margin
        return -lost_profit # Negative = loss
    else: # Overforecast
        excess = -error
        storage_weeks = 4 # Assume stored for a month
        storage = excess * storage_cost * storage_weeks
        markdown_loss = excess * margin * 0.3 # 30% markdown
        return -(storage + markdown_loss)

# Example calculation
forecast = 1000
actual = 1200
impact = calculate_financial_impact(forecast, actual, margin=80,
storage_cost=2)
print(f"Financial impact of error: €{-impact:,.0f} loss")
```

Good Luck!

Bibliography