Python

Table of contents

1

1.1 NumPy -

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

# NumPy
print("=== NumPy   ===")

#
arr1 = np.array([1, 2, 3, 4, 5])
arr2 = np.array([[1, 2, 3], [4, 5, 6]])

print(f"1  : {arr1}")
print(f"2  :\n{arr2}")
print(f"   : {arr2.shape}")
print(f"   : {arr2.dtype}")

#
zeros = np.zeros((3, 4))
ones = np.ones((2, 3))
random_arr = np.random.random((3, 3))

print(f"\n  :\n{zeros}")
print(f"   :\n{random_arr}")

#
data = np.array([1, 4, 9, 16, 25])
print(f"\n   : {data}")
print(f"  : {np.sqrt(data)}")
print(f" : {np.log(data)}")
print(f" : {np.sum(data)}")
```

```
print(f" : {np.mean(data)}")
print(f"  : {np.std(data)}")
```

```
=== NumPy   ===
1   : [1 2 3 4 5]
2   :
[[1 2 3]
 [4 5 6]]
   : (2, 3)
  : int64

  :
[[0. 0. 0. 0.]
 [0. 0. 0. 0.]
 [0. 0. 0. 0.]]
    :
[[0.49887506 0.3036612  0.25071226]
 [0.41575243 0.51012525 0.12361981]
 [0.79932375 0.20264521 0.56489253]]

   : [ 1  4  9 16 25]
  : [1. 2. 3. 4. 5.]
 : [0.         1.38629436 2.19722458 2.77258872 3.21887582]
 : 55
 : 11.0
  : 8.648699324175862
```

1.2 Pandas -

```
#
print("=== Pandas   ===")

# DataFrame
sales_data = {
    ' ': pd.date_range('2024-01-01', periods=10, freq='D'),
    ' ': [120, 150, 98, 200, 175, 160, 210, 185, 145, 190],
    ' ': ['A', 'B', 'A', 'C', 'B', 'A', 'C', 'B', 'A', 'C'],
    ' ': [' ', ' ', ' ', ' ', ' ', ' ', ' ', ' ', ' ', ' ']
}
```

```
df = pd.DataFrame(sales_data)
print("   :")
print(df)

#
print(f"\n  :")
print(df.describe())

#
print(f"\n   :")
product_sales = df.groupby(' ')[' '].agg(['sum', 'mean', 'count'])
print(product_sales)

print(f"\n   :")
region_sales = df.groupby(' ')[' '].sum().sort_values(ascending=False)
print(region_sales)

#
high_sales = df[df[' '] > 150]
print(f"\n    (>150):")
print(high_sales)
```

```
=== Pandas   ===
   :

0 2024-01-01  120  A
1 2024-01-02  150  B
2 2024-01-03   98  A
3 2024-01-04  200  C
4 2024-01-05  175  B
5 2024-01-06  160  A
6 2024-01-07  210  C
7 2024-01-08  185  B
8 2024-01-09  145  A
9 2024-01-10  190  C

  :

count                       10   10.000000
mean   2024-01-05 12:00:00  163.300000
min    2024-01-01 00:00:00   98.000000
```

```
25%    2024-01-03 06:00:00  146.250000
50%    2024-01-05 12:00:00  167.500000
75%    2024-01-07 18:00:00  188.750000
max    2024-01-10 00:00:00  210.000000
std                    NaN   35.761711

   :
    sum    mean  count

A   523  130.75      4
B   510  170.00      3
C   600  200.00      3

   :

     600
     523
     510
Name:  , dtype: int64

    (>150):

3 2024-01-04  200  C
4 2024-01-05  175  B
5 2024-01-06  160  A
6 2024-01-07  210  C
7 2024-01-08  185  B
9 2024-01-10  190  C
```

1.3

```
# matplotlib   seaborn
print("===     ===")

#
plt.style.use('seaborn-v0_8')
fig, axes = plt.subplots(2, 2, figsize=(12, 10))

# 1.
axes[0, 0].plot(df[' '], df[' '], marker='o', linewidth=2)
```

```
axes[0, 0].set_title('    ')
axes[0, 0].set_xlabel(' ')
axes[0, 0].set_ylabel(' ')
axes[0, 0].tick_params(axis='x', rotation=45)

# 2.
product_totals = df.groupby(' ')[' '].sum()
axes[0, 1].bar(product_totals.index, product_totals.values, color=['skyblue', 'lightgreen',
axes[0, 1].set_title('    ')
axes[0, 1].set_xlabel(' ')
axes[0, 1].set_ylabel('  ')

# 3.
region_totals = df.groupby(' ')[' '].sum()
axes[1, 0].pie(region_totals.values, labels=region_totals.index, autopct='%1.1f%%', startangl
axes[1, 0].set_title('     ')

# 4.
axes[1, 1].hist(df[' '], bins=6, color='orange', alpha=0.7, edgecolor='black')
axes[1, 1].set_title('   ')
axes[1, 1].set_xlabel(' ')
axes[1, 1].set_ylabel(' ')

plt.tight_layout()
plt.show()

print("     ")
```

```
===     ===

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/home/ryuichi/dev/python-tutorial/.venv/lib/python3.12/site-packages/IPython/core/pylabtools
  fig.canvas.print_figure(bytes_io, **kw)
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/home/ryuichi/dev/python-tutorial/.venv/lib/python3.12/site-packages/IPython/core/pylabtools
  fig.canvas.print_figure(bytes_io, **kw)
```

100
120
140
160
180
200
2024-01-01
2024-01-02
2024-01-03
2024-01-04
2024-01-05
2024-01-06
2024-01-07
2024-01-08
2024-01-09
2024-01-10
0
100
200
300
400
500
600
A
B
C
31.2%
36.7%
32.0%
0.0
0.5
1.0
1.5
2.0
2.5
3.0
100
120
140
160
180
200

2

2.1

```
#
np.random.seed(42)

customer_data = {
    ' ID': range(1, 1001),
    ' ': np.random.normal(40, 15, 1000).astype(int),
    ' ': np.random.normal(500, 150, 1000).astype(int),
    '  ': np.random.normal(100, 30, 1000),
    '  ': np.random.poisson(3, 1000),
    ' ': np.random.choice([' ', ' '], 1000),
    ' ': np.random.choice([' ', ' ', '  ', ' '], 1000, p=[0.4, 0.3, 0.2, 0.1])
}

#
customer_data[' '] = np.clip(customer_data[' '], 18, 80)
customer_data[' '] = np.clip(customer_data[' '], 200, 1500)
customer_data['  '] = np.clip(customer_data['  '], 10, 500)

customers_df = pd.DataFrame(customer_data)

print("===      ===")
print(f"   : {customers_df.shape}")
print(f"\n  5 :")
print(customers_df.head())

#
print(f"\n    :")
print(customers_df.describe())

#
print(f"\n   :")
```

```python
gender_stats = customers_df.groupby(' ').agg({
    ' ': ['mean', 'std'],
    ' ': ['mean', 'std'],
    '  ': ['mean', 'std'],
    '  ': ['mean', 'std']
}).round(2)
print(gender_stats)

#
print(f"\n   :")
region_stats = customers_df.groupby(' ').agg({
    '  ': ['count', 'mean', 'sum'],
    '  ': 'mean'
}).round(2)
print(region_stats)
```

```
===      ===
   : (1000, 7)

  5 :
    ID
0     1  47  709  79.744652     5
1     2  37  638  95.664440     1
2     3  49  508  76.227402     3
3     4  62  402  90.761154     3
4     5  36  604  43.191560     4

    :
               ID
count  1000.000000  1000.000000  1000.000000  1000.000000  1000.00000
mean    500.500000    40.155000   511.496000   100.175612     2.96000
std     288.819436    13.876005   146.279211    29.501832     1.59089
min       1.000000    18.000000   200.000000    10.000000     0.00000
25%     250.750000    30.000000   408.750000    80.560012     2.00000
50%     500.500000    40.000000   509.000000    99.992477     3.00000
75%     750.250000    49.000000   609.000000   119.827459     4.00000
max    1000.000000    80.000000   978.000000   217.787131     9.00000

   :

     mean    std    mean     std    mean    std  mean    std
```

```
40.85   14.05   510.74   145.94    98.88   28.21   3.00   1.59
39.52   13.70   512.19   146.72   101.36   30.62   2.93   1.60

:

  count     mean       sum   mean

   185    97.25   17991.28   3.03
    337   100.67   33925.58   2.81
    388   101.66   39443.79   3.01
     90    97.94    8814.96   3.18
```

2.2

```
#
print("===     ===")

#
numeric_columns = [' ', ' ', '   ', '   ']
correlation_matrix = customers_df[numeric_columns].corr()

print("     :")
print(correlation_matrix.round(3))

#
plt.figure(figsize=(10, 8))

#
plt.subplot(2, 2, 1)
sns.heatmap(correlation_matrix, annot=True, cmap='coolwarm', center=0)
plt.title('    ')

#
plt.subplot(2, 2, 2)
plt.scatter(customers_df[' '], customers_df['   '], alpha=0.6)
plt.xlabel(' ')
plt.ylabel('   ')
plt.title('  vs    ')

#
```

```python
plt.subplot(2, 2, 3)
age_groups = pd.cut(customers_df[' '], bins=[0, 30, 50, 100], labels=[' ', ' ', ' '])
customers_df[' '] = age_groups
sns.boxplot(data=customers_df, x=' ', y=' ')
plt.title(' ')

#
plt.subplot(2, 2, 4)
region_avg = customers_df.groupby(' ')[' '].mean().sort_values(ascending=False)
plt.bar(region_avg.index, region_avg.values, color=['red', 'blue', 'green', 'orange'])
plt.title(' ')
plt.ylabel(' ')

plt.tight_layout()
plt.show()

print(" ")
```

```
===    ===
    :

     1.000 -0.047  0.028 -0.069
    -0.047  1.000 -0.012  0.067
     0.028 -0.012  1.000  0.009
   -0.069  0.067  0.009  1.000

/home/ryuichi/dev/python-tutorial/.venv/lib/python3.12/site-packages/seaborn/utils.py:61: Use
  fig.canvas.draw()
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  plt.tight_layout()
```

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  fig.canvas.print_figure(bytes_io, **kw)
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/home/ryuichi/dev/python-tutorial/.venv/lib/python3.12/site-packages/IPython/core/pylabtools
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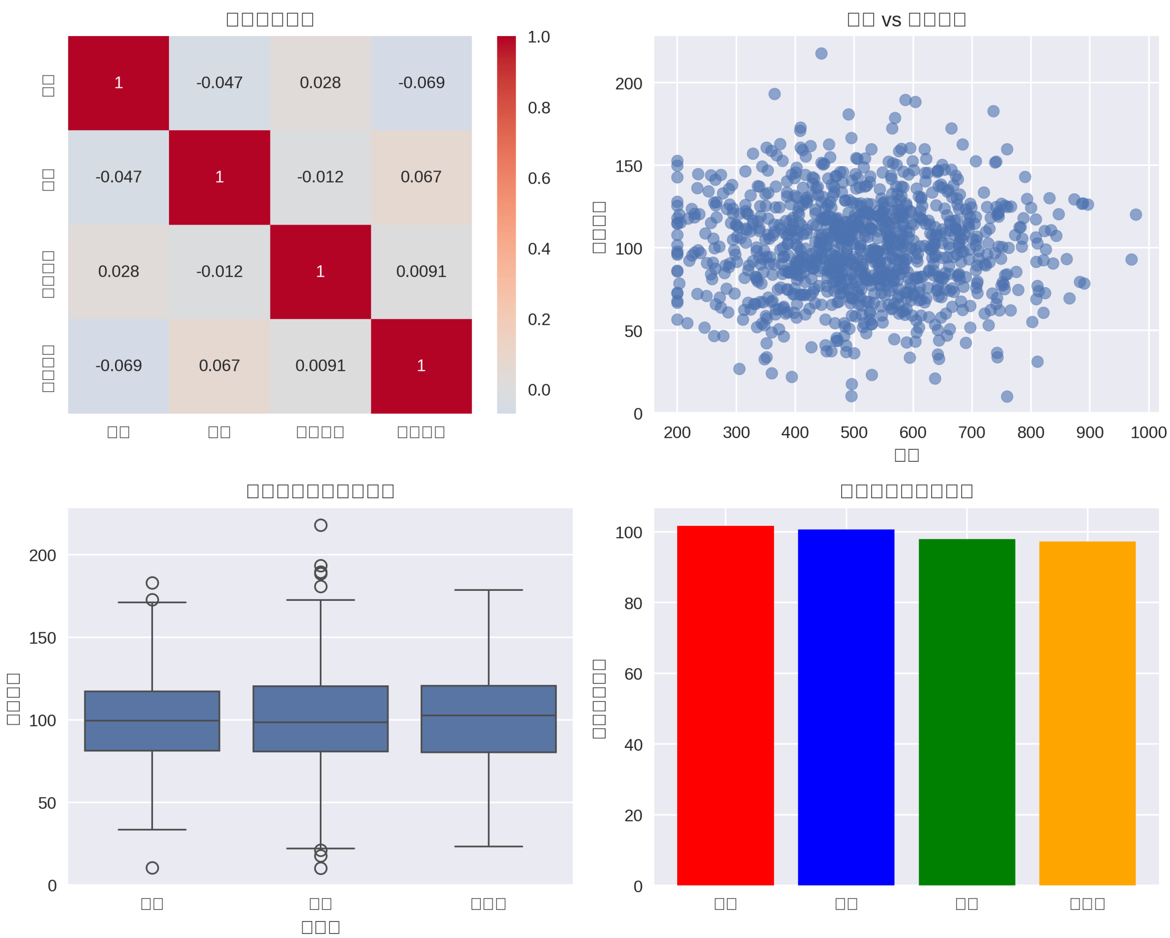
```



2.3

```
#
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_squared_error, r2_score

print("===      ===")

#
```

```python
X = customers_df[[' ', ' ', '  ']]  #
y = customers_df['  ']  #

#
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

#
model = LinearRegression()
model.fit(X_train, y_train)

#
y_pred = model.predict(X_test)

#
mse = mean_squared_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)

print(f"   :")
print(f"    (MSE): {mse:.2f}")
print(f"   (R²): {r2:.3f}")

#
feature_importance = pd.DataFrame({
    '  ': X.columns,
    ' ': model.coef_,
    '  ': np.abs(model.coef_)
}).sort_values('  ', ascending=False)

print(f"\n    :")
print(feature_importance)

#
plt.figure(figsize=(10, 6))

plt.subplot(1, 2, 1)
plt.scatter(y_test, y_pred, alpha=0.6)
plt.plot([y_test.min(), y_test.max()], [y_test.min(), y_test.max()], 'r--', lw=2)
plt.xlabel('    ')
plt.ylabel('    ')
plt.title(f'   (R² = {r2:.3f})')

plt.subplot(1, 2, 2)
```

```
residuals = y_test - y_pred
plt.scatter(y_pred, residuals, alpha=0.6)
plt.axhline(y=0, color='r', linestyle='--')
plt.xlabel('  ')
plt.ylabel(' ')
plt.title('    ')

plt.tight_layout()
plt.show()

print("         ")
```

```
===     ===
   :
     (MSE): 895.43
    (R²): -0.007

     :

0       0.075560  0.075560
2      0.007800  0.007800
1      -0.000179  0.000179

/tmp/ipykernel_385794/3532273101.py:58: UserWarning: Glyph 23455 (\N{CJK UNIFIED IDEOGRAPH-5I
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```

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/home/ryuichi/dev/python-tutorial/.venv/lib/python3.12/site-packages/IPython/core/pylabtools
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```

```
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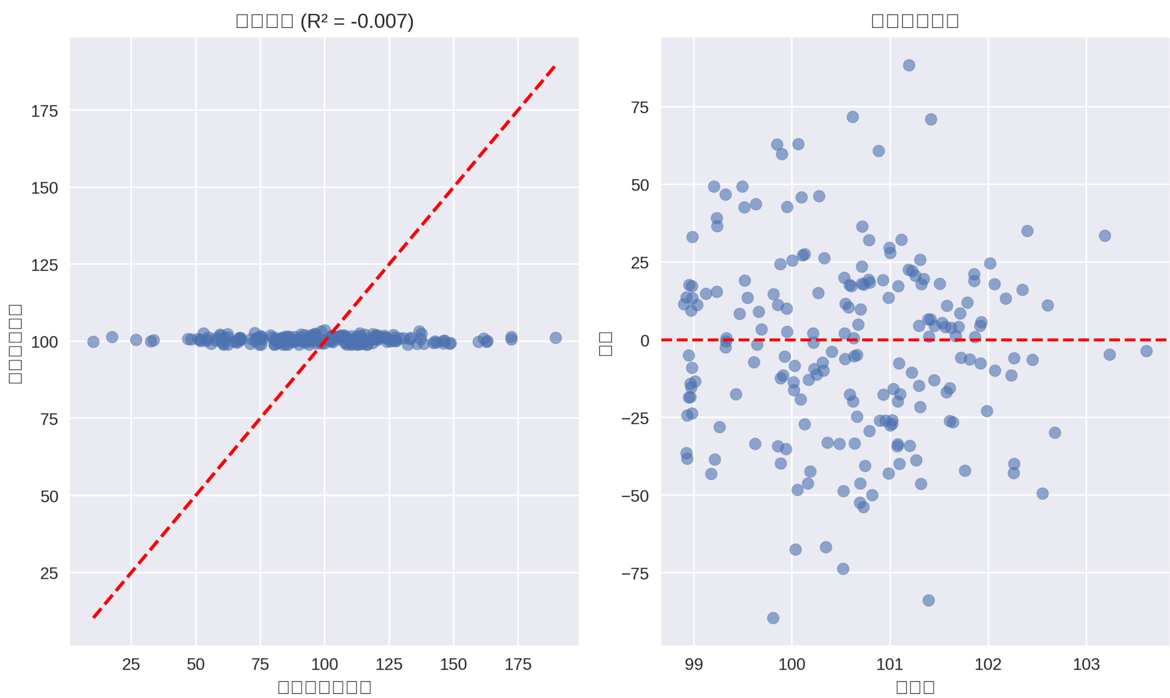
```



3

3.1

```
#
print("===      ===")

#
date_range = pd.date_range('2022-01-01', '2024-12-31', freq='M')
np.random.seed(42)

#
trend = np.linspace(1000, 1500, len(date_range))
seasonal = 200 * np.sin(2 * np.pi * np.arange(len(date_range)) / 12)
noise = np.random.normal(0, 50, len(date_range))
sales = trend + seasonal + noise

time_series_df = pd.DataFrame({
    ' ': date_range,
    ' ': sales
})

print(f"    : {time_series_df.shape}")
print(f" : {time_series_df[' '].min()}   {time_series_df[' '].max()}")

#
print(f"\n  :")
print(f" : {time_series_df[' '].mean():.2f}")
print(f" : {time_series_df[' '].min():.2f}")
print(f" : {time_series_df[' '].max():.2f}")

#
time_series_df['  _3M'] = time_series_df[' '].rolling(window=3).mean()
time_series_df['  _12M'] = time_series_df[' '].rolling(window=12).mean()
```

```
#
time_series_df['   '] = time_series_df[' '].pct_change(periods=12) * 100

#
plt.figure(figsize=(15, 10))

#
plt.subplot(3, 1, 1)
plt.plot(time_series_df[' '], time_series_df[' '], label='   ', alpha=0.7)
plt.plot(time_series_df[' '], time_series_df['  _3M'], label='3   ', linewidth=2)
plt.plot(time_series_df[' '], time_series_df['  _12M'], label='12   ', linewidth=2)
plt.title('    ')
plt.ylabel(' ')
plt.legend()
plt.grid(True, alpha=0.3)

#
plt.subplot(3, 1, 2)
monthly_avg = time_series_df.groupby(time_series_df[' '].dt.month)[' '].mean()
plt.bar(monthly_avg.index, monthly_avg.values, color='lightblue', edgecolor='navy')
plt.title('      ')
plt.xlabel(' ')
plt.ylabel('  ')
plt.xticks(range(1, 13))
plt.grid(True, alpha=0.3)

#
plt.subplot(3, 1, 3)
plt.plot(time_series_df[' '], time_series_df['   '], marker='o', linewidth=2, color='green')
plt.axhline(y=0, color='red', linestyle='--', alpha=0.7)
plt.title('   ')
plt.xlabel(' ')
plt.ylabel('   (%)')
plt.grid(True, alpha=0.3)

plt.tight_layout()
plt.show()

print("        ")
```

```
===      ===
    : (36, 2)
```

```
: 2022-01-31 00:00:00   2024-12-31 00:00:00

  :
: 1241.86
: 917.61
: 1604.50

/tmp/ipykernel_385794/130288318.py:5: FutureWarning: 'M' is deprecated and will be removed i
  date_range = pd.date_range('2022-01-01', '2024-12-31', freq='M')
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  plt.tight_layout()
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  plt.tight_layout()
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  plt.tight_layout()
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```

```
  plt.tight_layout()
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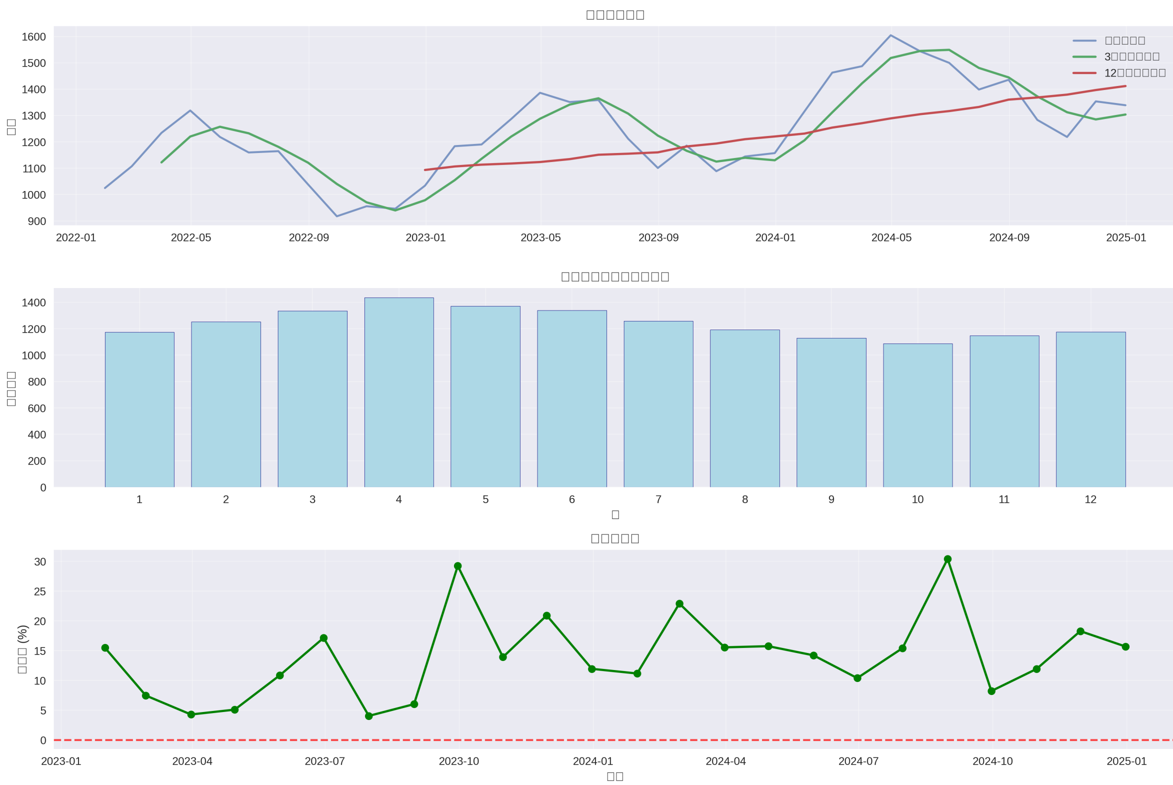
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1500
1400
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2022-05
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7
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(%)
2023-01
2023-04
2023-07
2023-10
2024-01
2024-04
2024-07
2024-10
2025-01

4

4.1 A/B

```
# A/B
print("=== A/B    ===")

np.random.seed(42)

# A/B
n_users_a = 1000
n_users_b = 1000

#    A B
conversion_rate_a = 0.12  # 12%
conversion_rate_b = 0.15  # 15%

#
group_a = np.random.binomial(1, conversion_rate_a, n_users_a)
group_b = np.random.binomial(1, conversion_rate_b, n_users_b)

ab_test_df = pd.DataFrame({
    '   ': ['A'] * n_users_a + ['B'] * n_users_b,
    '     ': np.concatenate([group_a, group_b])
})

#
results = ab_test_df.groupby('   ')['     '].agg(['count', 'sum', 'mean']).round(4)
results.columns = ['   ', '     ', '     ']

print("A/B   :")
print(results)

#
from scipy.stats import chi2_contingency
```

```
contingency_table = pd.crosstab(ab_test_df['  '], ab_test_df['    '])
chi2, p_value, dof, expected = chi2_contingency(contingency_table)

print(f"\n    :")
print(f"    : {chi2:.4f}")
print(f"p : {p_value:.4f}")
print(f"  0.05 {' ' if p_value < 0.05 else '   '} ")

#
plt.figure(figsize=(12, 6))

plt.subplot(1, 2, 1)
conversion_rates = results['    ']
colors = ['lightblue', 'lightgreen']
bars = plt.bar(conversion_rates.index, conversion_rates.values, color=colors, edgecolor='navy
plt.title('       ')
plt.ylabel('    ')
plt.ylim(0, max(conversion_rates.values) * 1.2)

#
for bar, rate in zip(bars, conversion_rates.values):
    plt.text(bar.get_x() + bar.get_width()/2, bar.get_height() + 0.005,
             f'{rate:.1%}', ha='center', va='bottom', fontweight='bold')

plt.subplot(1, 2, 2)
improvement = (results.loc['B', '    '] - results.loc['A', '    ']) / results.loc['A', '
plt.bar(['  '], [improvement], color='orange', edgecolor='red')
plt.title(f'  B  ')
plt.ylabel('   (%)')
plt.text(0, improvement + 1, f'{improvement:.1f}%', ha='center', va='bottom', fontweight='bol

plt.tight_layout()
plt.show()

print(f"  B   A {improvement:.1f}% ")
```

```
=== A/B    ===
A/B   :


A      1000       124     0.124
```

```
B      1000       152     0.152

    :
    : 3.0642
p : 0.0800
  0.05

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```

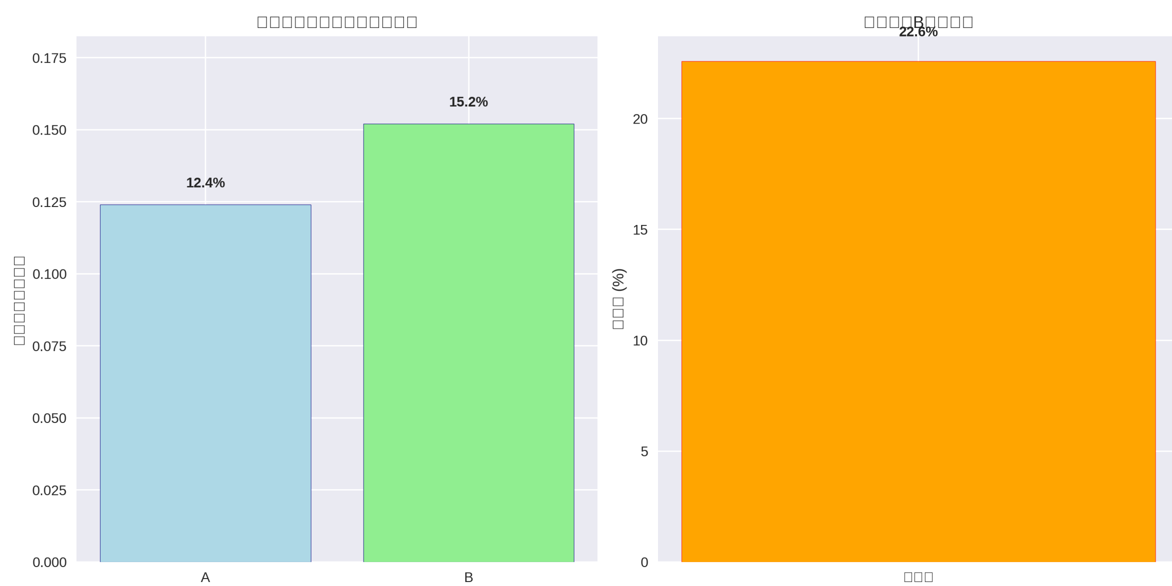

B A 22.6%

4.2

```
#
print("===      ===")

#
np.random.seed(42)

#
cohort_data = []
for month in range(12):  # 12
    n_customers = np.random.randint(80, 120)  #

    for customer in range(n_customers):
        customer_id = f"C{month:02d}_{customer:03d}"
        first_purchase = pd.Timestamp('2024-01-01') + pd.DateOffset(months=month)

        #
        for future_month in range(6):  # 6
            retention_prob = 0.8 * (0.85 ** future_month)  #
            if np.random.random() < retention_prob:
                purchase_date = first_purchase + pd.DateOffset(months=future_month)
                cohort_data.append({
                    ' ID': customer_id,
                    '   ': first_purchase,
                    '  ': purchase_date,
                    '   ': future_month
                })

cohort_df = pd.DataFrame(cohort_data)

#
cohort_table = cohort_df.pivot_table(
    index='   ',
    columns='   ',
    values=' ID',
    aggfunc='nunique'
).fillna(0)

#
cohort_sizes = cohort_df.groupby('   ')[' ID'].nunique()
```

```python
retention_table = cohort_table.divide(cohort_sizes, axis=0)

print("      :")
print(retention_table.round(3))

#
plt.figure(figsize=(15, 8))

plt.subplot(2, 1, 1)
sns.heatmap(retention_table, annot=True, fmt='.2%', cmap='YlOrRd', cbar_kws={'label': '    '}
plt.title('       ')
plt.ylabel('   ')
plt.xlabel('  ')

plt.subplot(2, 1, 2)
avg_retention = retention_table.mean()
plt.plot(avg_retention.index, avg_retention.values, marker='o', linewidth=3, markersize=8)
plt.title('       ')
plt.xlabel('  ')
plt.ylabel('     ')
plt.grid(True, alpha=0.3)
plt.gca().yaxis.set_major_formatter(plt.FuncFormatter(lambda y, _: '{:.0%}'.format(y)))

plt.tight_layout()
plt.show()

print(f"     :")
for month, rate in avg_retention.items():
    print(f"  {month}  : {rate:.1%}")
```

```
===     ===
      :
              0      1      2      3      4      5

2024-01-01  0.829  0.795  0.547  0.470  0.393  0.350
2024-02-01  0.826  0.661  0.591  0.487  0.357  0.330
2024-03-01  0.813  0.710  0.551  0.458  0.439  0.364
2024-04-01  0.832  0.726  0.593  0.558  0.407  0.310
2024-05-01  0.830  0.594  0.575  0.425  0.387  0.340
2024-06-01  0.765  0.718  0.588  0.494  0.424  0.365
2024-07-01  0.821  0.695  0.600  0.537  0.400  0.337
2024-08-01  0.768  0.758  0.705  0.474  0.326  0.379
```

```
2024-09-01  0.841  0.732  0.610  0.476  0.341  0.402
2024-10-01  0.777  0.696  0.545  0.455  0.455  0.411
2024-11-01  0.767  0.718  0.544  0.534  0.456  0.379
2024-12-01  0.773  0.659  0.568  0.409  0.500  0.386
```

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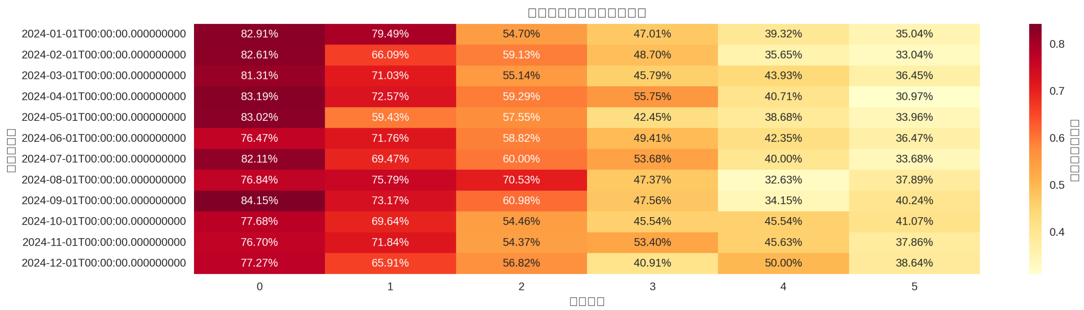

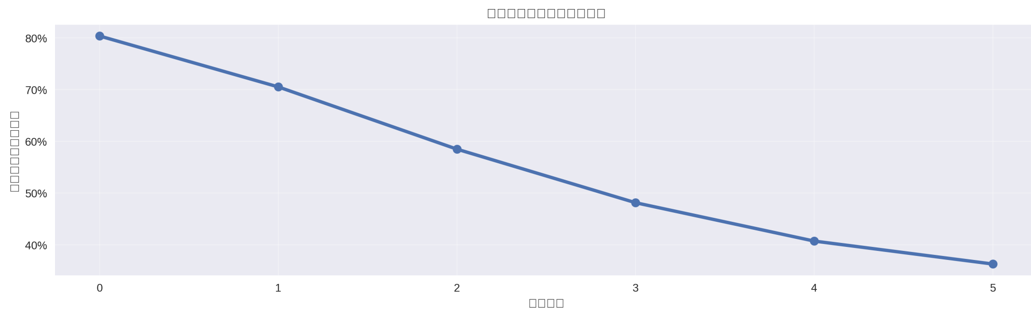

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0 : 80.4%
1 : 70.5%
2 : 58.5%
3 : 48.1%
4 : 40.7%
5 : 36.3%

Python NumPy Pandas Matplotlib