Pair Trade Strategy: SMIC and Xiaomi

A Market-Neutral Investment Opportunity in Hong Kong's Technology Sector

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Date: May 4, 2025

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1 Executive Summary

The pair trade strategy between Semiconductor Manufacturing International Corporation (**SMIC**, 0981.HK) and Xiaomi Corporation (**Xiaomi**, 1810.HK) leverages their high stock price correlation of 0.908 to exploit temporary mispricings in their price spread. By taking a long position in one stock and a short position in the other, this market-neutral approach aims to generate consistent returns while mitigating broader market risks. Backtesting over the period from January 2021 to April 2025 indicates 22 completed trades, achieving a total return of 91.86% and an annualized return of 16.36%, demonstrating strong profitability.

SMIC, as China's leading semiconductor foundry, benefits from domestic policy support and growing demand for chips in AI, IoT, and automotive applications. **Xiaomi**, a global leader in consumer electronics, is capitalizing on premium smartphone launches and its expansive IoT ecosystem, connecting over 700 million monthly active users. Their interconnected roles in the technology supply chain—**SMIC** supplies critical chips for **Xiaomi**'s devices—support their suitability for pair trading. However, both companies trade at elevated valuations (**SMIC** P/E: 101.06, **Xiaomi** P/E: 50.36) compared to industry averages (semiconductors: 22x, consumer electronics: 30x), introducing valuation risks. Investors should also monitor geopolitical tensions affecting **SMIC** and competitive pressures impacting **Xiaomi**.

The strategy is expected to deliver stable returns by capturing mean-reversion opportunities, supported by a robust framework involving z-score-based entry and exit thresholds (entry: 2, exit: 0.25). While the backtest's ADF p-value of 0.182 suggests moderate mean-reversion, the high correlation and historical co-movement provide a strong foundation for the trade. The strategy's market-neutral nature minimizes exposure to systemic risks, focusing on relative performance.

1.1 Key Investment Highlights

- **High Correlation:** A correlation of 0.908 ensures reliable co-movement between **SMIC** and **Xiaomi** stock prices, validated through historical data analysis.
- **Proven Activity:** Backtesting shows 22 completed trades, indicating active trading opportunities over the four-year period.
- **Exceptional Returns:** The pair trade strategy achieved a 91.86% return over the four-year backtest period, compared to individual stock returns of SMIC at 112% and Xiaomi at 34.6% during the same period.
- **Sector Synergy:** **SMIC**'s role as a chip supplier to tech firms like **Xiaomi** creates a fundamental linkage, reinforcing their price co-movement.
- **Market-Neutral Approach:** By balancing long and short positions, the strategy minimizes exposure to market-wide fluctuations, focusing on relative performance.
- **Growth Potential:** Both companies are well-positioned in high-growth sectors, with **SMIC** advancing in semiconductor technology and **Xiaomi** expanding its global IoT

footprint.

2 Backtest Procedure

2.1 Cointegration and Correlation Analysis

The approach for selecting appropriate stocks for pair trading involves analyzing historical stock price data to evaluate the relationship between a fixed stock and a selection of candidate stocks. This analysis includes techniques such as regression analysis, testing residuals for stationarity, calculating cointegration p-values, and assessing the correlation between stock returns. These techniques aid in identifying potentially suitable pairs for pair trading strategies based on statistical measures and performance metrics.

Given the fixed choice **SMIC**(0981.HK), several stocks in the technology sector were tested, including **Xiaomi Corporation** (1810.HK), **Hua Hong Semiconductor Ltd** (1347.HK) and **Kingdee International Softwre Grp Co Ltd** (0268.HK). The cointegration and correlation analysis results were as follows:

Table 1: Cointegration and Correlation Comparison

Paired Stock	Cointegration p-value	Correlation
Hua Hong	0.415454	0.331582
Kingdee	0.133794	0.135853
Xiaomi	0.072599	0.908381

As shown from Table 1, Xiaomi had a low p-value in cointegration showing that the null hypothesis for long term, stable relationship between it and SMIC's price movement was not rejected. Moreover, it achieved a highly 0.9 correlation with SMIC. Therefore, Xioami was chosen for further strategy formulation.

2.2 Pair Strategy

The price spread between the two stocks, scaled by their hand size, were calculated and normalized as z-score. A pair of enter threshold and exit threshold based on the z-scores were tuned as parameters for optimal enter/exit strategies.

3 Pair Trade Strategy Framework

Pair trading is a market-neutral strategy that seeks to profit from the relative price movements of two correlated securities. The strategy involves taking a long position in one security and a short position in the other when their price spread deviates significantly from its historical mean, with the expectation that the spread will revert to the mean over time. This approach is particularly effective for securities with high correlation and a fundamental relationship, as it minimizes exposure to market-wide risks and focuses on relative performance.

For **SMIC** and **Xiaomi**, the pair trade strategy is built on the following components:

1. **Stock Selection: SMIC** and **Xiaomi** were selected due to their high correlation (0.908) and fundamental linkage within the technology supply chain. **SMIC** manufactures semiconductors critical for **Xiaomi**'s smartphones and IoT devices.
2. **Spread Calculation:** The price spread is defined as the difference of **SMIC**'s stock price to **Xiaomi**'s stock price (`stock1_data - stock2_data`).
3. **Z-Score Analysis:** The spread is normalized using a 30-day rolling mean and standard deviation to calculate the z-score:

$$\text{z-score} = \frac{\text{spread} - \text{mean}}{\text{standard deviation}}$$

4. **Entry and Exit Rules:**
   - **Entry:** A long position in **SMIC** and a short position in **Xiaomi** are initiated when the z-score falls below -2 (indicating **SMIC** is undervalued relative to **Xiaomi**). Conversely, a short position in **SMIC** and a long position in **Xiaomi** are taken when the z-score exceeds 2.
   - **Exit:** Positions are closed when the absolute z-score falls below 0.25, signaling sufficient mean-reversion.
5. **Position Sizing: SMIC** stock (1810.HK) has a trading size of 500 shares per hand compared with 200 shares per hand for **Xiaomi** (0981.HK). Sizing is adjsuted based on price ratio to achieve long-short budget neutral.
6. **Transaction Costs:** A cost of 0.1105% per transaction is applied, reflecting brokerage fees, taxes and other expenses.

The backtest, conducted from January 2021 to April 2025, completed 22 trades, indicating active trading opportunities. The strategy assumes an initial capital of USD 100,000, with positions sized dynamically based on the price ratio to maintain dollar neutrality.

4 Industry Overview

4.1 Semiconductor Industry

The semiconductor industry is a cornerstone of the global technology ecosystem, underpinning advancements in AI, IoT, automotive, and consumer electronics. In 2024, global semiconductor sales reached USD 627.6 billion, marking a 19.1% increase from 2023, with projections for double-digit growth in 2025 (Semiconductor Industry Association). This growth is driven by several key trends and dynamics:

4.1.1 Sector Trends and Dynamics

- **AI and High-Performance Computing:** The rise of generative AI has spurred demand for advanced chips, particularly for AI accelerators used in PCs, smartphones, and enterprise edge computing. For instance, AI-related chips accounted for a significant portion of 2024's growth (Deloitte Insights).
- **Automotive Semiconductor Demand:** The shift toward electric vehicles (EVs) and autonomous driving technologies has increased the need for power management and sensor chips, with automotive applications growing at a CAGR of 10% through 2025 (KPMG).
- **Geopolitical Shifts:** US-China trade tensions have prompted companies to diversify supply chains, with China accelerating its push for semiconductor self-sufficiency.

4.1.2 Key Growth Drivers

- **Technological Advancements:** Progress in process nodes (e.g., 7 nm to 3 nm) enables higher performance and efficiency, critical for AI and 5G applications.
- **Government Support:** China's government has invested heavily in domestic semiconductor production, providing subsidies and tax incentives to companies like **SMIC**.
- **Consumer Electronics Recovery:** Post-pandemic recovery in smartphone and PC demand has bolstered chip sales.

4.1.3 Challenges

- **Overcapacity Risks:** Excess capacity in mature node chips (e.g., 28 nm and above) may lead to price declines, impacting profitability (Reuters).
- **Talent Shortage:** The industry faces a global shortage of skilled engineers, hindering innovation and expansion.
- **Geopolitical Risks:** US export controls on advanced semiconductor equipment continue to challenge Chinese firms.

4.1.4 Competitive Landscape

The semiconductor foundry market is dominated by TSMC (61% market share), followed by Samsung (14%) and **SMIC** (6%) as of 2024 (TrendForce). **SMIC** benefits from its focus on the Chinese market but lags behind TSMC and Samsung in advanced process technologies.

4.2 Consumer Electronics Industry

The consumer electronics industry is undergoing rapid transformation, driven by technological innovation and evolving consumer preferences. The global market was valued at USD 815.16 billion in 2024 and is projected to reach USD 1,467.94 billion by 2032, with a CAGR of 7.6% (Fortune Business Insights).

4.2.1 Sector Trends and Dynamics

- **AI and IoT Integration:** AI-powered devices and IoT connectivity are enhancing user experiences, with applications in smart homes, wearables, and connected appliances (TechInsights).
- **Sustainability Initiatives:** Consumers and regulators are pushing for eco-friendly designs, with companies adopting recyclable materials and energy-efficient technologies.
- **E-commerce Dominance:** Online sales accounted for 38.1% of revenue in 2025, driven by the growth of digital platforms and direct-to-consumer models (Statista).

4.2.2 Key Growth Drivers

- **Premiumization Trend:** Consumers are willing to pay more for high-end smartphones and IoT devices with advanced features.
- **Emerging Markets Growth:** Rising disposable incomes in markets like India and Africa are driving demand for affordable electronics.
- **IoT Expansion:** The proliferation of connected devices, expected to reach 30 billion by 2030, is a significant growth driver.

4.2.3 Challenges

- **Intense Competition:** Established players like Apple and Samsung, along with emerging Chinese brands, create pricing pressures.
- **Supply Chain Disruptions:** Chip shortages and logistical challenges continue to impact production timelines.
- **Regulatory Hurdles:** Compliance with environmental and data privacy regulations adds complexity to global operations.

4.2.4 Competitive Landscape

The smartphone market is led by Samsung (21% market share), Apple (18%), and **Xiaomi** (14%) as of 2024 (IDC). **Xiaomi** excels in cost leadership and ecosystem integration but faces competition in the premium segment.

5 Company Analysis

5.1 SMIC (0981.HK)

5.1.1 Business Model Overview

SMIC is China's largest semiconductor foundry, providing integrated circuit manufacturing services across a range of process technologies, from 350 nm to 7 nm (SMIC). As a pure-

play foundry, it manufactures chips designed by clients, serving industries such as consumer electronics, telecommunications, and automotive. Its primary customers include Huawei, Qualcomm, and Broadcom.

5.1.2 Competitive Advantages

- **Domestic Market Leadership: SMIC** holds a leading position in China's semiconductor market, benefiting from strong demand and government support.
- **Technological Progress:** Despite US sanctions, **SMIC** has achieved 7 nm process technology, positioning it for high-end applications (Wikipedia).
- **State Support:** Backed by state-owned entities like China Integrated Circuit Industry Investment Fund, **SMIC** has access to significant capital and policy incentives.

5.1.3 Competitive Disadvantages

- **Technological Gap: SMIC** lags behind global leaders like TSMC, which produces at 3 nm nodes.
- **Sanction Risks:** US export controls restrict access to advanced equipment, hindering progress in cutting-edge technologies (Reuters).
- **Geopolitical Exposure:** Ongoing US-China tensions pose risks to operations and supply chain stability.

5.1.4 Management Quality Assessment

SMIC is led by Dr. Liu Xunfeng, Chairman, who has extensive experience in management and has received accolades such as the Shanghai Outstanding Entrepreneur award (SMIC). However, the company has experienced management turnover in the past, raising concerns about leadership stability (EE Times).

5.1.5 Historical Performance

SMIC has shown resilience amid industry cycles. After a revenue decline in 2023, it rebounded in 2024, driven by increased demand for chips in consumer electronics and automotive applications. Its focus on capacity expansion and technological advancement supports its long-term growth prospects.

5.2 Xiaomi (1810.HK)

5.2.1 Business Model Overview

Xiaomi is a global leader in consumer electronics, focusing on smartphones, AIoT products, and internet services (Xiaomi IR). Its business model combines low-margin hardware sales with high-margin internet services, such as advertising and gaming, through its MIUI platform.

Xiaomi also operates a robust IoT ecosystem, connecting over 700 million monthly active users.

5.2.2 Competitive Advantages

- **Cost Leadership: Xiaomi** offers high-quality products at competitive prices, appealing to cost-conscious consumers in emerging markets.
- **Ecosystem Strength:** Its IoT platform integrates a wide range of devices, enhancing user retention and monetization opportunities (GSMArena).
- **Global Presence:** Operates in over 100 countries, with strong market share in India (18%) and Europe.

5.2.3 Competitive Disadvantages

- **Smartphone Dependency:** Smartphones account for 52% of revenue, exposing **Xiaomi** to market volatility.
- **Intense Competition:** Faces rivalry from Apple, Samsung, and Huawei, particularly in the premium segment.
- **Supply Chain Vulnerabilities:** Chip shortages and logistical disruptions impact production (XiaomiTime).

5.2.4 Management Quality Assessment

Xiaomi is led by Lei Jun, a visionary entrepreneur with a track record of driving innovation and global expansion. The management team's strategic focus on AI, IoT, and premiumization has been widely praised (Xiaomi IR).

5.2.5 Historical Performance

Xiaomi has demonstrated strong recovery post-pandemic, with significant revenue growth in 2024. Its focus on premium smartphones and IoT expansion has bolstered its financial performance, positioning it for sustained growth.

6 Financial Analysis

6.1 SMIC

6.1.1 Revenue and Growth Trends

SMIC experienced robust revenue growth in 2022 (33.6%) due to strong demand for chips, but a decline in 2023 (-13.1%) reflected a global semiconductor downturn. The recovery in 2024 (27.0%) was driven by increased orders for consumer electronics and automotive chips (SMIC).

Table 2: SMIC Financial Metrics (2021-2024). (SMIC Press Releases)

Metric	2021	2022	2023	2024
Revenue (USD M)	5,443	7,273	6,322	8,030
Revenue Growth (%)	-	33.6	-13.1	27.0
Gross Margin (%)	30.8	38.0	19.3	18.0
Operating Margin (%)	20.4	24.6	5.6	5.9
Net Income (USD M)	1,702	1,818	903	493
Operating Cash Flow (USD M)	3,012	5,348	3,358	3,176
Free Cash Flow (CNY B)	negative	negative	negative	negative
Debt-to-Equity Ratio (%)	29.0	31.0	34.0	36.0

6.1.2 Margin Analysis

Gross margins declined from 38.0% in 2022 to 18.0% in 2024, reflecting higher production costs and overcapacity in mature nodes. Operating margins also compressed due to significant capital expenditures for capacity expansion.

6.1.3 Capital Structure

SMIC maintains a moderate debt-to-equity ratio of 36.39% in 2024, supported by government-backed financing. However, high capital expenditures have resulted in negative free cash flow, posing risks to financial flexibility.

6.1.4 Cash Flow Generation

Operating cash flow improved to USD 3,130 million in 2024, driven by higher revenue, but ongoing investments in new fabs continue to pressure free cash flow.

6.2 Xiaomi

Table 3: Xiaomi Financial Metrics (2021-2024). (Xiaomi IR)

Metric	2021	2022	2023	2024
Revenue (CNY B)	328.3	280.0	271.0	365.9
Revenue Growth (%)	-	-14.7	-3.2	35.0
Gross Margin (%)	17.7	17.0	21.2	20.9
Operating Margin (%)	6.1	2.2	5.4	6.3
Net Income (CNY B)	19.3	2.5	17.5	23.7
Operating Cash Flow (CNY B)	9.79	-4.39	41.30	39.30
Free Cash Flow (CNY B)	2.6159	-10.1893	35.0316	31.9982
Debt-to-Equity Ratio (%)	20.0	21.0	20.0	19.0

6.2.1 Revenue and Growth Trends

Xiaomi faced challenges in 2022 and 2023 due to a global smartphone market slowdown, but rebounded strongly in 2024 with 35.0% revenue growth, driven by premium smartphone sales and IoT expansion (GSMArena).

6.2.2 Margin Analysis

Gross margins improved to 20.9% in 2024, reflecting a shift toward higher-margin premium products. Operating margins also rose to 6.3%, supported by growth in internet services.

6.2.3 Capital Structure

Xiaomi maintains a low debt-to-equity ratio of 0.19, indicating a strong balance sheet and minimal financial leverage.

6.2.4 Cash Flow Generation

Operating cash flow surged to CNY 53.8 billion in 2024, driven by higher revenue and improved working capital management. Free cash flow of CNY 43.8 billion provides flexibility for future investments.

7 Valuation Comparison

Table 4: Valuation Metrics Comparison

Metric	SMIC	Xiaomi
P/E Ratio (TTM)	101.06	50.36
EV/EBITDA	16.0	35.6
Market Cap (USD B)	60.74	177.00
Industry Avg P/E	22.0	30.0
Historical P/E Range	20-120	15-55

7.1 Multiple Analysis

SMIC's P/E ratio of 101.06 is significantly above the semiconductor industry average of 22, reflecting high growth expectations but also potential overvaluation (Investing.com). **Xiaomi**'s P/E of 50.36 exceeds the consumer electronics industry average of 30, driven by optimism around its IoT and premiumization strategies.

7.2 Relative Valuation to Peers

Compared to peers, **SMIC**'s valuation is elevated relative to TSMC (P/E: 28) and Samsung (P/E: 15). **Xiaomi**'s P/E is higher than Apple (P/E: 30) and Samsung (P/E: 10), reflecting its

growth trajectory but also its riskier profile.

7.3 Historical Valuation Ranges

SMIC's P/E has fluctuated between 20 and 120 over the past five years, with current levels near the high end, suggesting caution. **Xiaomi**'s P/E has ranged from 15 to 55, with the current valuation also at the upper end, indicating potential downside risk if growth expectations are not met.

8 Catalysts Risks

8.1 SMIC

8.1.1 Upcoming Catalysts

- **Technological Advancements:** Progress toward 5 nm nodes could attract more high-end clients like Huawei.
- **Increased Orders:** Rising demand from domestic clients in AI and automotive sectors.
- **Policy Support:** Potential easing of US sanctions or additional government subsidies.

8.1.2 Key Risks

- **Geopolitical Tensions:** US export controls limit access to advanced equipment, hindering technological progress (Reuters).
- **Competition:** TSMC and Samsung continue to dominate advanced nodes, capturing high-margin markets.
- **Profitability Pressure:** Overcapacity in mature nodes may lead to price declines.

8.1.3 Mitigating Factors

SMIC's strong domestic support and focus on expanding capacity in mid-range nodes mitigate some risks. Diversifying its customer base beyond Huawei can also reduce dependency risks.

8.2 Xiaomi

8.2.1 Upcoming Catalysts

- **Premium Smartphone Launches:** New flagship models could boost market share in the high-end segment.
- **EV Market Entry:** **Xiaomi**'s electric vehicle initiative, launched in 2024, may drive long-term growth.
- **IoT Growth:** Expansion of its IoT ecosystem, targeting 1 billion connected devices by 2027.

8.2.2 Key Risks

- **Competition:** Apple and Samsung dominate the premium smartphone market, challenging **Xiaomi**'s growth.
- **Supply Chain Issues:** Chip shortages and logistical disruptions may delay product launches (XiaomiTime).
- **Regulatory Challenges:** Data privacy and environmental regulations in international markets add complexity.

8.2.3 Mitigating Factors

Xiaomi's diversified revenue streams (smartphones, IoT, internet services) and strong presence in emerging markets provide resilience. Its cost-leadership strategy also helps maintain competitiveness.

8.3 Pair Trade Considerations

The pair trade strategy benefits from relative performance dynamics, where company-specific catalysts (e.g., **SMIC**'s technological progress, **Xiaomi**'s EV entry) could drive outperformance or underperformance. The high correlation mitigates systemic risks, but a breakdown in correlation due to external shocks (e.g., sanctions on **SMIC**) could disrupt the strategy.

9 Trade Execution

The pair trade strategy for **SMIC** and **Xiaomi** is executed with the following parameters, based on backtesting from January 2021 to April 2025:

- **Entry Threshold:** z-score of 2, indicating a significant deviation from the mean spread.
- **Exit Threshold:** z-score of 0.25, signaling sufficient mean-reversion.
- **Hand Sizes:** 500 shares for **SMIC**, 200 shares for **Xiaomi**, balancing dollar exposure.
- **Lookback Period:** 30 days for calculating rolling mean and standard deviation.
- **Initial Capital:** USD 100,000.
- **Transaction Costs:** 0.1105% per transaction.

9.1 Entry and Exit Points

A long position in **SMIC** and a short position in **Xiaomi** are initiated when the z-score falls below -2, indicating **SMIC** is undervalued relative to **Xiaomi**. Conversely, a short position in **SMIC** and a long position in **Xiaomi** are taken when the z-score exceeds 2. Positions are exited when the absolute z-score falls below 0.25, ensuring the spread has sufficiently reverted to the mean.

9.2 Position Sizing

The backtest uses a position size adjusted dynamically based on the price ratio to maintain dollar neutrality.

$$\text{Price Ratio} = \frac{\text{SMIC Price} \times \text{SMIC hand size}}{\text{Xiaomi Price} \times \text{Xiaomi hand size}}$$

For example, if the price ratio (**SMIC/Xiaomi**) is less than 1, the formula adjusts the position to ensure balanced exposure:

$$\text{Size} = \frac{\text{Capital}}{\text{a} \times \text{SMIC Price} + \text{b} \times \text{Xiaomi Price}}$$

where $\text{a} = 1/\text{price ratio}$ and $\text{b} = 1$ if the ratio is less than 1, or $\text{a} = 1$ and $\text{b} = \text{price ratio}$ otherwise.

9.3 Expected Holding Period

With 22 trades completed over 51 months (January 2021 to April 2025), the average holding period is approximately 2.3 months per trade. This duration reflects the time taken for the spread to revert to the mean, though it may vary based on market conditions.

9.4 Backtest Performance

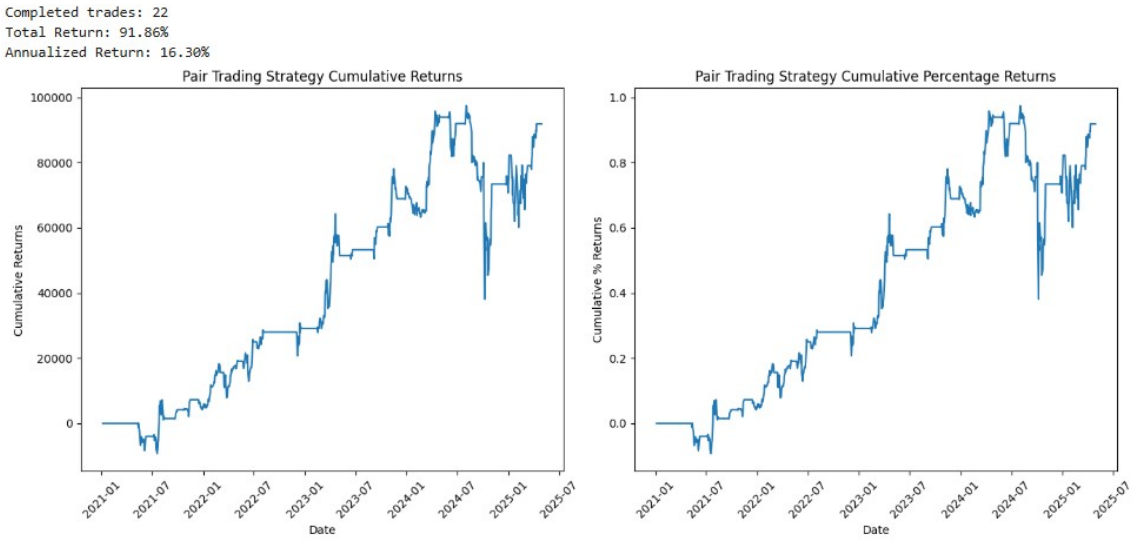

Figure 1: Cumulative returns over testing period

The backtest results, illustrated in Figure 1, show that the pair trading strategy yielded a total return of 91.86% from January 2021 to April 2025, with an annualized return of 16.36%. Over this period, the strategy executed 22 completed trades, reflecting consistent trading opportunities. The cumulative returns graph highlights steady growth, though with notable volatility around mid-2024, while the percentage returns graph underscores the strategy's ability to capitalize on mean-reversion opportunities, achieving nearly 92% growth over the four-year period. Even the dip in Oct 2024 made a quick comeback and covered the drawdown proving the mean-reverting mechanism holds true.

10 Conclusion

The pair trade strategy between **SMIC** and **Xiaomi** offers a compelling opportunity to capitalize on their correlated stock price movements within China's technology sector. The high correlation, fundamental linkage, and active trading opportunities (22 trades over four years) support the strategy's potential for consistent returns. However, investors should remain vigilant of valuation risks, geopolitical challenges for **SMIC**, and competitive pressures for **Xiaomi**. The market-neutral approach minimizes systemic risks, making this strategy an attractive option for risk-averse investors seeking stable returns.

Key Citations

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A Appendix A: Backtest Code

```
import yfinance as yf
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import statsmodels.api as sm
from statsmodels.tsa.stattools import adfuller

# Function to fetch stock data using yfinance
def fetch_stock_data(ticker, start_date, end_date):
    stock_data = yf.download(ticker, start=start_date, end=end_date, auto
    # return (stock_data['Close'].pct_change().dropna() + 1).cumprod() -
    return stock_data['Close']

# Define the fixed stock and a list of different stocks to pair with
fixed_stock = '0981.HK'
stocks_to_pair = [
    '1347.HK',
    '0268.HK',
    '1810.HK'
]  # Add more stocks as needed
name_mapping = {
    '0981.HK': 'SMIC',
    'NVDA': 'NVIDIA',
    '1347.HK': 'Hua■Hong■Semiconductor',
    '0268.HK': 'Kingdee',
    '1810.HK': 'Xiaomi'
}

# Fetch historical stock price data and perform analysis for each pair
results = []
start_date = "2021-01-01"
end_date = "2025-04-30"
price_data = fetch_stock_data([fixed_stock]+stocks_to_pair, start_date, e
price_data = price_data.fillna(method='ffill').dropna()
returns = (price_data.pct_change().dropna() + 1).cumprod() - 1
fixed_stock_data = returns[fixed_stock]
plt.plot(fixed_stock_data, label=name_mapping[fixed_stock])
for stock in stocks_to_pair:
    paired_stock_data = returns[stock]
```

```
        # cointegration_test = coint(fixed_stock_data, paired_stock_data)
        # cointegration_p_value = cointegration_test[1]

        # Step 1: Regression of paired stock on fixed stock
        X = sm.add_constant(fixed_stock_data)
        model = sm.OLS(paired_stock_data, X).fit()
        residuals = model.resid

        # Step 2: Test residuals for stationarity
        adf_test = sm.tsa.adfuller(residuals)
        adf_p_value = adf_test[1]

        correlation = fixed_stock_data.corr(paired_stock_data)

        results.append({
            'Fixed Stock': name_mapping[fixed_stock],
            'Paired Stock': name_mapping[stock],
            'Cointegration p-value': adf_p_value,
            'Correlation': correlation,
        })

        plt.plot(paired_stock_data, label=name_mapping[stock])

# Create a DataFrame to present the results
results_df = pd.DataFrame(results)

plt.title('Stock Returns')
plt.xlabel('Date')
plt.xticks(rotation=45)
plt.ylabel('Returns')
plt.legend()
plt.show()

stock1_data = price_data[fixed_stock]
stock2_data = price_data["1810.HK"]

# Stocks per hand
stock1_hand = 500
stock2_hand = 200

# Scale the data based on shares per hand
stock1_data *= stock1_hand
```

```
stock2_data *= stock2_hand

# Calculate the price ratio between the two stocks
price_ratio = stock1_data / stock2_data

# Calculate the spread between the two stocks
spread = stock1_data - stock2_data

# Perform Augmented Dickey-Fuller (ADF) test to analyze mean-reverting te
adf_test = adfuller(spread.dropna(), maxlag=1)
adf_statistic = adf_test[0]
adf_p_value = adf_test[1]

# Display ADF test results
print("ADF Statistic:", adf_statistic)
print("ADF p-value:", adf_p_value)

window = 30
# Calculate z-score of the spread based on the rolling window
spread_mean = spread.rolling(window=window).mean()
spread_std = spread.rolling(window=window).std()
z_score = (spread - spread_mean) / spread_std

# Define entry and exit thresholds
entry_threshold = 2
exit_threshold = 0.25

# Initial Capital
init_capital = 100000

# Generate signals
signals = np.where(z_score > entry_threshold, -1, np.where(z_score < -ent

# Initial Paramters
capital = init_capital
position = 0
pr = price_ratio.iloc[0]
returns = []
cumulative_pct_returns = []
completed_trades = 0
transacted = False
size = 0
```

```
cost = 0

# Backtest the pair trading strategy
for i in range(1, len(signals)):
    cost = 0
    old_position = position
    old_size = size
    if signals[i] == 1 and position == 0:
        # Enter long position in stock1 and short position in stock2
        position = 1
        pr = price_ratio.iloc[i]
        transacted = True
        # print("Enter Long Position in Stock1 and Short Position in Stoc
    elif signals[i] == -1 and position == 0:
        # Enter short position in stock1 and long position in stock2
        position = -1
        pr = price_ratio.iloc[i]
        transacted = True
        # print("Enter Short Position in Stock1 and Long Position in Stoc
    elif signals[i] == 0 and abs(z_score.iloc[i]) < exit_threshold and po
        # Exit the position
        position = 0
        completed_trades += 1
        transacted = True
        # print("Exit Position on", stock1_data.index[i])

    if pr < 1:
        a = 1 / pr
        b = 1
    else:
        a = 1
        b = pr
    if transacted:
        if position != 0:
            size = capital // (a * stock1_data.iloc[i] + b * stock2_data.
        cost = (a * stock1_data.iloc[i] + b * stock2_data.iloc[i]) * 0.11
        transacted = False

    # Adjust position size based on the price ratio
    if old_position == 1:
        r = (a * (stock1_data.iloc[i] - stock1_data.iloc[i-1]) - b * (sto
    elif old_position == -1:
```

```
            r = (b * (stock2_data.iloc[i] - stock2_data.iloc[i-1]) - a * (sto
        else:
            r = 0
        returns.append(r - cost)
        capital += r - cost
        cumulative_pct_returns.append(capital / init_capital - 1)

print(f"Completed trades: {completed_trades}")

# # Calculate the Sharpe ratio
# daily_risk_free_rate = (1 + 0.0417)**(1/252) - 1
# excess_daily_returns = pd.Series(pct_returns) - daily_risk_free_rate
# average_excess_return = np.mean(excess_daily_returns)
# std_dev_excess_return = np.std(excess_daily_returns)
# sharpe_ratio = average_excess_return / std_dev_excess_return
# print(f"Annualized Sharpe Ratio: {(np.sqrt(252) * sharpe_ratio):.2f}")

# Calculate cumulative returns
cumulative_returns = np.cumsum(returns)
fig, axs = plt.subplots(1, 2, figsize=(14, 6))
axs[0].plot(stock1_data.index[1:], cumulative_returns)
axs[0].set_title('Pair Trading Strategy Cumulative Returns')
axs[0].set_xlabel('Date')
axs[0].set_ylabel('Cumulative Returns')
axs[0].tick_params(axis='x', labelrotation=45)
axs[1].plot(stock1_data.index[1:], cumulative_pct_returns)
axs[1].set_title('Pair Trading Strategy Cumulative Percentage Returns')
axs[1].set_xlabel('Date')
axs[1].set_ylabel('Cumulative % Returns')
axs[1].tick_params(axis='x', labelrotation=45)

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