Quantitative Trading on NSE, India

Investment size – USD $5.0m
Unlevered Return – 18.7%
December 2023

Executive Summary

- **Quantitative trading system** – Quantitative investing is an investment philosophy which involves mathematical and statistical tools for number crunching past data to identify trading opportunities. A quantitative trading system is a diversified portfolio of low or inversely correlated quantitative strategies with strong execution capabilities and robust risk management systems.

- **National Stock Exchange is the** biggest stock exchange of India. It has three asset classes – i) Capital Markets, ii) Fixed Income, and iii) Derivatives. With an average daily turnover of $7.7 billion in equity options, it is ranked number 1 in the global rankings for derivatives contracts traded. The criteria to select a stock for derivatives trading is laid down by SEBI, India's financial regulator.

- **Historical movement in underlying stocks** – A long position in the stocks of 10 large-cap companies between 2015 till 2023 produced an average CAGR of 20.0%, individually. However, the stocks have a daily average range of 3.14%, totaling to an annual range of 776.5% for the same period. This presents an opportunity to develop a quantitative trading system.

- **Investment Opportunity** – An opportunity to invest ~$5.0 million in a quantitative trading system designed for NSE to advantage from the intraday movement of equity stocks using derivatives. A four-stage process is built to ensure continuous development and execution of strategies – i) Data Collection, ii) Hypothesis Development, iii) Trade Execution, and iv) Risk Management.

- **Historical returns & drawdowns** – The quantitative trading system was backtested on a portfolio of ten large cap companies. It generated a CAGR of 18.7% between 2015 and 2023, as against 17.2% generated by a long-only portfolio of same stocks. However, the latter experienced an average of two drawdowns of more than 5% each year with a maximum of drawdown of 50.7% in the year 2020. By contrast, the quantitative system experienced a drawdown of more than 5% only once in the year 2022.

- **Investment rationale** – includes **i) Strong liquidity** – Average time to enter or exit the portfolio is 1 day, **ii) Uncorrelated returns** – The returns are inversely correlated to long-only portfolios by benefitting from short-term long and short trades, **iii) Diversification** – Strategies are run on a portfolio of stocks to diversify the risks associated with individual stocks, and **iv) Negligible operating costs** of developing or upgrading a quantitative execution platform by leveraging the services of Zerodha.

Quantitative Trading

What is Quantitative Trading?

- Quantitative trading consists of trading strategies based on quantitative analysis, which rely on the use of mathematical and statistical methods to identify trading opportunities.
- The process usually consists of searching vast databases for patterns, such as correlations among liquid assets, price-movement patterns (trend following or reversion), or volatility due to events.
- Quantitative finance techniques were first developed in 19th century with Jules Regnault modelling stock prices as a random walk. However, this trading style gained fame with the advent of computers in 1970's which assisted trading firms with collection and analysis of big data.
- A Quantitative Trading system is a collection of quantitative trading strategies developed and executed using a process-based system. Examples of large investment managers using such systems include Renaissance Technologies, DE Shaw, and AQR Capital Management.

When is Quantitative Trading used?

- A quantitative trading strategy is generally opted when an investor wants to eliminate emotional-trading and develop a rule-based system to advantage from movements in the market rather than follow the conventional 'buy and hold' approach.
- Assets selected for such an approach have a rich history of transaction data and sales volume, such as publicly listed equities, to analyze past patterns in their transactions for future trading opportunities.
- The duration of a trade can vary by the length of the past patterns. High frequency trading systems benefit from market opportunities lasting for several minutes (such as arbitrage trading) while opportunities identified where stocks of companies are trading below their book value can last for several months or even years.

Attributes of a strong Quantitative Trading system.

- **Rule-based system over emotions** – A strong system consists of rules to guide the purchase and sale of an investment. The rules must cover all possible scenarios in the market, leaving little scope for human interference. This eliminates 'emotions' involved with an investment decision.
- **Process-based over conviction** - An ideal system employs a research-based 'systematic and consistent approach' to portfolio construction. It is a disciplined approach of identifying repeatable sources of return, with a high conviction in the process rather than a particular stock or an asset.
- **Diversified strategies** - Diversification is achieved within a quantitative portfolio by adding strategies with low or negative correlations to existing strategies.
- **Little variation in execution** – The rule-based systems are not just paper-worthy but can be executed in real-markets, and execution systems are consistently updated for faster execution of existing as well as more complicated systems in future. Overall, the expected trade and the actual trade should be similar.

News and articles on Quantitative Trading:

Renaissance Technologies - Since 1988, their flagship Medallion fund has generated average annual returns of 66% before charging hefty investor fees—39% after fees—racking up trading gains of more than $100 billion. No one in the investment world comes close. Warren Buffett, George Soros, Peter Lynch, Steve Cohen, and Ray Dalio all fall short.

— *'The Man Who Solved the Market: How Jim Simons Launched the Quant Revolution' by Gregory Zuckerman 2019*

As on Dec 31, 2023, quantitative funds Citadel and DE Shaw are the top two money managers in terms of net gains posted (net of fees) since their inception in 1990 and 1988, respectively.

— *'The Capital Holdings Funds, one of the world's oldest fund of hedge funds (launched in 1969).*

Regular Investors Are Moving Into Quant-Style Trading – Wall Street has been transformed by the world revolution, in which hedge funds and other sophisticated investors use algorithms to spot market signals and trade automatically. For years, ordinary people could only watch – or pay quant fund's hefty management fees. Now, they are getting in the game themselves.

— *By Bob Henderson, Wall Street Journal, Jan 2024*

NSE at a glance

- National Stock Exchange (NSE) is the biggest stock exchange of India by number of contracts traded. Based in Mumbai, it commenced operations in 1994 and was the first exchange in India to implement electronic trading. NSE is under the ownership of various financial institutions such as Life Insurance Corporation (10.7%) and State Bank of India (7.6%), the country's largest insurance company and bank, respectively.

- NSE's product are organized into 3 asset classes for trading – i) Capital Markets for the listing and trading of equities, ii) Fixed Income securities, and iii) Derivatives Market (Table II). It's flagship index, Nifty 50, represents the weighted average of 50 of the largest Indian companies listed on the platform.

- NSE has adopted a vertically-integrated business model to strengthen its position as one of the world's largest and reliable exchanges. Its key subsidiaries include:
  - i) NSE Clearing for clearing and settlement of all trades executed on NSE, as well as deposit and collateral management and risk management functions,
  - ii) NSE Indices to provide customized indices for investment funds,
  - iii) NSEIT provides end-to-end technology solution for trading applications and infrastructure services. It offers services in i) Artificial Intelligence, ii) Applications, iii) Cloud, iv) Cybersecurity, and v) Data Analytics.
  - iv) NSE Data & Analytics consolidates data and info-vending business.

- During FY 2023-24, NSE mobilized $172.5 billion (17.5% debt, 82.5% equity), listed 213 companies through IPOs, and had an average daily turnover of $7.7 billion in the equity options market. In terms of numbers of contracts traded, it is Ranked 1 & 3 in the Derivatives and Equity exchanges, respectively amongst the world exchanges.

- NSE currently provides F&O contracts on 5 major indices and more than 180 securities. The eligibility of selection is based upon the criteria laid down by Securities & Exchange Board of India (SEBI), India's financial regulator, which can be found here.

Global Ranking as Derivatives Exchange	Global Ranking as Equity Exchange	Market Share in Indian Equity Cash & Futures
Rank 1	Rank 3	92.7% 99.9%

Sources: International Monetary Fund (IMF); Investing.com; NSE Annual Reports

Table I: CAGR of GDP and marquee equity index of countries

Country	GDP FY 2019 – 23	GDP FY 2023 – 29 (E)	Equity Index	CAGR FY 2019 – 23
USA	5.78%	4.17%	S&P 500	12.02%
China	5.00%	5.85%	SSE 100	3.73%
Canada	4.40%	4.62%	S&P/TSX 225	6.16%
India	5.73%	10.31%	Nifty 50	14.94%
UK	3.07%	5.69%	FTSE 100	2.10%
Germany	2.31%	3.11%	DAX 40	8.44%
Japan	-3.52%	2.71%	Nikki 225	10.01%

Table II: NSE's products and services

Segment	Products & Services
Capital Markets	Equity shares, ETFs, REITs, Mutual funds, Sovereign Gold Bond (SGB), Government securities, treasury bills, state development loan and STRIPS.
Fixed Income	Corporate bonds, G-Sec, Commercial Paper, Commercial Debt, convertible and non-convertible debt instruments.
Derivatives Market	Equity derivatives, including index derivatives and single stock derivatives, currency derivatives, Interest rate derivatives and commodity derivatives including bullion, energy and base metals
Data & Information Vending	NSE's real-time data feed, 15-minute delayed data, 5 minutes, 2 minutes and 1-minute snapshot data, end of day data, historical trade & order, historical trade data, corporate data, bond valuation, indicative NAV for ETFs, analytical products using trading data, NSE Fixed In (fixed income analytical platform) etc
Index Services	Equity indices (flagship indices such as Nifty 50, Nifty Bank etc.), ESG indices, debt indices, hybrid indices, customised indices and index constituent data subscription etc.

Intraday movement in equity stocks listed on NSE

Analyzing selected equity stocks listed on NSE from Jan 1st, 2015, till Dec 31st, 2023 (Table I) -

- A portfolio of ten equity stocks was built. Each stock weighs equally in the portfolio in terms of value and the portfolio is re-balanced at the end of each year.

- The stocks were selected on the following basis –
  - i) Large cap companies across various industries
  - ii) F&O contracts were available on these stocks

- CAGR (Column A) – Lists the % CAGR for investing in the companies from Jan 1st,2015, till Dec 31st, 2023. The overall portfolio generated CAGR of 20.0% per annum.

- Average Intraday Range (Column B) calculates the average movement of a stock between 2015 and 2023. It is calculated by averaging a stock's daily range, i.e.,

$$\text{Avg} \sum (\text{High(i)} - \text{Low (i)})/\text{Close(i)}$$

  where i represents the ith day.

- Average Annual Intraday Range (Column C) calculates the sum of average intraday ranges in a year by multiplying Column B by 247 (average trading days in a year). In other words, this is the average annual returns for an investor who can identify a stock's daily high and low point. We use this as the benchmark for our trading strategies.

- Average % days in a year with intraday range of > 2% (Column D) indicates how likely it is for the stock to move. Higher percentage means higher chances of trading opportunities for a momentum-based strategy.

Table I – Key characteristics of 10 stocks from Jan 1st, 2015 till Dec 31st, 2023

Stock Name	Industry	Col A: CAGR % (2015 – 2023)	Col B: Avg Intraday Range (in %)	Col C: Avg Annual Intraday Range (Col B*247)	Col D: Avg % days in a year with intraday range > 2%
Adani Enterprises	Diversified	45.4%	4.66%	1152.2%	90.2%
Axis Bank	Banking	9.1%	2.75%	679.1%	64.5%
DLF Ltd	Real Estate	20.3%	3.87%	957.5%	87.7%
IndusInd Bank	Banking	7.8%	3.02%	747.1%	63.2%
Kotak Bank	Banking	13.1%	2.33%	575.3%	50.0%
Maruti Suzuki	Automobile	13.3%	2.28%	562.8%	46.5%
PFC	Infra	10.7%	3.37%	833.7%	81.6%
SBI	Banking	8.3%	2.73%	674.1%	62.3%
Tata Motors	Automobile	5.1%	3.24%	801.1%	76.9%
Tata Power	Infra	16.8%	3.16%	782.0%	70.7%
Average		**20.0%**	**3.14%**	**776.5%**	

Investment Opportunity

An opportunity to invest $5.0m in short-term (intraday & swing) quantitative trading strategies on NSE to advantage from the intraday movement of equity stocks using derivatives.

A four-stage investment process has been developed for the execution of the opportunity –
i) accuracy of past data, ii) hypothesis development, iii) execution capabilities, and iv) robust risk management systems**:**

i) Data Collection
- **Collect & Store Data** - An in-house tool has been developed to collect data from Zerodha, the largest stockbroker in India. For verification, secondary data is collected from NSE-listed data provider.
- **Data Analysis** – The collected data is used to analyze past patterns using pre-defined techniques.

ii) Hypothesis Development
- **Develop hypothesis** - Trading ideas are constantly innovated using research papers and trading books.
- **Hypothesis Testing** – The hypothesis, once developed, is tested on the data of a portfolio of stocks. The returns and drawdowns are analyzed over different periods of time.
- **Transfer the successful hypothesis to execution** – Hypothesis with returns and drawdowns meeting the hurdle rates, and lower or negative correlations with existing live strategies are transferred for execution, subject to the approval from the risk management team.
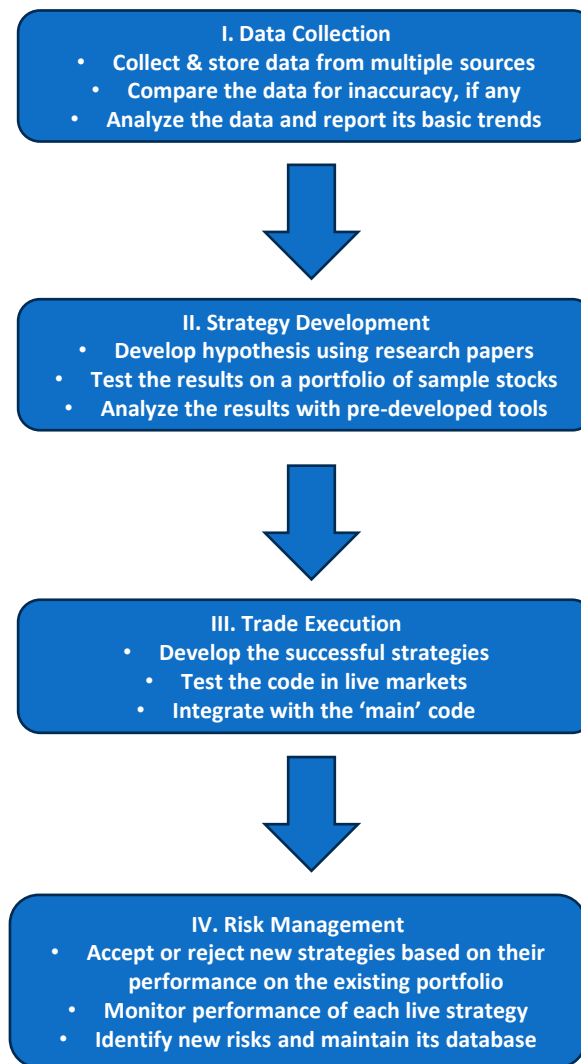
iii) Trade Execution
- **Develop the code** - The successful hypothesis are coded on 'Python' software.
- **Testing the code** -The code is run in live markets independently to resolve bugs, if any.
- **Code integration** - The code is integrated with the 'main' code with existing live strategies.

iv) Risk Management
- **Hypothesis acceptation/ rejection** – Successful hypothesis are re-checked from beginning to determine any flaws. If passed, the hypothesis is ready for the execution team.
- **Monitor portfolio's performance** - Each live strategy in the portfolio is monitored. Strategies deviating from the expected returns are reported, corrected, or removed if necessary.
- **Identify risks and solve/ mitigate them** – Existing risks are monitored, and new risks are identified, evaluated, and resolved. A repository of all risks in maintained and updated regularly.

Chart I – The four-stage investment process

I. Data Collection
- Collect & store data from multiple sources
- Compare the data for inaccuracy, if any
- Analyze the data and report its basic trends

II. Strategy Development
- Develop hypothesis using research papers
- Test the results on a portfolio of sample stocks
- Analyze the results with pre-developed tools

III. Trade Execution
- Develop the successful strategies
- Test the code in live markets
- Integrate with the 'main' code

IV. Risk Management
- Accept or reject new strategies based on their performance on the existing portfolio
- Monitor performance of each live strategy
- Identify new risks and maintain its database

Historical Returns & Drawdowns

Portfolio

- A portfolio was built with ten stocks (listed on Slide 5) with equal weightage.
- Quantitative trading strategies were backtested on each stock's equity and future contracts from Jan 2015 till Dec 2023.
- Returns and drawdowns were analyzed on the portfolio with the quantitative trading system. The results were compared with a portfolio with long-only positions of the same stocks.

Returns (Graph I)

- The quantitative portfolio generated a CAGR of 18.7% vs long-only 17.2%.
- The correlation between the two portfolios is -0.15, indicating a reverse correlation.
- Long-only performed better during periods of low/ climbing global interest rates (2021 – 2023). However, quantitative portfolio has a lower variation (Table I).

Drawdowns (Table I)

- Drawdown means a scenario when the value of a portfolio falls by 5% or more.
- For example, a portfolio valued at $100.0 on Jan 1st, 2023, reaches $120.0 on May 31st, 2023. It falls to $114.0 on Sep 30th, 2023, before climbing back to $125.0 on Dec 31st, 2023. The drawdown is 5.0% ($120.0 - $114.0)/$114.0.
- Table I captures the number of drawdowns and the maximum drawdown each year. Long-Only portfolio has witnessed an average of two drawdowns each year with an average drawdown of 15.4%. By contrast, the quantitative system has only experienced a single drawdown event in 9 years (in year 2022).

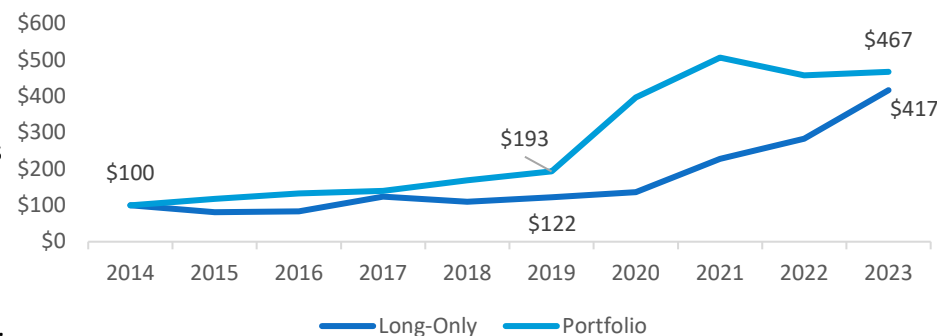**Graph I – Equity vs Futures Portfolio ($100 invested in 2015)**

Table I – Yearly drawdowns in Equity vs Futures Portfolio

Year	Long-Only			Quantitative System		
	Returns	DD (#)	Max DD	Returns	DD (#)	Max DD
2015	-18.9%	2	36.7%	17.9%	0	-
2016	2.6%	2	22.4%	12.6%	0	-
2017	48.7%	1	9.5%	5.2%	0	-
2018	-11.6%	1	26.4%	20.8%	0	-
2019	11.4%	3	20.57%	14.6%	0	-
2020	11.6%	2	50.7%	105.3%	0	-
2021	67.6%	4	12.2%	27.6%	0	-
2022	24.3%	4	16.4%	-9.6%	1	11.8%
2023	47.0%	2	13.9%	2.1%	0	-
CAGR/ Avg	17.2%	2	15.4%	18.7%	0	11.8%

I. Strong liquidity

NSE is the largest derivatives exchange in the world by the number of contracts traded. The positions held in any stock at any time is less than 0.1% of its overall open interest in the market. It allows to square off the trades instantly. Moreover, NSE offers T+1 settlement.

II. Uncorrelated returns

The returns are inversely uncorrelated to the market movement. Quantitative strategies aim at providing absolute returns under all market conditions by taking advantage of both long & short trades.

Investment Rationale

III. Diversification

The strategies, divided into two segments – momentum and anti-momentum, run on a portfolio of various stocks. This diversifies unsystematic risks associated with individual stocks.

IV. Lower operating costs

Zerodha, one of the biggest broker on NSE, provides end-to-end services for developing and running automated strategies. This significantly lowers the costs and hassles for quantitative firms.