Trading Algorithms

INTRODUCTION TO AUTOMATED TRADING

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Outlines

- A Brief History of Stock Trading
- Algorithmic Trading: Definition
- Algorithmic Trading: Pros and Cons
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A Brief History of Stock Trading

- Companies need **capital** to operate and expand their businesses.
- To raise capital, they can either **borrow money** then pay it back over time *with interest*, or they can **sell a stake (equity)** in the company to an investor.
- As part owner of the company, the investor would then receive a portion of the profits in the form of **dividends**.
- The price of an equity is influenced by factors related to the performance of the company, existing market conditions and in particular, the future outlook of the company, the sector, the demand and supply of capital and the economy as a whole.

A Brief History of Stock Trading …

- When we discuss trading, we refer to the act of **buying** and **selling** equity of various companies and institutions among investors who have different views of their intrinsic value.
- Buyers and sellers meet and agree on a price to exchange a security, called **price discovery**.
- When that transaction is made public, it in turn informs other potential buyers and sellers of the most recent market valuation of the security.

A Brief History of Stock Trading …

- The tale begins on May 17, 1792 when a group of 24 brokers signed the **Buttonwood Agreement**. This bound the group to trade only with each other under specific rules.
- This agreement marked the birth of the **New York Stock Exchange (NYSE)**.
- While the NYSE is not the oldest Stock Exchange in the world, nor the oldest in the US, it is without a question the most historically important and undisputed symbol of all financial markets.
- For the next almost 200 years, stock exchanges evolved in complexity and in scope. They, however, **conceptually remained unchanged**, functioning as **physical locations where traders and stockbrokers met in person to buy and sell securities**.

A Brief History of Stock Trading …

- Changes came in the late 1960s and early 1970s.
- In 1971, the NASDAQ Stock Exchange launched as a **completely electronic system**.
- In 1969, the Institutional Networks Corporation launched Instinet, a computerized link between banks, mutual fund companies, insurance companies so that they could trade with each other with immediacy, completely bypassing the NYSE.
- **Instinet** was the first example of an **Electronic Communication Network (ECN)**, an alternative approach to trading that grew in popularity in the 80s and 90s.

A Brief History of Stock Trading …

- The year 2001 brought another momentous change in the structure of the market.
- On April 9th, the Securities and Exchange Commission (SEC) mandated that the minimum price increment on any exchange should change from **1/16th of a dollar (approximately 6.25 cents)** to **1 cent**.
- This seemingly minor rule change with the benign name of **Decimalization (moving from fractions to decimal increments)** had a dramatic effect, causing the average spread to significantly drop and with that, the profits of market makers and broker dealers also declined.
- The **reduction in profit** forced many market making firms to exit the business which in turn reduced available market liquidity.

A Brief History of Stock Trading …

- Some market participants argued that actual market liquidity did in fact remain stable after decimalization, although **it was spread out over a larger number of price points.**
- For example
  - Suppose that prior to decimalization the best offer for a stock was 5000 shares at $30.00. However, after decimalization the market offers were 500 shares at $29.98, 1000 shares at $29.99, 2000 shares at $30.00, 1000 shares at $30.01, and 500 shares at $30.02.
- In this example, **neither the total liquidity or average offered price for 5000 shares has changed**, but the **measured liquidity at the best market ask has decreased** from 5000 shares pre-decimalization to 500 shares post-decimalization.

A Brief History of Stock Trading …

- So, while **market depth** (e.g., "transaction liquidity") measured as the total quantity of shares at the best bid and ask has decreased, **actual market liquidity** may be unaffected.
- What has changed in this example is that now it takes **five times as many transactions** to fill the 5000 share order.
- Thus, even if liquidity has remained stable, **trading difficulty**, as **measured by the number of transactions required to complete the order**, has in fact increased.

A Brief History of Stock Trading …

- To bring liquidity back, exchanges introduced the **Maker-Taker fee model**.
- This model compensated the traders **providing liquidity (makers)** in the form of rebates, while continuing to charge a fee to the **consumer of liquidity (takers)**.
- The maker-taker model created unintentional consequences. If one could provide liquidity, one could make a small profit, due to the rebate with minimal risk and capital.
- This **process needs to be fairly automated** as the per trade profit would be minimal, requiring heavy trading to generate real revenue.

A Brief History of Stock Trading …

- **Trading also needs to be very fast** as position in the order book and speed of **cancellation** of orders are both critical to profitability.
- This led to the explosion of what we today call **High Frequency Trading (HFT)** and to the wild ultra-low latency technology arms race.
- HFT style trading already existed but never as a significant portion of the market. At its peak it was estimated that more than **60%** of all trading was generated by HFTs.
- The **decrease in average trading cost**, the **trend of on-line investing**, the **increase in the trading volumes** and the **increase the frequency of trades** slowly evolved into a field that we now call **algorithmic trading**.

Algorithmic Trading: Definition

- **Algorithmic trading** is the use of a program containing a **set of instructions for trading purposes** which is executed in a pre-determined manner specifically *without any human intervention*.
- Algorithmic trading has been referred to as **automated**, **black box**, **robo** and **quantitative** **trading**.
- The most popular market sectors traded in algo trading are **commodities** (metals, agricultural produce), **energy** (oil, gas), **equities** (stocks of different companies), **interest rate bonds** (coupons you get in exchange for debt, which accrues interest, hence the name), and **foreign exchange** (cash exchange rates between currencies for different countries)

Algorithmic Trading: Definition …

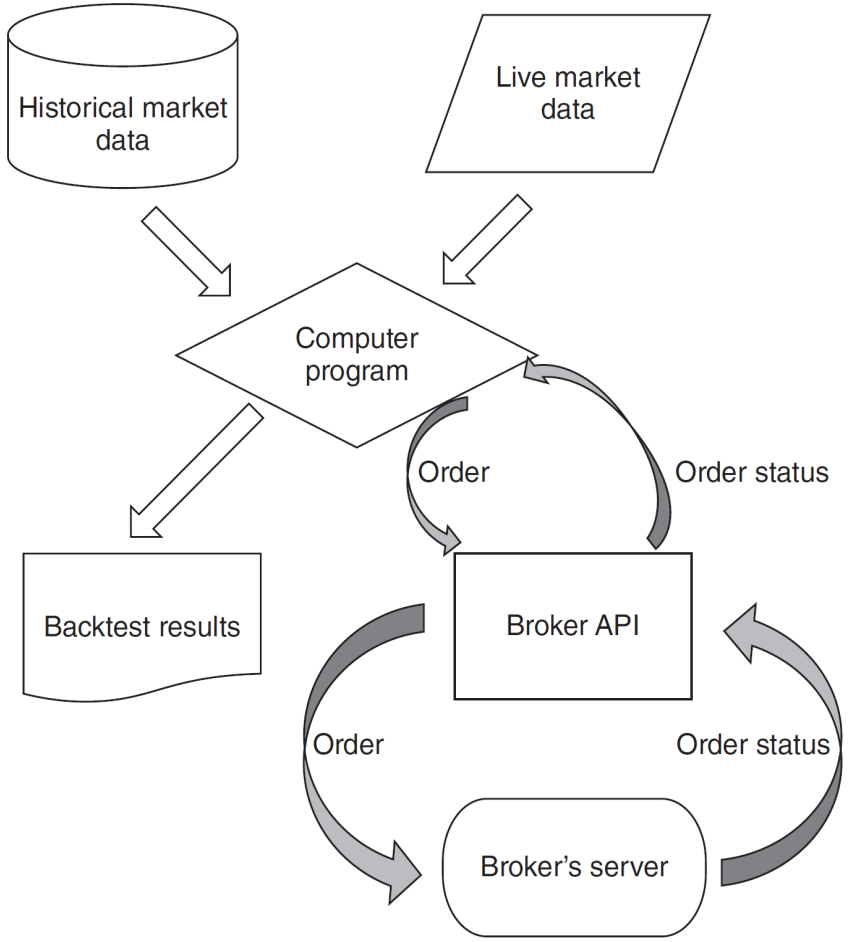
- *Is quantitative trading just a fancy name for technical analysis?*
- Granted, a strategy based on technical analysis can be part of a quantitative trading system if it can be fully encoded as computer programs.
- However, not all technical analysis can be regarded as quantitative trading.
- For example, certain chartist techniques such as **look for the formation of a head and shoulders pattern** might not be included in a quantitative trader's arsenal because they are quite subjective and may not be quantifiable.
- **Yet quantitative trading includes more than just technical analysis.**

Algorithmic Trading: Definition …

- Many quantitative trading systems incorporate fundamental data in their inputs: numbers such as **revenue**, **cash flow**, **debt-to-equity ratio**, and others.
- When it comes to judging the current financial performance of a company compared to its peers or compared to its historical performance, the computer is often just as good as human financial analysts—**and the computer can watch thousands of such companies all at once.**
- Advanced quantitative systems can even incorporate news events as inputs since it is possible to use a computer to parse and understand the news report.
- So you get the picture: **As long as you can convert information into bits and bytes that the computer can understand, it can be regarded as part of quantitative trading.**

Algorithmic Trading: Definition …

Algorithmic trading at a glance



Algorithmic Trading: Pros and Cons

- Algorithmic trading possesses numerous advantages over discretionary methods.
  - **Historical Assessment (Ability to Backtest)**
    - The most important advantage in creating an automated strategy is that its performance can be ascertained on **historical market data**, which is (hopefully) representative of future market data.
    - This process is known as **backtesting** that allows the (prior) statistical properties of the strategy to be determined, providing insight into whether a strategy is likely to be profitable in the future.

Algorithmic Trading: Pros and Cons …

- **Comparison**
  - Systematic strategies provide statistical information on both historical and current performance.
  - In particular, it is possible to determine equity growth, risk (in various forms), trading frequency and a myriad of other metrics.
  - This allows an *apples to apples* comparison between various strategies such that capital can be allocated optimally. This is in contrast to the case where only **profit & loss (P&L) information** is tracked in a discretionary setting, since it masks **potential drawdown risk**.

Algorithmic Trading: Pros and Cons …

- **No Discretionary Input (Minimization of human emotions)**
  - One of the primary advantages of an automated trading system is that there is (theoretically) no subsequent discretionary input.
  - This refers to modification of trades at the **point of execution** or **while in a position**.
  - **Fear and greed** can be overwhelming motivators when carrying out discretionary trading.
  - In the context of systematic trading it is rare that discretionary input improves the performance of a strategy.

Algorithmic Trading: Pros and Cons …

- **Increased Speed (Higher Frequencies)**
  - One of the most significant advantages of algo trading is the speed it offers.
  - The algorithms have the capability to analyze a variety of parameters and technical indicators in a split second and **execute the trade immediately**.
  - The increased speed becomes very important as the **price movements can be captured by the traders as soon as they occur**.
- **More Accuracy**
  - The algos are checked and rechecked, so they do not get affected by the human errors.
  - It is possible for a trader to make an error and analyze the technical indicators incorrectly, however, the computer programs do not make such mistakes in ideal scenarios. Thus, the **trades get executed with maximum accuracy**.

Algorithmic Trading: Pros and Cons …

- **Increased market volumes**
  - With the help of algo trading, **large volumes of shares** can be bought and sold within a fraction of seconds.
  - As a result, the **overall volume and liquidity** of the market get increased and the trading process becomes more streamlined and systematic.
- **Diversification (Automation of the asset selection process)**
  - Since algo trading uses algorithms and computers, the process of executing multiple trades at the same time and multiple strategies at the same time becomes fairly easy.
  - The trading opportunities can be scanned over a range of markets, assets and instruments and orders are executed simultaneously.
  - This leads to **diversification which is very challenging in the absence of automation and algorithms.**

Algorithmic Trading: Pros and Cons …

- While the advantages of algorithmic trading are numerous there are some disadvantages.
  - **Dependence on Technology**
    - The biggest con of algo trading is its **immense dependence on technology**.
    - The trade orders, in many cases, reside on the computer, and not on the server. This means that if the internet connection is lost, the order will not be sent for execution. This fails the entire ideology of algo trading. **In such cases, the traders miss out on the opportunities and may end up losing money**.
    - There are major systemic problems with algo trading that may also lead to huge flash crashes of the entire market.

Algorithmic Trading: Pros and Cons …

- **Requirement of Resources**
  - Algo trading helps in the reduction of the **transaction costs**, however, **it also adds on a lot of expenditure**.
  - The traders need to be equipped with high-end resources, must have an access to the server and must develop the algorithms using costly technology.
  - Another big expense is the cost of data feeds that help in formulating intraday strategies.
- **Programming/Scientific Expertise (Need to Know the Programming Process)**
  - Algo trading requires for the traders to **develop the algorithms**.
  - Not all investors are technically skilled. Therefore, they may either need to learn new processes or hire someone (programmer).
  - The need for technical know-how makes algo trading quite complicated for the general public.

Algorithmic Trading: Pros and Cons …

- **Risk of Over-Optimization**
  - It is highly probable that the strategies formulated on paper may not turn out to be successful and effective during live trading.
  - This is called **over-optimization**, wherein the trading plan becomes **unreliable in live markets**.
  - Despite strategies being built on historical data, there is a large possibility of the strategy failing as soon as it goes live, if the right methods are not employed.
- **Regulations**
  - Another con of algo trading is that it is subject to a lot of regulations.
  - The regulatory bodies of different countries have not been able to reach a consensus on whether **algo trading should be legal or not**.
  - There are many restrictions on algorithmic trading, and they must be dealt with before making a decision to start.

Algorithmic Trading: Pros and Cons …

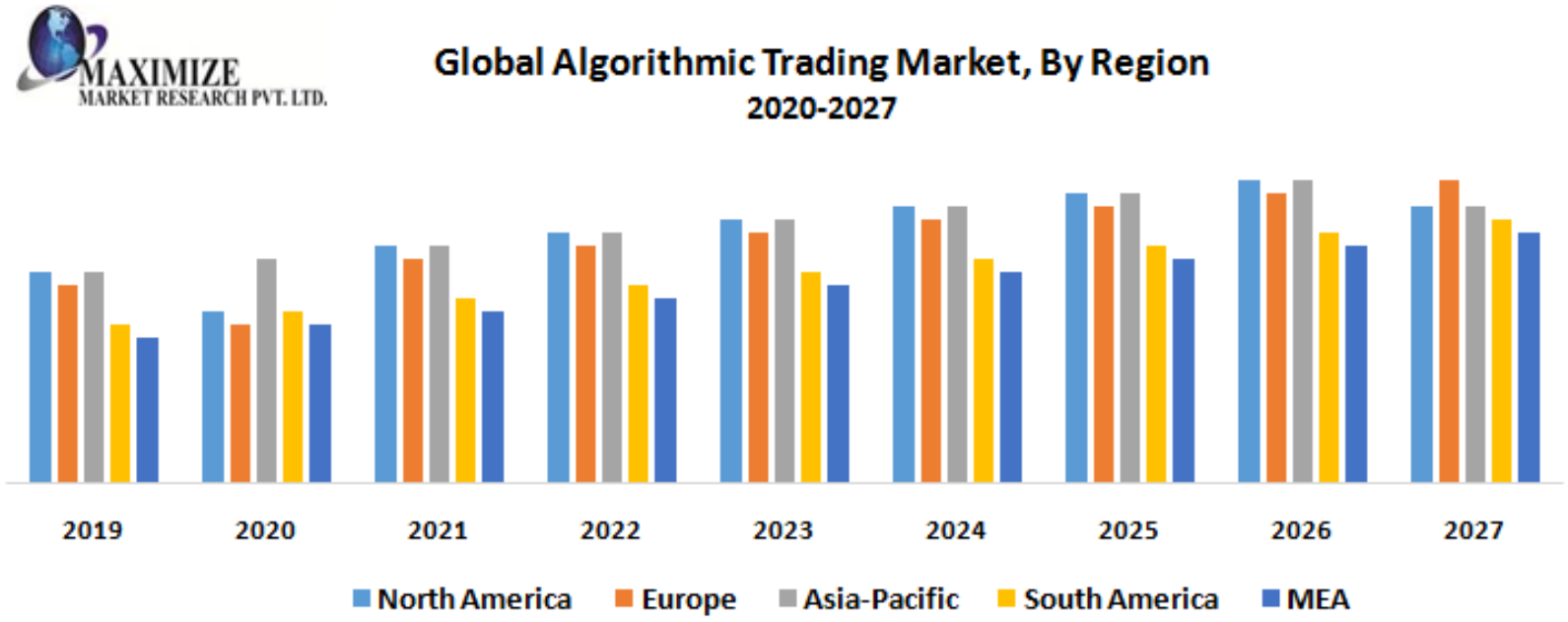
- **Loss of Human Control (Inability to Understand Irrational Markets)**
  - Algo trading is completely automated. Even if a trader realizes before the execution of the order that the strategy will not work in the **particular scenario**, he does not have the control to abandon the program and stop the trade.
  - Even if the program runs in **a direction that the trader does not want to**, there is **no way to stop it** and control the losses.
- **Short life span of the algorithms**
  - Most of the trading algorithms have a very short lifespan.
  - They work till they are suitable, and then suddenly stop working in the **rapidly changing market**. They are, then, required to be fixed or recreated.
  - The **formulation of algorithms** and strategies is a **continuous process** and it consists of regular monitoring, improvement, and reinventing.

Algorithmic Trading Market

- The global algorithmic trading market size is predicted to grow from USD 11.1 billion in 2019 to USD 18.8 billion by 2024, at a Compound Annual Growth Rate (CAGR) of 11.1% during the forecast period.

Source: MarketsandMarkets Analysis

Algorithmic Trading Market …



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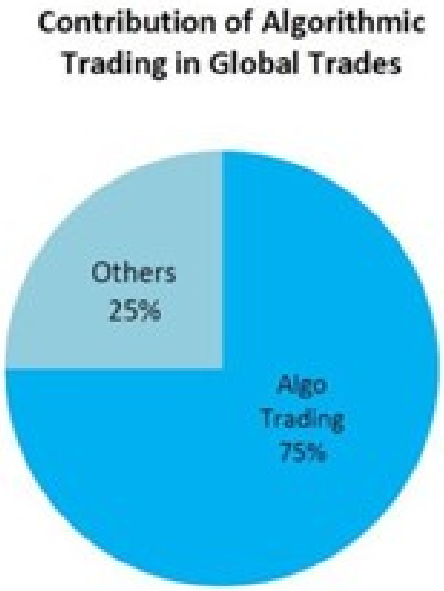

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Algorithmic Trading in Academia

Number	University name	Country	Program name	Link
1	UC Berkeley	USA	Financial Engineering	/https://mfe.haas.berkeley.edu
2	Carnegie Mellon University	USA	Computational Finance	/https://www.cmu.edu/mscf
3	University of Illinois Urbana-Champaign	USA	Financial Engineering	https://ise.illinois.edu/research/financial-engineering
4	Georgia Tech	USA	Quantitative & Computational Finance	https://www.scheller.gatech.edu/degree-programs/interdisciplinary-ms/quantitative-and-computational-finance/index.html
5	UCLA	USA	Financial Engineering	https://www.anderson.ucla.edu/degrees/master-of-financial-engineering/academics
6	Duke University	USA	Financial Technology	/https://fintech.meng.duke.edu
7	Johns Hopkins University	USA	Financial Mathematics	https://engineering.jhu.edu/ams/academics/graduate-studies/ms-in-financial-/mathematics
8	Boston University	USA	Mathematical Finance & Financial Technology	https://www.bu.edu/questrom/degree-/programs/ms-in-mathematical-finance
9	New York University	USA	Financial Engineering	https://engineering.nyu.edu/academics/programs/financial-engineering-ms
10	University of Chicago	USA	Financial Mathematics	/https://finmath.uchicago.edu

Algorithmic Trading in Academia …

Number	University name	Country	Program name	Link
11	Stony Brook University	USA	Quantitative Finance	https://www.stonybrook.edu/commcms/ams/graduate/qf
12	University of Washington	USA	Computational Finance and Risk Management	/https://depts.washington.edu/compfin
13	University of Michigan	USA	Quantitative Finance and Risk Management	https://quant.lsa.umich.edu/
14	Rutgers University	USA	Quantitative Finance	https://www.business.rutgers.edu/masters-quantitative-finance
15	University of Minnesota	USA	Financial Mathematics	https://cse.umn.edu/mcfam/curriculum
16	Columbia University in the City of New York	USA	Financial Engineering	/https://msfe.ieor.columbia.edu
17	Columbia University	USA	Mathematics of Finance	/https://www.math.columbia.edu/mafn
18	NC State University	USA	Financial Mathematics	/https://financial.math.ncsu.edu
19	University of Waterloo	Canada	Computing and Financial Management	https://uwaterloo.ca/future-students/programs/computing-and-financial-management
20	University of Essex	UK	Financial Technology	https://www.essex.ac.uk/courses/pg01382/1/msc-financial-technology-computer-science

Algorithmic Trading in Academia …

Number	University name	Country	Program name	Link
21	University College London	UK	Computational Finance	https://www.ucl.ac.uk/prospective-students/graduate/taught-degrees/computational-finance-msc
22	Royal Holloway University of London	UK	Computational Finance	https://www.royalholloway.ac.uk/studying-here/postgraduate/computer-/science/computational-finance
23	University of Liverpool	UK	Financial Computing	https://www.liverpool.ac.uk/study/undergraduate/courses/e-finance-bsc-/hons/overview
24	Politecnico di Milano	Italy	Fintech, Finance and Digital Innovation	https://www.som.polimi.it/en/course/master/fintech-international-master-in-fintech-/finance-and-digital-innovation
25	University of Hong Kong	Hong Kong	Financial Technology	https://www.cs.hku.hk/programmes/basc-fintech/curriculum

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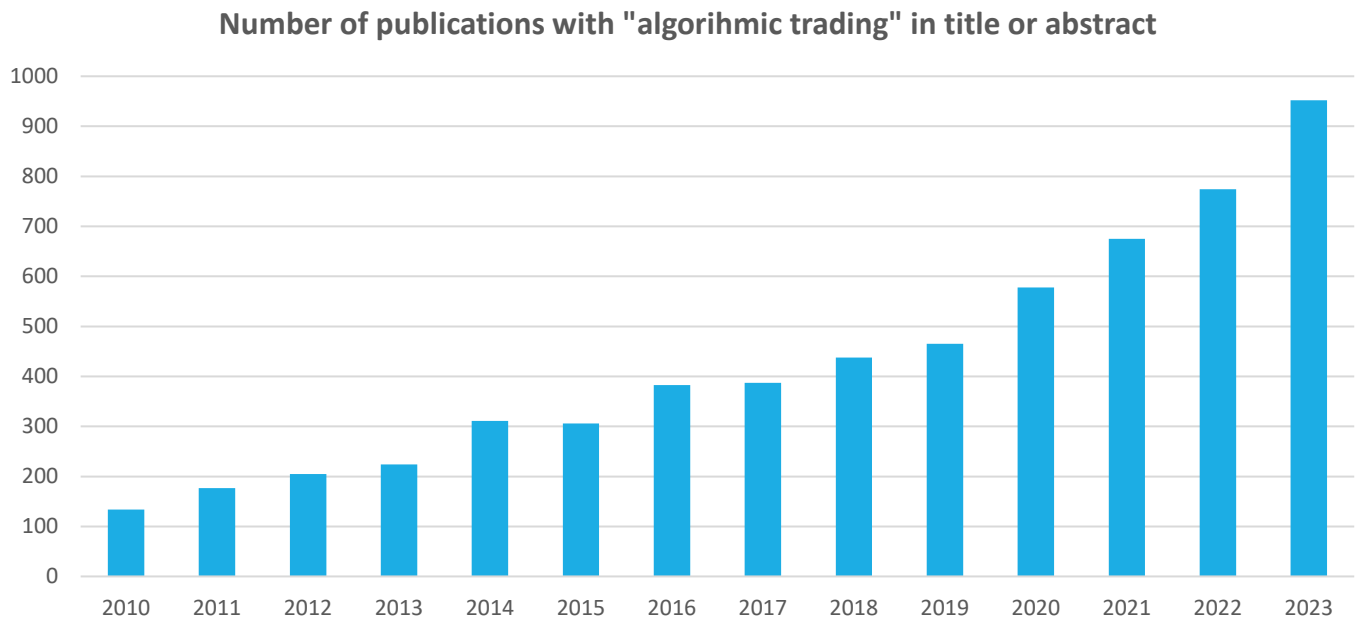

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