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The Investment Engineers

ROBECO QUANTITATIVE INVESTING

What the future holds for quant investing: Ten hypotheses

- Quant strategies will evolve as AI/ML automate processes, multi-modal data enhances insights, and alpha decays faster
- Advanced technology will enable real-time risk management, improved stress testing, and automated compliance for firms
- The industry will face talent shortages, potential disruptions, and cultural challenges as technology reshapes quant investing

This year, we celebrate 20 years of Quant Equities at Robeco. What better time, then, to take a deep dive into what the *next* 20 years of quant asset management might look like? Our Head of Next Gen Research, Mike Chen, guides us through ten tantalizing hypotheses on where quant might go in the decades to come. But first, let's take a look at where we've been.

Quant investing: Then and now

The theory and practice of quantitative investing, as we understand it today, kicked off in the 1950s. Leading the way were well-known academic models such as Markowitz's Modern Portfolio Theory (1952), Sharpe's Capital Asset Pricing Model (1964), and Fama's Efficient Market Hypothesis (1970) – and, of course, the latter's collaboration with French on their seminal three-factor model (1992).

Today, quant investing continues to evolve in terms of relevance and sophistication. Practitioners such as LSV, BGI/BlackRock, AQR, and our own Robeco researchers have contributed to the field, and quantitatively managed AuM has grown steadily along the way. Initially viewed as an academic curiosity, quant investing came into its own in the 1990s, and is nowadays viewed as equally integral to the market as its fundamental counterpart.

We believe new technological development will continue to be one of the most profound and critical influences on the evolution of quant investing. The rate of this development (most recently in data and computing) over the next 20 years looks to be as fast, if not faster, than what we witnessed in the previous 20. And when we add in the

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tremendous rise of AI, we believe the rate will only pick up speed. It's an especially opportune moment, therefore, to undertake the mental exercise of imagining how the next 20 years of asset management business might evolve.

Underpinning the exercise is the belief that advancements in technology will likely continue to enhance quant investors' ability to deliver alpha and manage risks, as well as increase quant firms' operational efficiency in terms of clients' realized results and experience.

A note of caution

Three notes of caution to the armchair futurist: We undertake this exercise while being fully aware of Niels Bohr's words: "Prediction is very difficult, especially if it is about the future." Moreover, all of the hypotheses mentioned here are based on plausible, mostly foreseeable trends, in other words, 'linear' extrapolations. By definition, truly epochal changes are driven by unexpected, non-linear developments. Finally, changes always come with risks and challenges, which we discuss in particular in our last two hypotheses.

For now, step into the Robeco time machine and settle in for the ride. A glossary can be found at the end, and we start with alpha.

Hypotheses on alpha

Hypothesis 1: Advanced AI and ML models

AI's sophistication and potential shift toward AGI means it could automate strategy development, enhance prediction accuracy, and potentially take over the task of economic hypothesis generation, all leading to alpha.

In the year 2024, it is impossible to discuss how the future might evolve, whether quant asset management or otherwise, without discussing AI. Of course, AI, ML and NLP have been around for more than 50 years and applied in quantitative finance for at least the past 20 years.[1] But the recent excitement around AI centers on the way these algorithms seem to have expanded beyond the traditional narrow AI into something approximating Artificial General Intelligence' or AGI[2].

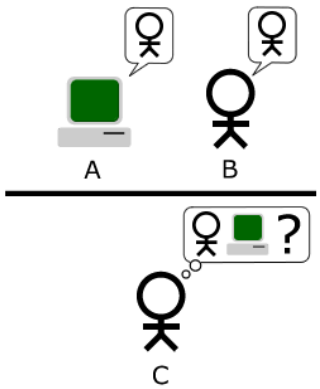
Historically, quant investment has been researched manually: quant investors first come up with a sensible investment hypothesis, test it, and, if successful, deploy the code replicating the hypothesis into the quantitative strategies.[3] In the future, AI could likely automate this development and refinement of strategies, continuously learning from new data to optimize performance with (and possibly without direct) human intervention.

We are already seeing AI play a big part in other knowledge-intensive scientific endeavors, such as new drug discovery. A significant aspect of the quant investing process that remains exclusively in the human domain is sensibility/economic hypothesis generation. However, as LLMs become more sophisticated and take on an increased ability to make logical inferences,[4] we may well see this task, too, shift away from humans to between humans and machines, or even exclusively machines.

But will AI algorithms ever flawlessly pass the Turing Test?[5] That's uncertain[6], but the sophistication of AI and ML models will almost definitely continue to grow. As AI processes larger datasets capturing subtle market signals and anomalies, it will also allow for more complex and accurate predictions of market movements and other elements pertinent to investing. They will also continuously be incorporated into the quant investment process – and the investment domain overall – for alpha discovery.

Figure 1 | When will we no longer be able to distinguish humans from AI?

1. The Turing Test, created by Alan Turing in 1950, is a way to see if a machine can "think" like a human.



2. In the test, a human judge chats separately with both a machine and another human, without knowing which is which.

3. If the judge can't reliably tell them apart, the machine is considered to have passed, showing it can convincingly mimic human conversation.

4. While the Turing Test is famous in AI, it mainly checks if a machine can act human in a conversation, not if it truly understands or thinks like we do.

[1] Not including more basic ML models such as OLS and trees.
[2] AGI (Artificial General Intelligence) refers to a more advanced form of AI that possesses the ability to understand, learn, and apply knowledge across a broad range of tasks, much like a human. AGI would have general reasoning and problem-solving capabilities, allowing it to adapt to new situations and potentially achieve human-level or greater intelligence. AI is task-specific, whereas AGI aims to be flexible and capable of performing any intellectual task that a human can.
[3] This is a very broad description of the quant investment approach. There are many more nuances, which determine the difference between a successful quant model and an unsuccessful one.
[4] For example, see Nafar, Venable, and Kordjamshidi, 2023.
[5] Turing Test: https://en.wikipedia.org/wiki/Turing_test
[6] Although no longer outside the realm of possibility as of August 2024.

Source: Robeco, image public domain

However, as LLMs become more sophisticated and take on an increased ability to make logical inferences[7], we may well see this task, too, shift away from humans to between humans and machines, or even exclusively machines.

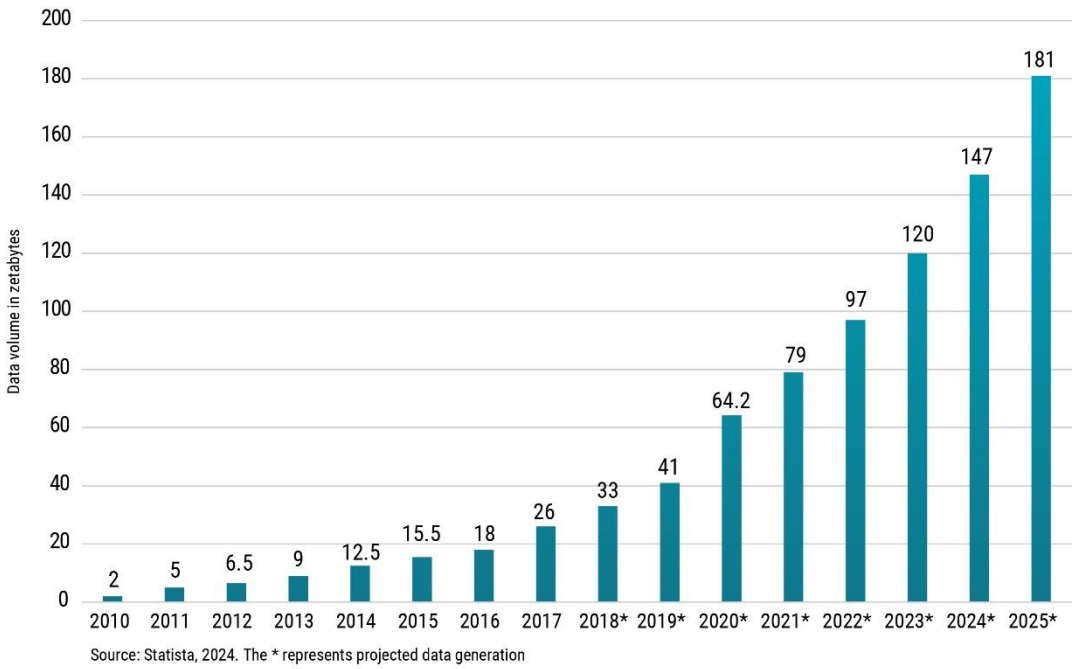
Hypothesis 2: Multi-modal data utilization

To gain a competitive edge, quant investors will leverage rapidly increasing alternative data sources including social media sentiment and satellite imagery, as well as multi-modal data from text, voice, image and video files.

The amount and speed of data generation by humans is ever accelerating. In 2024, the global internet user base reached 5.35 billion, growing by 1.8% over the past year,[8] and the total amount of data created, captured, copied, and consumed worldwide is forecasted to increase from 64.2 zettabytes in 2020 to 181 zettabytes by 2025[9], as seen in Figure 2 below.

As a result, we expect that quantitative managers will go beyond 'small data' to leverage even more Big Data and other alternative data sources, such as social media sentiment, satellite imagery, job listings, anonymized credit card transactions, and IoT data, to gain a competitive edge.

Figure 2 | Data generation accelerates exponentially



[7] For example, see (Nafar, Venable, and Kordjamshidi, 2023)
[8] We are social & Meltwater (2024), "Digital 2024: Global Overview Report", retrieved from https://datareportal.com/reports/digital-2024-global-overview-report on 19 September 2024
[9] https://www.statista.com/statistics/871513/worldwide-data-created/

Furthermore, these data sources will not only come in numerical and textual formats but will incorporate information from other modalities such as text, audio, picture, or video.

This multi-modal information is being incorporated by the latest AI models, and we anticipate they will also be used in and make an impact on quant investing, either as training for the AI model or incorporated into the quant investment process in other ways. In whatever way it's used, these multi-modal, non-traditional datasets will offer unique insights into market behavior.

Hypothesis 3: Faster model evolution and faster alpha decay

Powerful algorithms for model development will lead to more alpha, and the democratization of this process will lead to alpha decay. Continuous quant research (by humans, AIs, or a combination thereof) is key to staying ahead of the curve.

Today's quant models are developed manually, and in the future, we anticipate that algorithms will at least partly take over this task. This will lead to a shorter development time, all else being equal, and consequently, quant algorithms will become more adaptive and sophisticated, leveraging real-time data analytics to make continuous adjustments.

This is the positive side of the equation. The negative side? An increase in computing power and algorithms' ability to make logical inferences, combined with the availability and use of big and multi-modal data, will make detecting alpha signals quicker for *all* quant practitioners. We've seen this with each generation of new technology: the barrier to entry becomes less and less, and the speed of updates is faster and faster.[10] Case in point: to use the latest gen-AI, you don't even need to know how to program, as these sophisticated models can be accessed via natural language inputs.

This democratization of powerful algorithms for model development will likely lead to faster alpha decay, known as the loss in predictive power of an alpha model over time. Quant research, especially for alpha, therefore, has to be a constant and essential endeavor for quant practitioners.

Hypothesis 4: Cloud computing and quantum computing

Cloud computing will let quants process vast amounts of data without needing on-premises infrastructure, while quantum computing could help solve problems that are computationally infeasible today.

Besides the democratization of sophisticated algorithms, computing power has also been democratized. Computing power and data are the two critical components of the quant investment process, and the availability of an almost unlimited amount of data in the cloud has transformed all aspects of modern society, including quantitative finance. We anticipate cloud computing will continually be used to offer scalable resources for running complex simulations and models, letting quants process vast amounts of data without the massive upfront cost needed for significant on-premises infrastructure.

Beyond the currently available central processing units (CPUs) and graphics processing units (GPUs), another computing paradigm has caught futurists' attention. Although still in its early stages, quantum computing holds the promise of exponentially faster data processing, which could revolutionize quant strategies by solving problems that are currently computationally infeasible.[11] Table 1 gives a brief overview of key differences between classical and quantum computing.

[10] Electricity took about 30 years to become widely used. The internet took about 15 years. The latest generation of AI may take only 5 years.
[11] Although it will also create a host of other problems. For example, most encryption algorithms today are based on extremely long computation time (thousands of years or longer) to crack the encryption. Quantum computing have the promise to make all these encryption algorithms defeatable and obsolete.

Table 1 | Differences between classical and quantum computing

Aspect	Classical computing	Quantum computing
Basic principle	Uses binary bits (0 or 1) to perform calculations.	Uses quantum bits (qubits) that can exist in multiple states simultaneously (superposition).
Processing power	Linear and deterministic; handles complex financial models and data analysis, but can be time-consuming.	Exponential potential; can analyze vast datasets, optimize portfolios, and model complex financial systems much faster.
Speed	Efficient for many financial tasks, but some high-complexity problems can take a lot of time and computational power.	Could drastically reduce the time needed for complex simulations and optimizations, enabling near-instantaneous analysis and decision-making.
Data analysis	Powerful, but constrained by processing time when dealing with massive datasets and complex correlations.	Could analyze vast amounts of data simultaneously, identifying correlations and patterns that classical computing might miss.
Risk management	Effective but sometimes limited by computational constraints in stress testing and scenario analysis.	Could perform far more comprehensive and accurate risk assessments by evaluating many more scenarios in a fraction of the time.
Potential for disruption	Incremental; current methods and systems are stable but continually evolving.	Quantum computing could fundamentally change how financial markets operate, from risk assessment to real-time trading, offering potentially huge competitive advantages.

Source: Robeco 2024

Hypotheses on risk and compliance

Compared to alpha, the application of advanced algorithms to risk and compliance has been more widespread, especially for the latest generative AI models.[12] As of this writing, advanced techniques have already been making their way into risk and compliance processes, such as monitoring social media and economic officials' statements to detect possible downturns. Even large monetary transfers from known tax havens in anti-money laundering applications are routinely automatically flagged. We anticipate these techniques will only become more powerful and wider spread as technology marches on.

Hypothesis 5: Enhanced risk management

Algorithms and advanced analytics could rapidly process information for real-time risk assessments and more realistic stress testing by combining historical data with nowcasting, enabling immediate strategy adjustments.

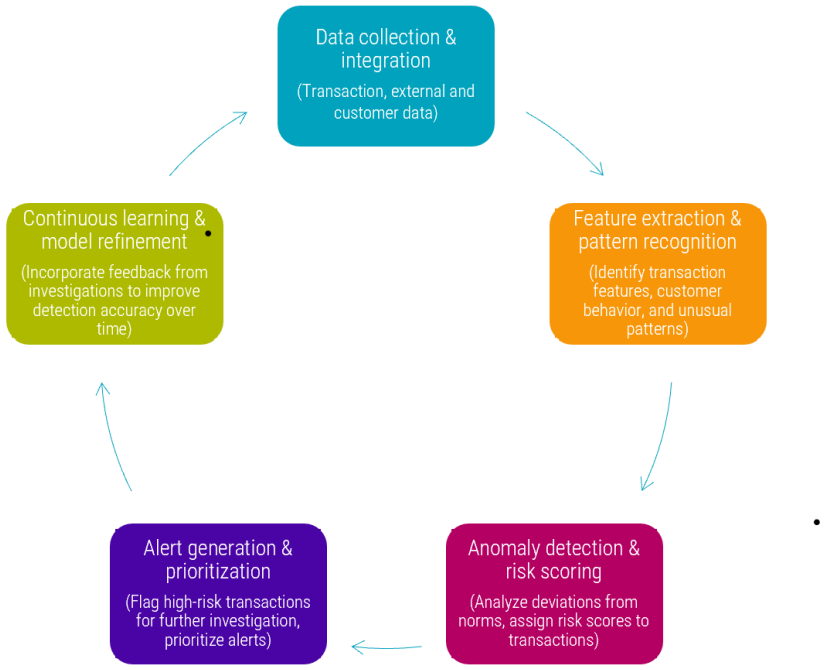
Whereas humans are limited by their available time and energy, one of the main advantages of algorithms and the digital machines that run these algorithms is their speed. The ability to rapidly process information and be available around the clock means that properly designed advanced analytics, combined with Big Data, will let the quant investor conduct real-time risk assessments more quickly. This will allow strategies to be adjusted immediately in response to changing market conditions.

Another risk application could be more realistic stress-testing scenarios. Currently, stress tests in quant investing and most of the financial industry use historical scenarios and correlations between various asset classes and securities to simulate how risk scenarios may play out. Taking account of the axiom that history rhymes, risk scenarios could benefit from assessing backward-looking future scenarios and reflecting on current developments (i.e., nowcasting).

With advancing technology, it may be possible to automatically update potential risk scenarios in near-real time by scouring various textual sources (news, social media, company statements, official economic statements, etc.). Combined to construct knowledge graphs, this information can then be used to enable more rigorous stress testing of portfolios, simulating a wider range of scenarios to understand potential vulnerabilities better. Figure 3 below illustrates what such a model might look like.

[12] For example, see Fritz-Morgenthal, Hein, and Papenbrock, 2021; and Aziz and Dowling, 2018.

Figure 3 | AI-driven money laundering and suspicious transaction detection model



Source: Robeco

Hypothesis 6: Regulation, process, and compliance automation

Advanced solutions could make it easier to comply with evolving regulations, reducing the risk of legal issues. By automating compliance and client reporting, LLMs could enable firms to realize lower running costs and/or to provide better services for the same costs.

For the back office, advanced regulation solutions will enable continuous monitoring of trades and strategies to ensure compliance with evolving regulations, reducing the risk of legal issues and penalties. Advanced algorithms (such as LLMs and other forms of AI) will likely also increasingly automate many of the more mundane processes of investment management. We are already seeing both these applications being deployed in the financial industry, and the trend to put such technologies to work at more and more complicated regulatory tasks is set to continue.

On the reporting front, compliance reporting will likely become more automated, allowing quantitative investors and quantitatively capable firms to meet regulatory requirements more efficiently and accurately. The reporting process will likely also extend to client reporting, offering individualized explanations of the client's strategies. The combined changes could lead to increased efficiency, lower running costs for the same services and task, or better service provision at the same current cost level.

Hypotheses on product design and client experience

Hypothesis 7: Personalized investment products

AI and ML could make customization affordable even for individual investors.

One of the things quants can do more easily than fundamental investors is to customize their strategies while keeping the underlying model more or less the same, from different investment universes and benchmarks to different restrictions and tracking errors. However, these customizations are currently available only to large institutional investors with individual mandates.

Advancing technology will likely take this to another level. AI, ML, and other advanced algorithms may facilitate the creation of personalized investment strategies tailored to individual investor profiles, preferences, and risk tolerances. In addition, portfolios will be dynamically rebalanced using advanced algorithms that respond to real-time market changes (alpha and risk opportunities) and individual client needs.

Hypothesis 8: Enhanced client interaction and transparency

Sophisticated, user-friendly platforms will provide transparency into the quant models driving investments, fostering greater client trust and engagement. Generative AI could provide insights into clients and client interactions.

In addition to product customization, the interaction between clients and asset managers will likely be enhanced and transformed by technology. Currently, portfolio reports and commentaries are produced manually by portfolio managers, giving broad, high-level summaries about the strategies they manage. But portfolio managers may not tailor these reports to their clients' portfolio due to the additional work involved.

Furthermore, communication is typically one-way, from manager to client. Client questions must be fed through various channels to reach the portfolio manager, whose ability and willingness to answer depends on the time they have available. But technological advancements can foster greater trust and engagement: asset managers can develop interactive interfaces and sophisticated, user-friendly platforms for clients that provide transparency into the quant models driving their investments.

Compared to the current, mostly one-way communication between asset managers and clients, future interactions will be more, well, interactive. Given what we've already seen with generative AI-powered chatbots, it is reasonable to believe that AI will soon be able to generate detailed, understandable, and accurate insights into portfolio performance and strategy rationale, enhancing client understanding and satisfaction.

Hypotheses on the quant industry

What we've outlined so far is an optimistic view of the future of quant asset management, where both asset managers and clients stand to benefit from advancements in technology. Of course, the path toward that vision will require investment and hard work by individuals and organizations and will be filled with challenges, setbacks, and uncomfortable changes.

Hypothesis 9: Talent acquisition and skills development

To keep up with the latest trends and technology, quant firms need to invest in talent acquisition and continuous education and training. In addition, they need to develop mixed and collaborative teams to meet this challenge.

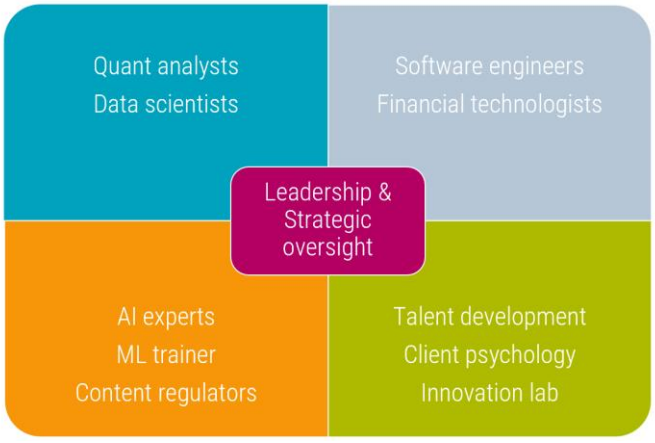
At the core of investment, quantitative or otherwise, lies human talent: the most essential element and the hardest to source. The transformation required and the work involved to action the previous eight hypotheses is huge, and they are implemented by humans. Employees with knowledge, skills, passion, and political dexterity to make it happen.

The first and biggest challenge for any organization to realize the hypotheses stated here will be to hire these employees, motivate and retain them, and enable them to do their best work. This means the demand for talent with expertise in finance and technology, particularly in AI, ML, and data science, will grow. A scarcity of suitable candidates and the ever-accelerated pace of technological change means that quant firms will need to invest in talent acquisition and their continuous education to keep up with the latest trends and technology.

As much as the hypotheses outlined here are driven by technology, these technologies must be applied in a financial context. Historically, finance and technology have been taught separately, and although some schools have started to offer programs that combine the disciplines,[13] the supply isn't enough to meet demand. This again means firms must offer training programs to equip promising employees with one or more skills to enable the transformations discussed here.

Another possibility to fill the talent need is to form mixed and collaborative teams. Under this approach, teams will increasingly consist of a diverse mix of quantitative analysts, data scientists, and software engineers, working collaboratively to develop and refine models. A possible team of the future is shown in Figure 4 below.

Figure 4 | Quant investing team of the future



Source: Robeco

[13] For example, some schools in the US such as MIT and UC Berkeley have been offering a Masters in Finance degree with heavy emphasis on math and technology.

Hypothesis 10: Industry reshuffling, disruption, and challenges

Despite advanced technology potentially transforming the quant investment industry, firms are still composed of people: people with desires, fears, and aspirations. Quant firms can only succeed under the right culture, management, and incentivization structure.

As history has shown repeatedly, an industry's evolutionary path is never straight or smooth, and firms that dominate in one era might not dominate in the next.[14] As with any epochal technology, the emergence of advanced algorithms such as LLM may disrupt the existing quant investment industry hierarchy and positioning. This would allow the industry participants who succeed in using these new technologies in their investment, operational, and client management processes to pull ahead and distance themselves from those who don't. New industry participants and economic models might also emerge, disrupting existing industry participants' profitability and standing.

At the company level, internal cultural and political battles can erupt if the culture and mode of work change too fast. Employees with long tenure but maybe not the latest skills may feel threatened by the emergence of a new class of employees with the required technology skills and backgrounds. Equally, employees with the necessary skills (newly hired or otherwise) may feel constrained, unappreciated, or otherwise unhappy if the culture and process do not change fast enough or if they feel unable to carry out their vision and work effectively.

Ultimately, neither of these two examples is a recipe for success. Each individual quant firm's business context and strategy is different, but success requires both groups of employees to be effective, and this can only happen with skillful management. Despite advanced technology potentially transforming the quant investment industry, firms are still composed of people: people with desires, fears, and aspirations. Quant firms can only succeed under the right culture, management, and incentivization structure. This part is universal and timeless.

[14] For example, IBM in the mainframe era was replace by Microsoft/Intel in the PC era. Nokia and Ericsson in the mobile phone era was replaced by Apple/Android in the smart phone era.

Conclusion

In this article, we shared ten hypotheses on how technological innovations will shape the quant investment industry over the next 20 years. Of course, many of these hypotheses, such as the advancement of AI models and increasing importance of transparency are mostly linear extrapolations of evolutions we can already see happening as of today.

But others, like a pivot to customization, cloud computing and multi-modal data utilization, could provide creative means to source alpha in the most unexpected places. And while technology will undoubtedly shape the future of quant asset management, it is the human element that will ultimately determine which firms thrive in this new landscape.

Whether the quant investment industry changes to the degree discussed here or not, one thing is certain. Change the quant industry will, and change the quant industry must. For us participants, we can take one of two paths: Participate, and hopefully, lead the change, or resist it and ultimately be left behind.

Glossary

AGI: Artificial General Intelligence. Artificial intelligence systems that are applicable to multiple tasks rather than any specific or narrow range of tasks.

AI: Artificial Intelligence. Computer systems and algorithms that can perform specific tasks traditionally done by humans and require human supervision and guidance.

ALDA: Alternative Data. Datasets used in finance that don't come from traditional sources of financial statements and market data. These datasets include satellite imaging, social media, audio files, etc.

Algorithms: Set of computation and instructions used to transform data into outputs.

Big Data: Extremely large datasets that may be analyzed computationally to reveal insights related to human behavior, economic trends, social zeitgeist, etc.

GPT: Generative Pre-Trained Transformers: A type of NLP model where algorithms can generate new texts and perform computations based on user prompts. GPT has shown that it can exhibit a crude approximation and understanding of the physical world.[15]

IoT: Internet of Things: A network of devices connected via sensors, software, and network connectivity that enables data collection and interaction.

LLMs: Large Language Models: A type of NLP model that can perform textual-based tasks such as sentiment detection or name entity recognition.

ML: Machine Learning: A branch of artificial intelligence that applies statistical algorithms to numerical data (or other information sources that have been translated to numerical data).

NLP: Natural Language Processing: A branch of artificial intelligence that works mostly with human communications, such as textual and audio information. In recent years, NLP has been based on ML techniques.

OLS: Ordinary Least Squares: Statistical method used to estimate the parameters of a linear relation between variables.

Trees and neural networks: Some of the algorithms used in machine learning.

[15] As of August 2024. The state of development for GPT is evolving extremely fast.

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