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Quant 4.0: engineering quantitative investment with automated, explainable, and knowledge-driven artificial intelligence

Key words: Artificial general intelligence; Artificial intelligence; Automated machine learning; Causality engineering; Deep learning; Feature engineering; Investment engineering; Knowledge graph; Knowledge reasoning; Knowledge representation; Model compression; Neural architecture search; Quant 4.0; Quantitative investment; Risk graph; Explainable artificial intelligence

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Quantitative investment strategy

- ❑ A standard quant strategy contains a series of components, such as an investment instrument, trading frequency, trading mode, strategy type, and data type.

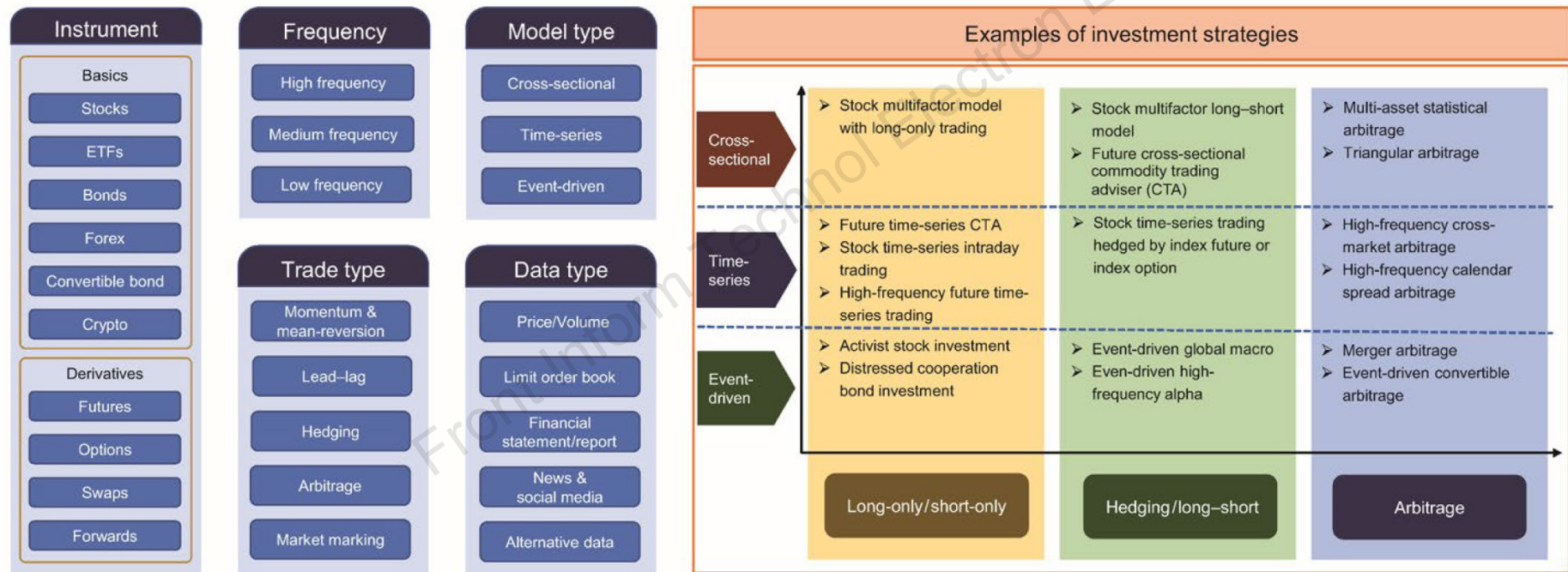


Fig. 1 Quant strategy components and classification of common strategies

Quantitative investment research

- Quant has been studied for a long time in both academia and industry. Originating a century ago (Bachelier, 1900), many researchers have contributed to the development of this interdisciplinary area, including many Nobel Prize laureates and Turing award winners.

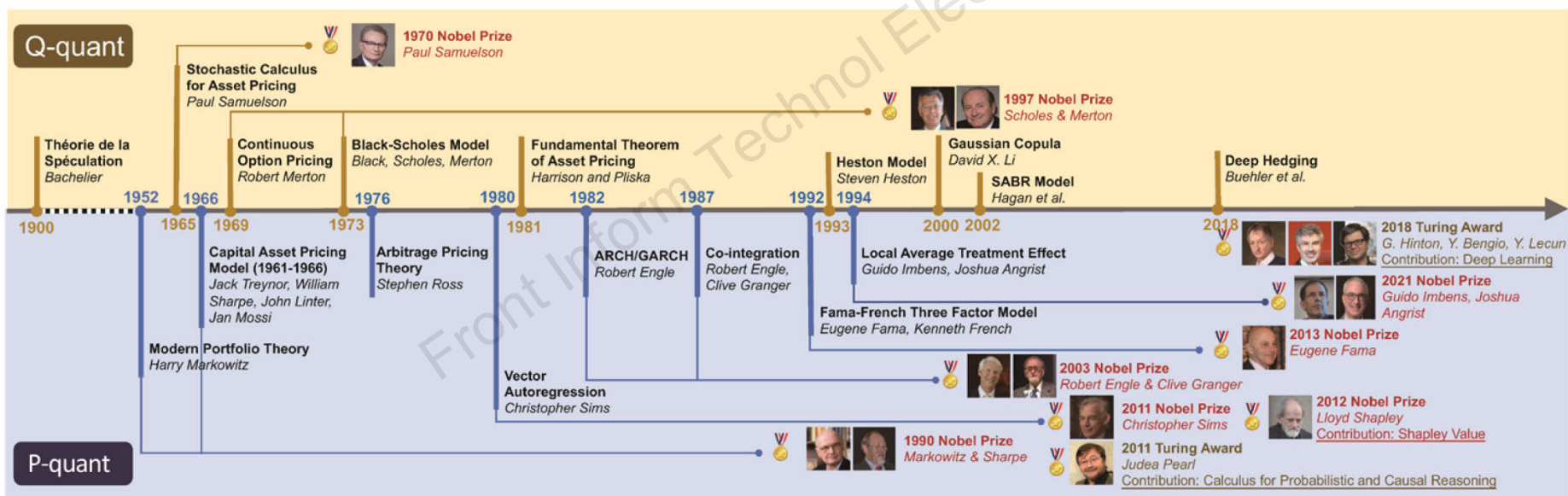


Fig. 2 Main academic contributors and their works that deeply influence the development of quantitative investment (photo credit: Wikipedia)

Development history of quant research

- ❑ The blooming era of quant in industry started in the 1990s, and its evolution can be generally categorized into three generations, denoted as quant 1.0–3.0.
- ❑ We propose the idea of quant 4.0, which defines the picture of next-generation quant technology by practicing the “all-in on artificial intelligence (AI)” philosophy.

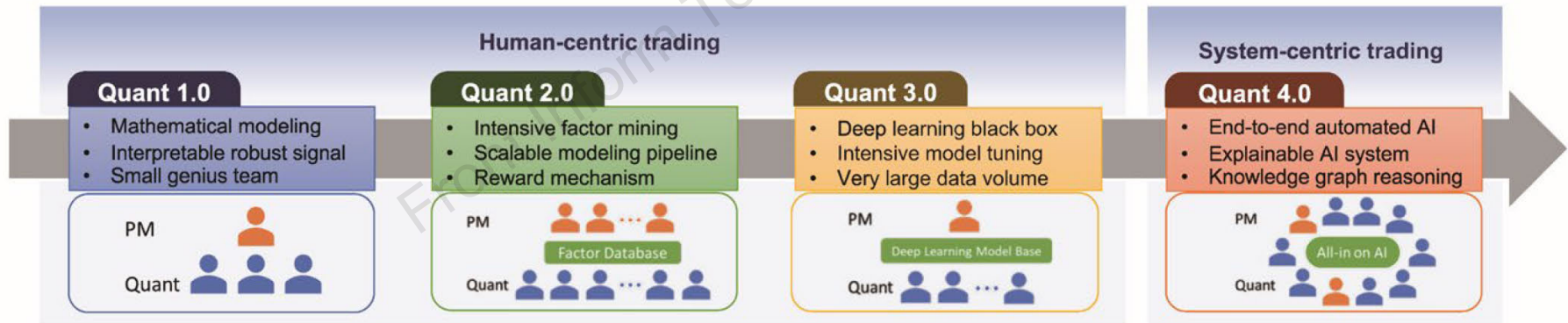


Fig. 3 The development history of quantitative investment in industry, from quant 1.0 to quant 4.0

Automated AI for quant 4.0

- ❑ Automated AI for quant 4.0 covers the automation of the full quant pipeline.

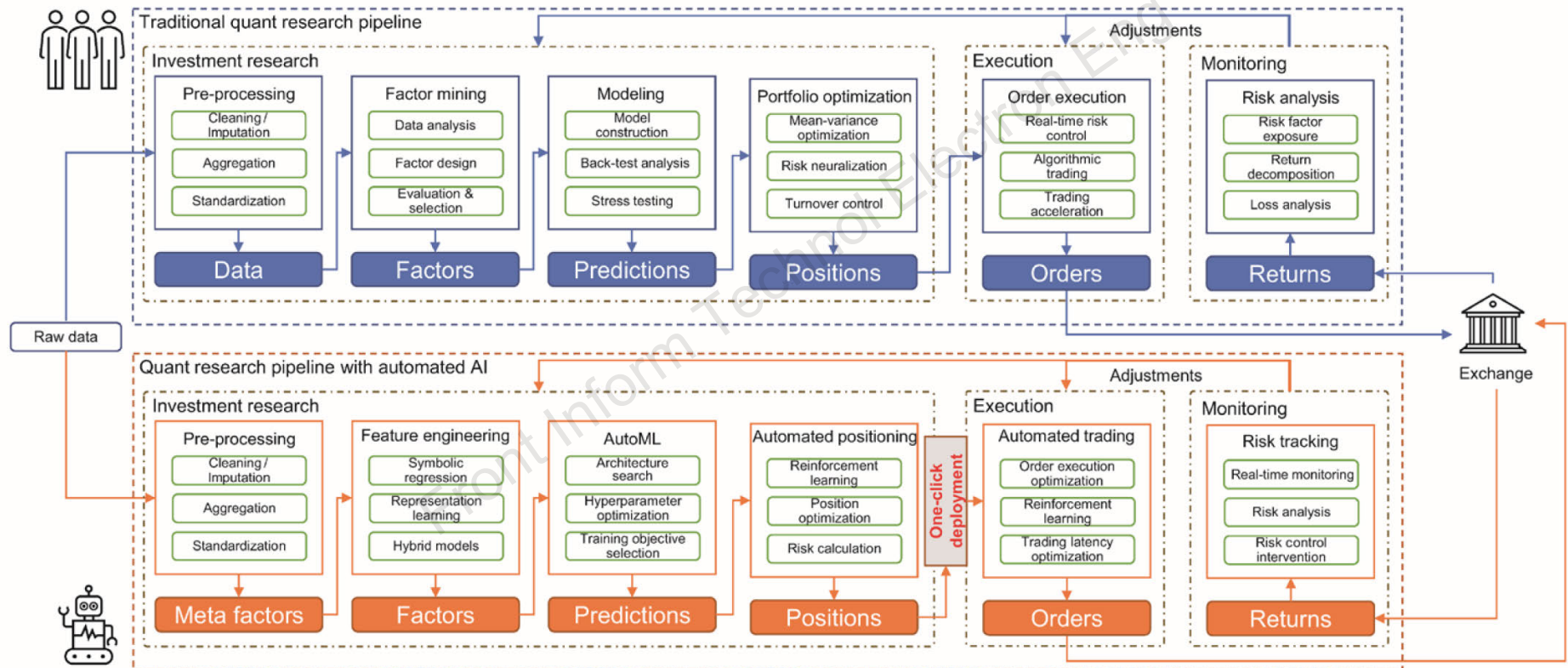


Fig. 4 A prototypical workflow of quantitative investment with comparisons between the current quantitative investment system (manual, upper blue part) and AI investment engineering (automated, lower orange part). References to color refer to the online version of this figure

Explainable AI for quant 4.0

- ❑ For quant, improvement in the explainability of AI can make the decision-making process more transparent and easier to analyze, provide insights to researchers and investors, and uncover potential risk exposures.

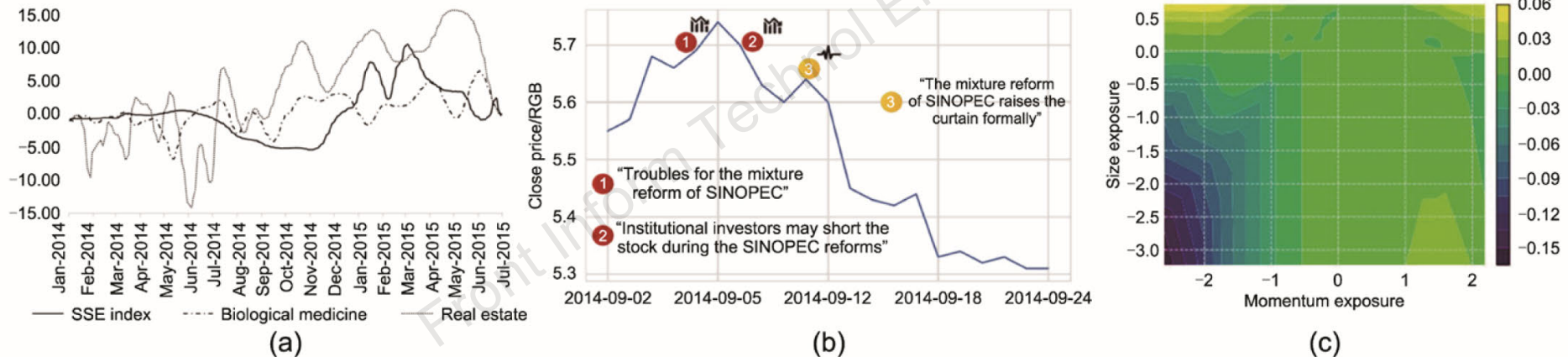


Fig. 6 XAI examples in quant: (a) lead-lag effect in Chinese stock market; (b) influence of breaking news across time; (c) interaction between size and momentum factors. (a) is reprinted from Guo K et al. (2017), Copyright 2017, with permission from Elsevier. (b) is reprinted from Hu et al. (2018), Copyright 2018, with permission from ACM. (c) is cited from Wang J et al. (2021)

Knowledge-driven AI for quant 4.0

- Knowledge-driven AI is an important complementary technology to data-driven AI, especially in low-frequency investment scenarios such as value investing and global macro investment. A knowledge-based system consists of two parts, a knowledge base and a knowledge reasoning engine, which correspond to the problems of knowledge representation and knowledge reasoning, respectively.

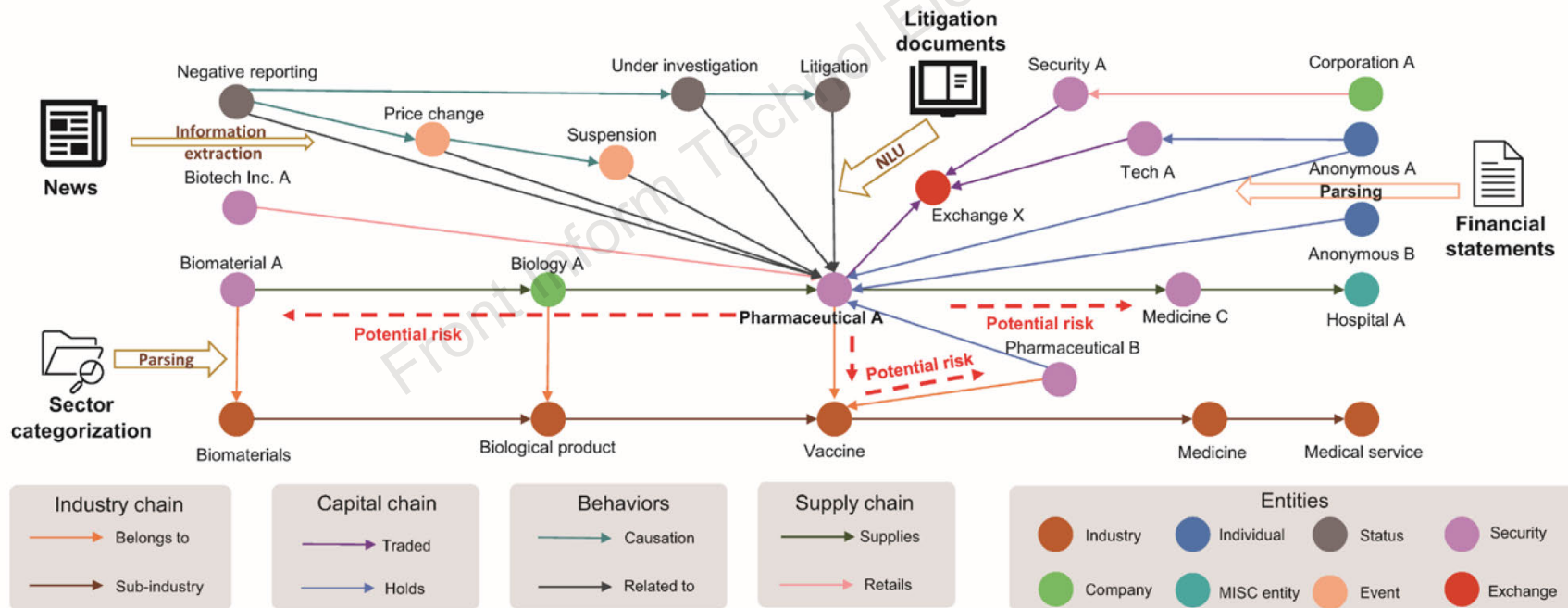


Fig. 7 An example of financial knowledge graph that contains behavioral information. All the financial entities and events are fictitious, only for illustration purposes. References to color refer to the online version of this figure

Engineering and architecture

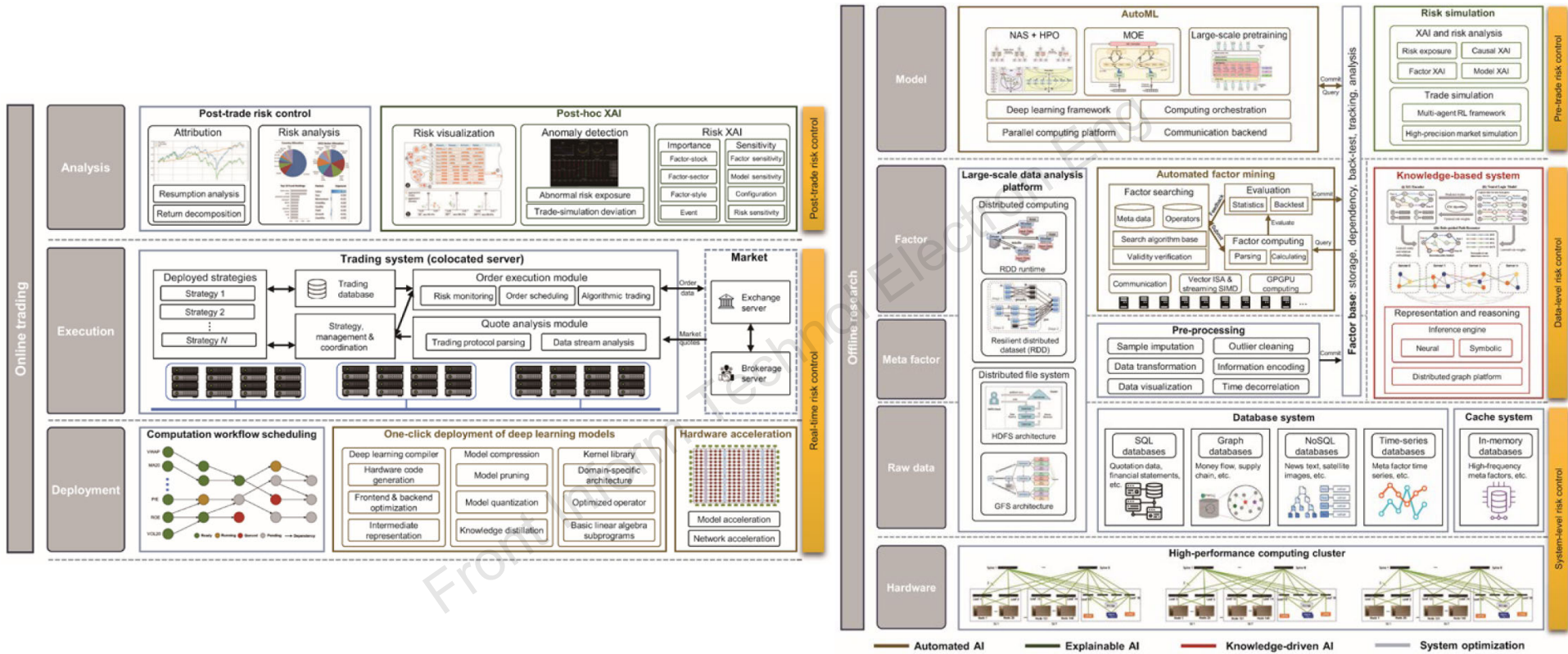


Fig. 9 Architecture of an example quant 4.0 engineering platform for investment research and trading. Parts of this figure are cited from Ghemawat et al. (2003), Shvachko et al. (2010), Zaharia et al. (2010, 2012), Bender et al. (2018), Real et al. (2019), Wang QW et al. (2021), and Fedus et al. (2022)

Large-language models and quant 4.0

- LLMs can play various roles in quant research, including as a quant copilot, financial analyst, and feature engineer.

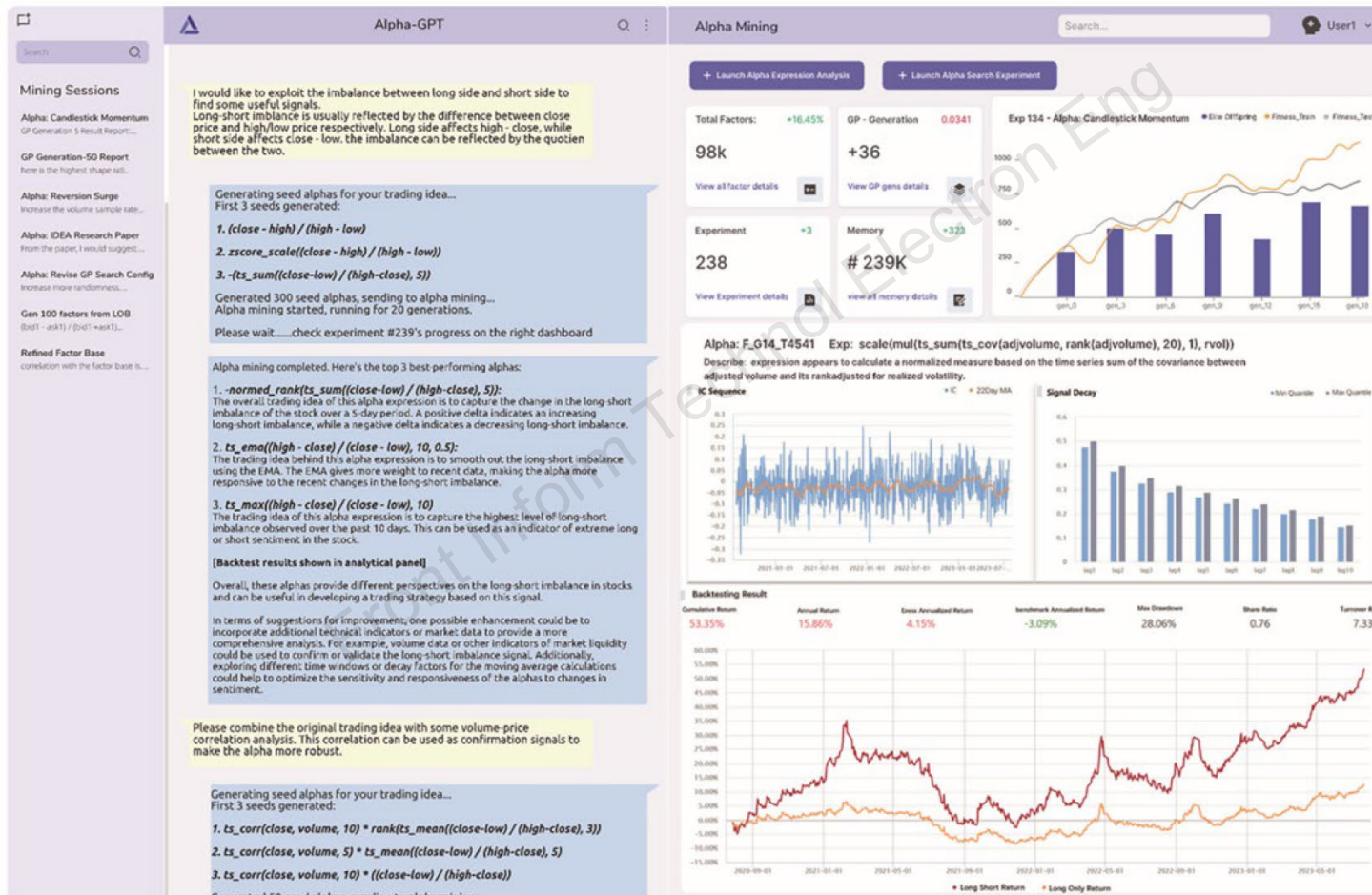


Fig. 11 (a) The Web-based user interface of Alpha-GPT (Wang SZ et al., 2023)

Ten challenges in quant technology

- ❑ We identify 10 challenges including computing and data infrastructure, investment modeling, risk modeling, market simulation, and cognitive AI technology, and provide new research directions for researchers interested in AI technology and quant.
- ❑ We believe that some problems might be solved in the next couple of years with the rapid development of AI technology, while others may remain challenging for a long time.

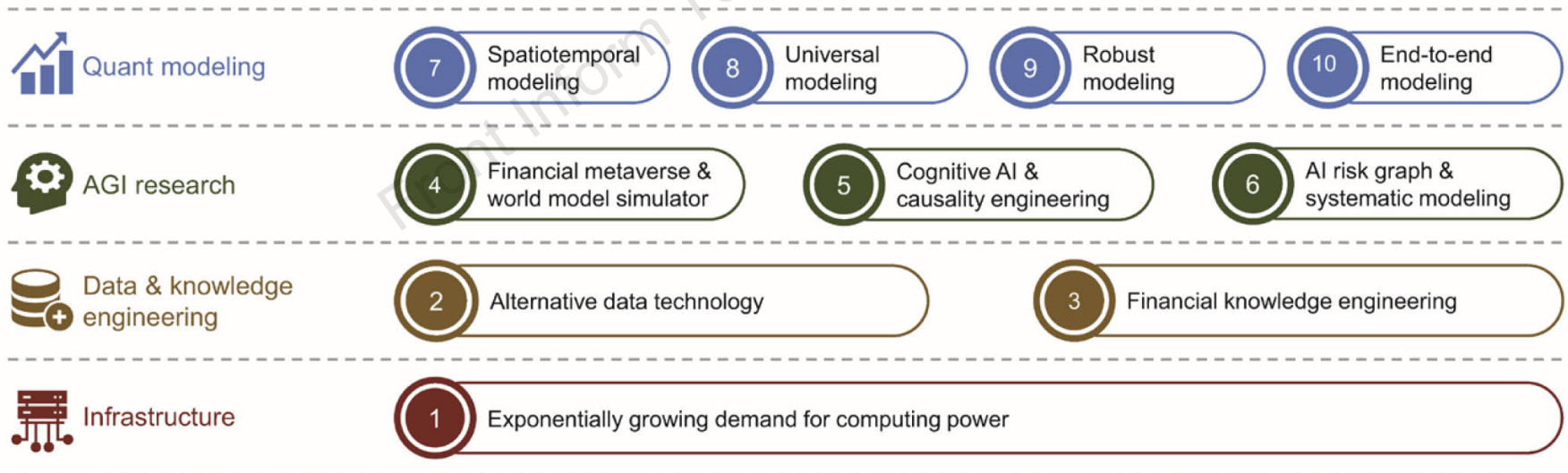


Fig. 14 The 10 challenges in quantitative investment technology



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