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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

Jian GUO
E-mail: guojian@idea.edu.cn
ORCID: https://orcid.org/0009-0003-5046-2588

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.

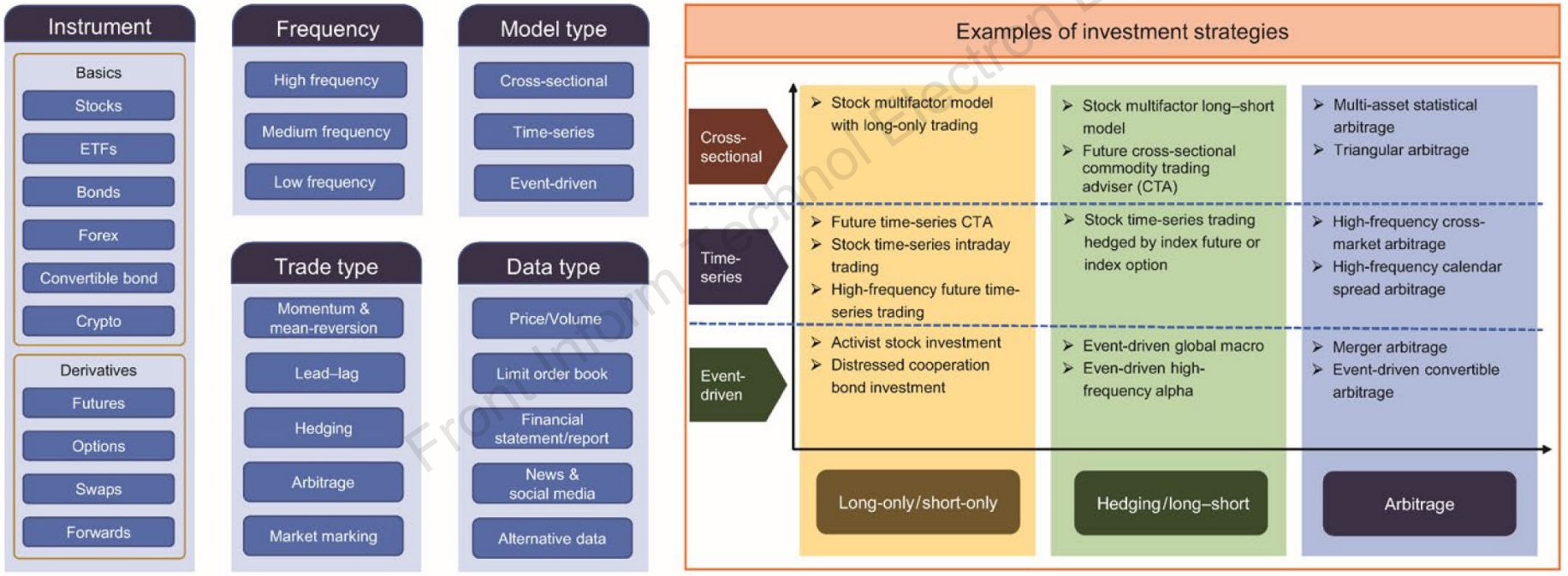

Fig. 1 Quant strategy components and classification of common strategies

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.

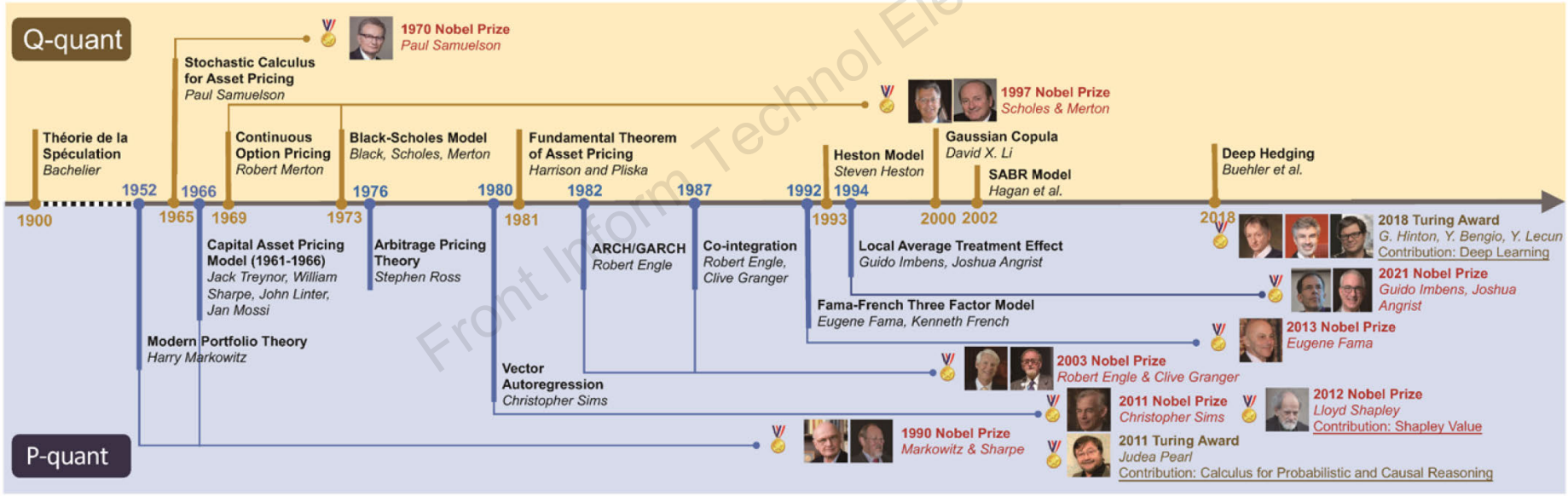

Fig. 2 Main academic contributors and their works that deeply influence the development of quantitative investment (photo credit: Wikipedia)

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.

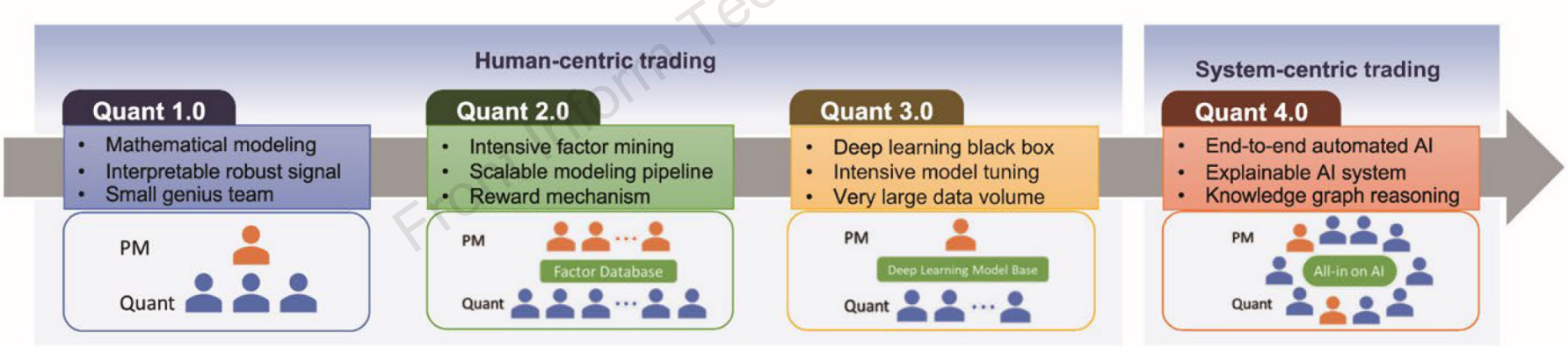

Fig. 3 The development history of quantitative investment in industry, from quant 1.0 to quant 4.0

Automated AI for quant 4.0

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

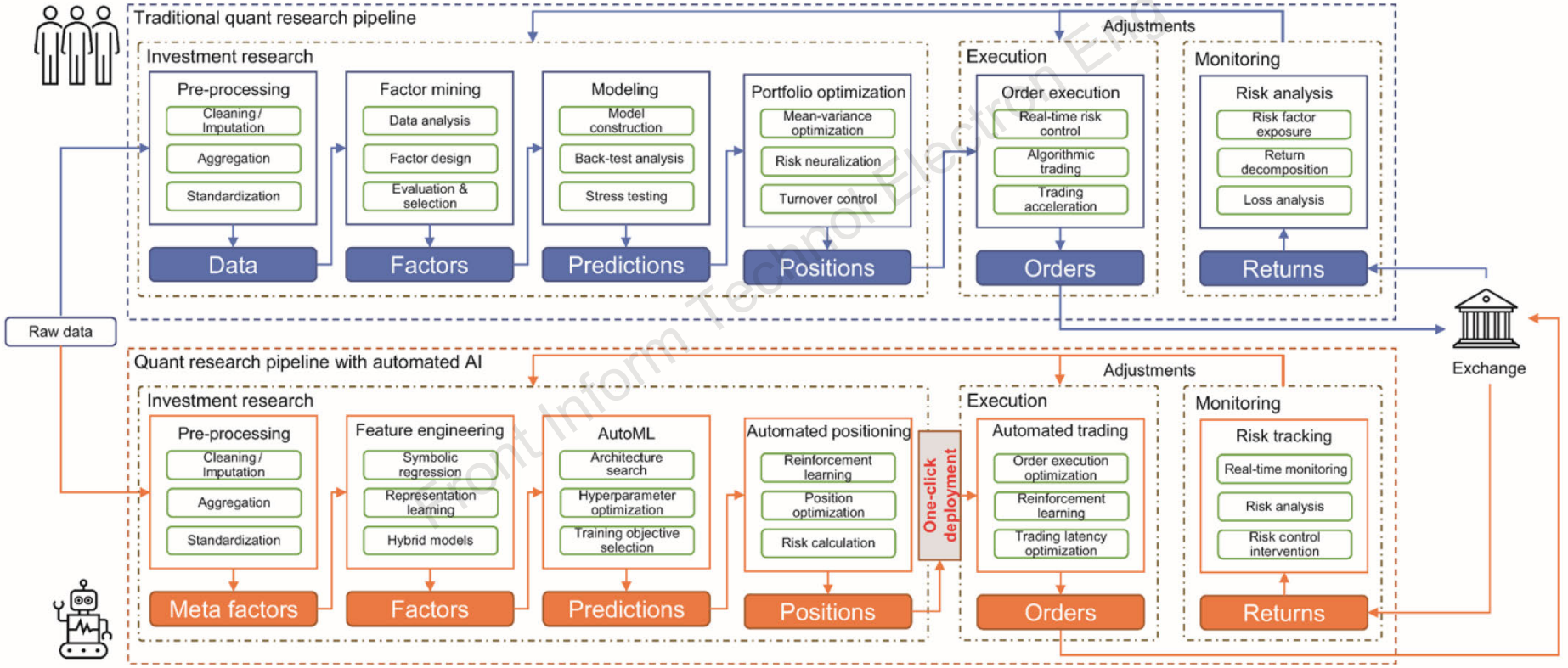

Fig. 4 A prototypical workflow of quantitative investment with comparisons between the current quantitative investment system (manual, upper blue part) and AI investment engineering (automated, lower orange part). References to color refer to the online version of this figure

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.

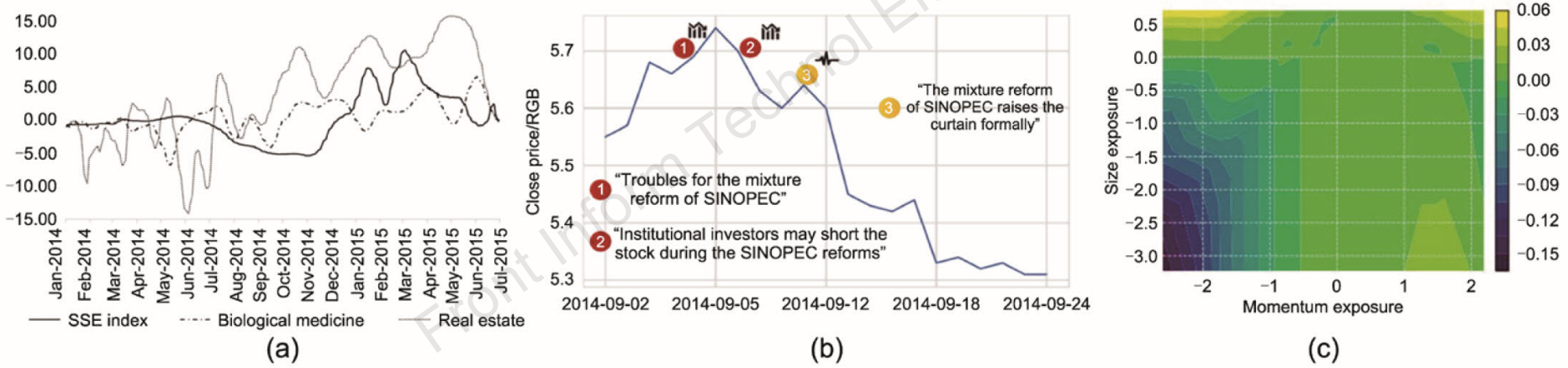

Fig. 6 XAI examples in quant: (a) lead-lag effect in Chinese stock market; (b) influence of breaking news across time; (c) interaction between size and momentum factors. (a) is reprinted from Guo K et al. (2017), Copyright 2017, with permission from Elsevier. (b) is reprinted from Hu et al. (2018), Copyright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

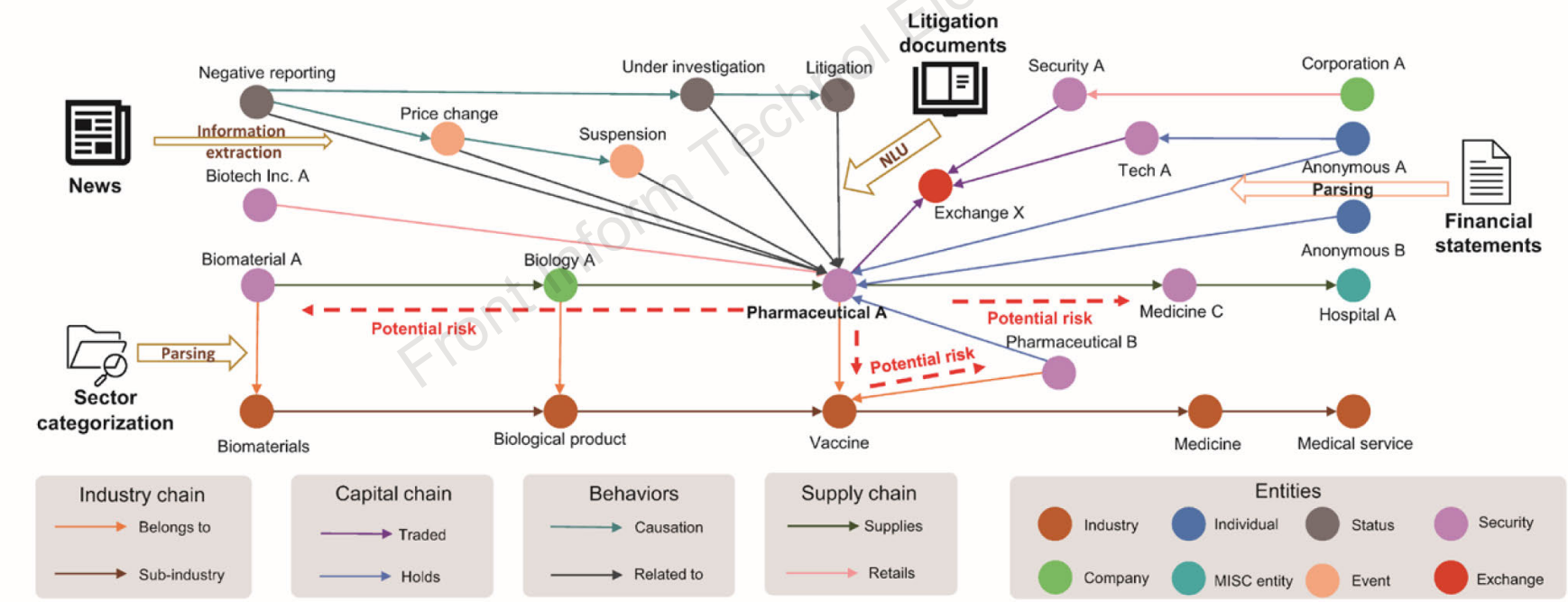

Fig. 7 An example of financial knowledge graph that contains behavioral information. All the financial entities and events are fictitious, only for illustration purposes. References to color refer to the online version of this figure

Engineering and architecture

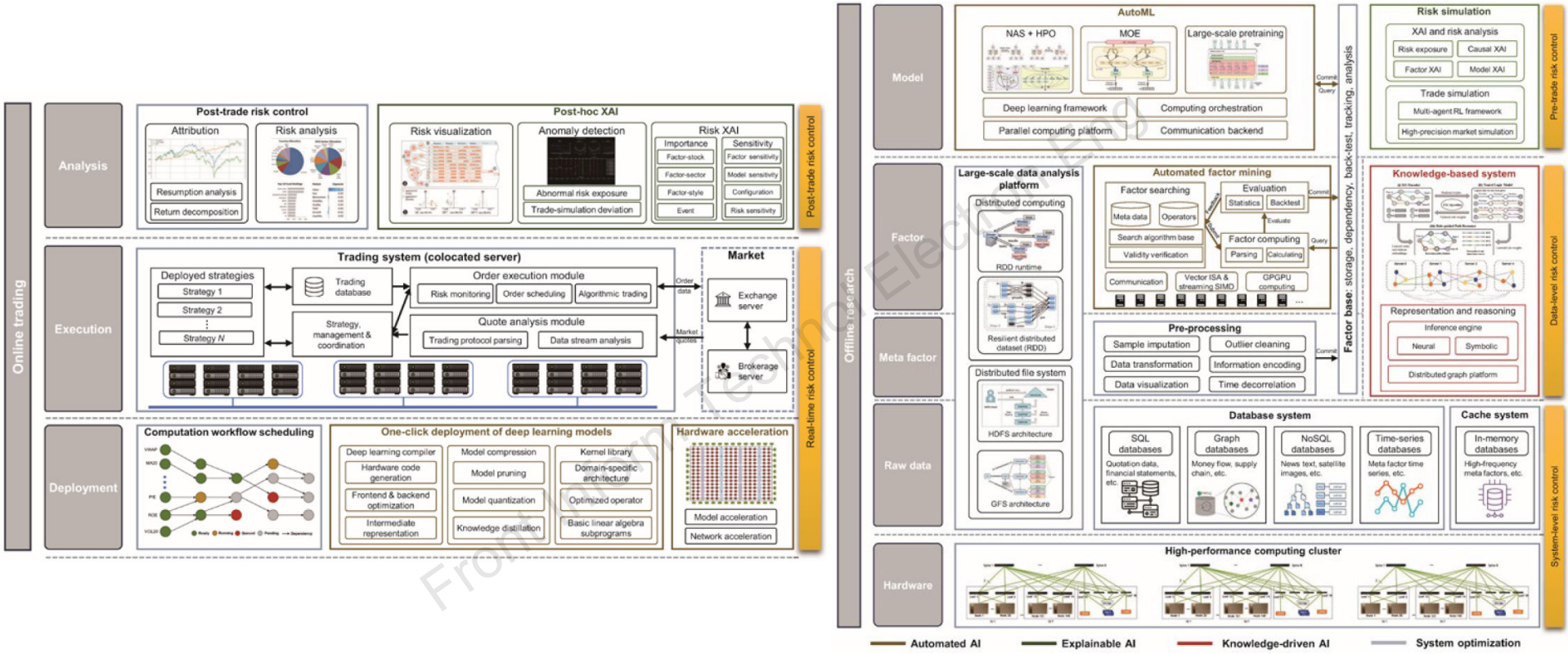

Fig. 9 Architecture of an example quant 4.0 engineering platform for investment research and trading. Parts of this figure are cited from Ghemawat et al. (2003), Shvachko et al. (2010), Zaharia et al. (2010, 2012), Bender et al. (2018), Real et al. (2019), Wang QW et al. (2021), and Fedus et al. (2022)

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.

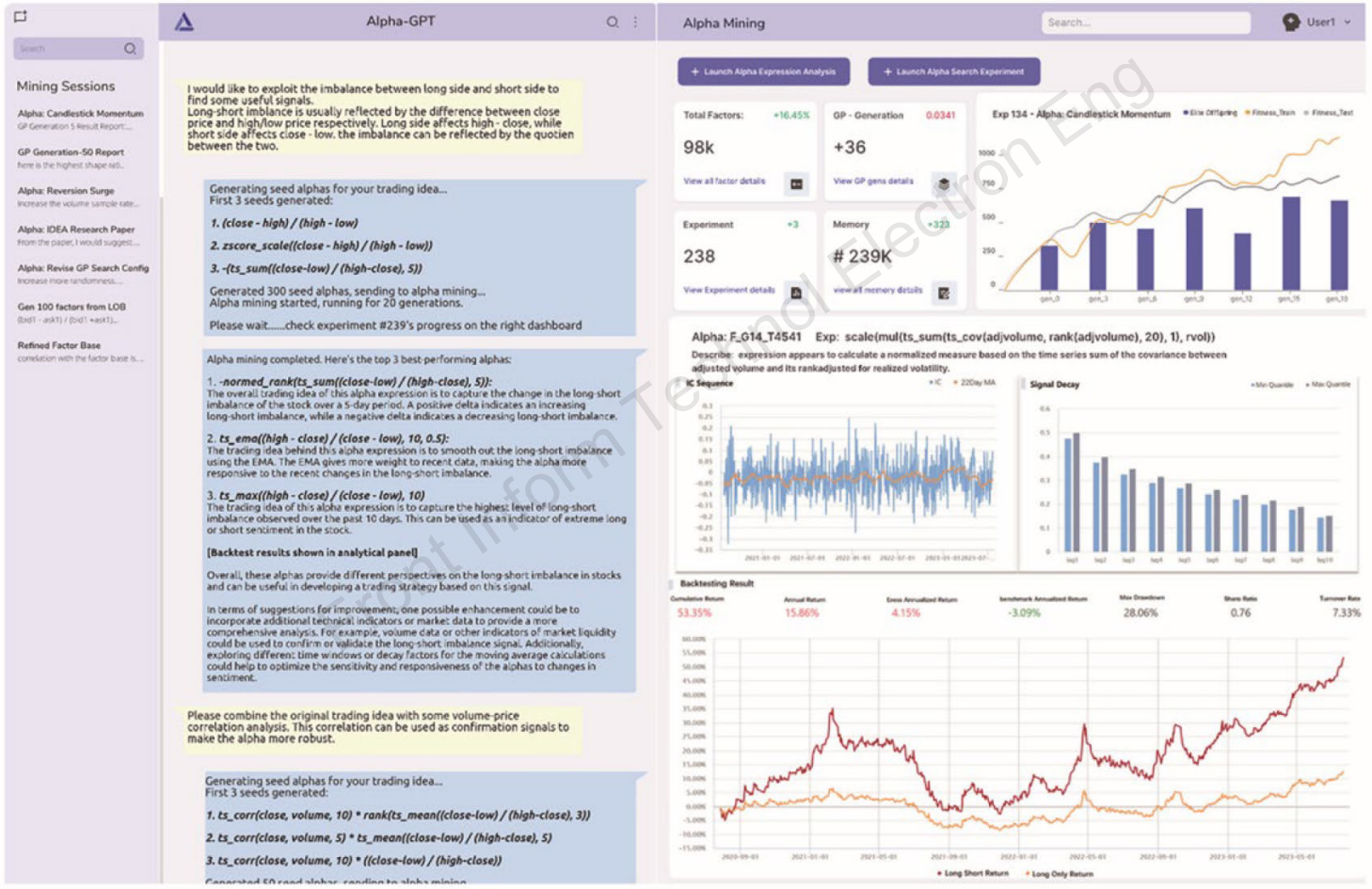

Fig. 11 (a) The Web-based user interface of Alpha-GPT (Wang SZ et al., 2023)

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.

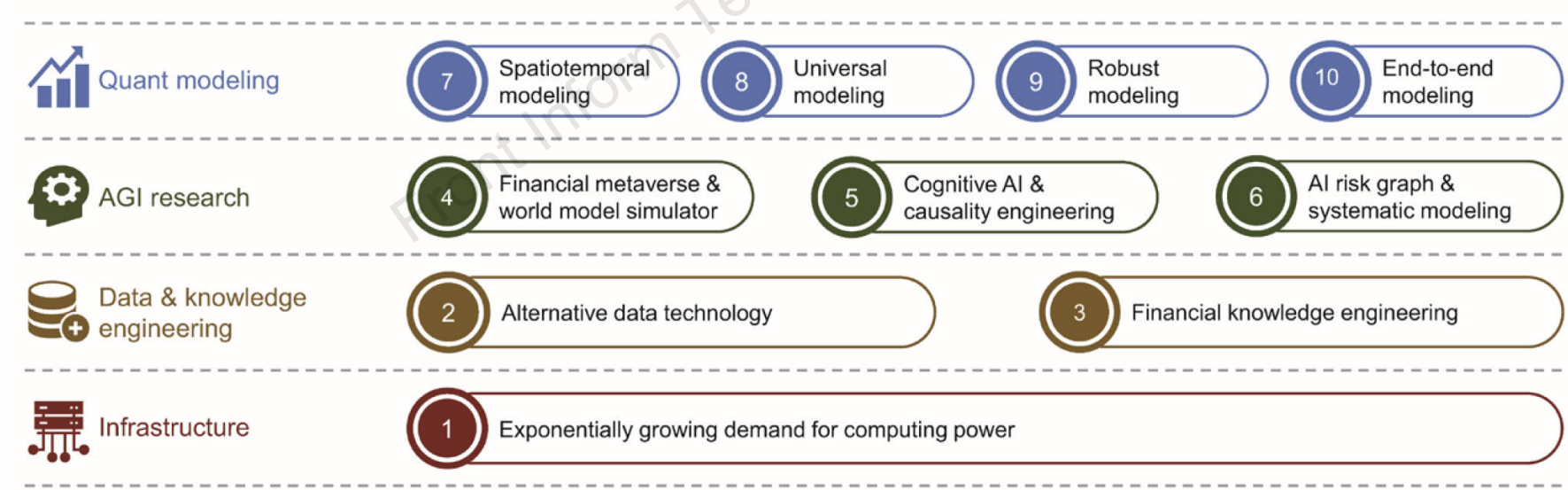

Fig. 14 The 10 challenges in quantitative investment technology

Jian Guo is currently the Executive President and a Chief Scientist at International Digital Economy Academy (IDEA). As a founding member of IDEA, he also serves as the head of IDEA Research Center of AI Finance & Deep Learning and a Professor of Practice at the Hong Kong University of Science and Technology (Guangzhou). He received his B.S. degree in mathematics from Tsinghua University, and his Ph.D. degree in statistics from University of Michigan. He started his professorship (tenure-track) at Harvard University in 2011. He has published a number of research papers in deep/reinforcement/ statistical learning, including theory and application. He is one of the pioneering AI finance researchers and an entrepreneur in quantitative investment industry.

Saizhuo Wang is currently a Ph.D. candidate in Department of Computer Science and Engineering at the Hong Kong University of Science and Technology, under the supervision of Prof. Harry Heung-Yeung Shum and Prof. Lionel Ming-Shuan Ni and working with Prof. Jian Guo. He received his bachelor of engineering degree in computer science from Chu Kochen Honors College at Zhejiang University. His research interests lie mainly in the interdisciplinary field of artificial intelligence and financial technology.

Lionel M. Ni is currently the Founding President of the Hong Kong University of Science and Technology (Guangzhou) and Chair Professor in the university's Data Science and Analytics Thrust, as well as Chair Professor of Computer Science and Engineering at the Hong Kong University of Science and Technology. Prof. Ni received his Ph.D. degree in electrical engineering from Purdue University in 1980. He is a Life Fellow of IEEE and a Fellow of the Hong Kong Academy of Engineering Science. His research includes high-performance computing, mobile computing, wireless networking, big data, and intelligent computing. He has published three books and 350+ refereed journal and conference articles. He has chaired 30+ professional conferences and received eight awards for authoring outstanding papers.

Heung-Yeung Shum is the Founding Chairman of International Digital Economy Academy (IDEA), and a Professor-at-Large at the Institute for Advanced Study, Hong Kong University of Science and Technology. Dr. Shum received his Ph.D. degree in robotics from School of Computer Science at Carnegie Mellon University. He is a Foreign Member of the National Academy of Engineering of the US, International Fellow of the Royal Academy of Engineering of the UK, ACM Fellow, and IEEE Fellow. Until March 2020, he was the Executive Vice President of Microsoft Corporation, responsible for AI and Research.