Deep Science Publishing
https://doi.org/10.70593/978-93-49910-98-0_12

Chapter 12: Envisioning the future of financial intelligence with decentralized systems, artificial intelligence regulation, and quantum finance

12.1. Introduction

This chapter serves as an introduction for the different themes presented in this book. The future poses many challenges to the proper functioning of Financial Systems at the local and global levels, such as the recent pandemic, increasing levels of poverty and inequality, conflicts, climate change, which have been accelerated by recent technological developments, or high levels of market volatility. We refer to the coordinated evolution of Societal and Digital Intelligence, as well as to the functioning of the Social Brain as Financial Intelligence. Therefore, we are creating the road map to accomplish to ensure the future progress of Financial Intelligence and the proper functioning of Financial Systems via the Decentralized Trust Infrastructure for Cyberpartnerships based on Cryptographic Signatures (Arner et al., 2017; Tapscott & Tapscott, 2018; Allen et al., 2020).

This book describes how it is possible to envision the Future of Financial Intelligence, starting from the concept of Financial Intelligence and the Decentralized Trust Infrastructure, Central Bank Digital Currencies and Stablecoins. Then, we focus on understanding how Current Developments in Cryptogenics and AI will shape the design of that new Future of Financial Intelligence. Finally, we also reflect on the role that Quantum Finance may develop in the World that we are creating with those Digital Trust Infrastructures Financial Systems, by redesigning Quantum Principles to develop a New Paradigm for Financial Systems. We envision a Future Empowering Citizens and Society, ensuring the protection of Basic Human Rights and Freedoms. In that sense, a Decentralized Trust Infrastructure is a Digital System that guarantees that two or more people working together remotely and asynchronously can rely on Digital Infrastructures to exchange Services and Digital Goods with a number of Cryptographic Signatures, decentralized Wallets and Smart Contracts without being manipulated by other people.

This Guaranteed Interaction can be mirroring the daily interaction between people working in the Real Economy and Society (Zetzsche et al., 2020; Kshetri, 2021).

12.2. Decentralized Financial Systems

Today's financial systems have been evolving toward increased dynamic complexity, from collaborative models to cooperatives, to startup-centric models, to centralized, hierarchical structures. The pandemic upheaval has accelerated the exponential growth of these networks to generate enormous amounts of non-linear financial flows evidenced by soaring stock prices, themed ETFs, inflated markets, and the dramatic entrance of Quantum Finance into the mainstream. Regulation, financial sovereignty, and digital awakening are in conflict with integrated, traditional financial models and systems.

Fig 12.1: The Rise of AI in FinTech: Transforming Fraud Detection and Risk.

No one paradigmatic design philosophy will govern finance in the coming century, but an interconnected and decentralized partnership design centered on advancing human capability development, establishing ideal motional vectors, and embracing the distributed quality of connection over control is likely to steer us collectively toward the goal of wealth and economic well-being for all. In proposed schemes outlined in this chapter, these ideal motional vectors become a demographic compass guiding all concerned parties toward mutual objective and incentive alignment based on shared information flows. These implementations could manifest into a Regulated Decentralized Architecture with Dynamic Design Pattern.

12.2.1. Understanding Decentralization

Decentralized finance (or DeFi) is a distributed community of financial services, in the form of software and smart contracts, that allow users to interact in various economic ways with reduced reliance on centralized authorities and institutions. From an economic perspective, a service is considered decentralized if it removes transfer of value to a centralized party in the transaction. In the case of most commercial, proprietary financial services, the transaction cost is a fee to the intermediary. In a decentralized financial service, value transfer (and associated business model) is shifted back to the participants and away from the service provider. The typical business model of a DeFi service is transaction fees or its payment with a governance token of the service offered by the service provider, holding the potential of a profit share. These services are then posited to be democratizing financial systems and sharing wealth more equitably. Additionally, when smart contract security is managed effectively, DeFi services typically have greater resilience against data manipulations that lead to exploitable errors in centralized models, which have worked poorly in the context of services like insurance and prediction markets.

The field of DeFi is heavily focused on systematic risk and contagion among both connected DeFi protocols, and between DeFi protocols and traditional financial and economic structures. DeFi users tend to be heavily blockchain fluent. That is, they typically prefer to hold blockchain-based assets instead of legal tender, prefer not using systems to share highly sensitive personal data with centralized institutions, and enjoy using financial services like trading on decentralized exchanges and lending currencies in DeFi lending pools, which are often more liquid and accessible than the counterparts (due to their 24/7 availability, for example). Also, where services are accessible (and not required), the transaction costs on decentralized crypto exchanges are less than on their centralized counterparts since they do not require large markups and asset transfers are mostly peer-to-peer. Such ease of use and liquidity advantages make these protocols popular for rapidly buying and selling tokens, often with free liquidity.

12.2.2. Benefits of Decentralized Finance

A decentralized finance ecosystem that is responsive to the concerns of today’s users presents a number of benefits to think about. It eliminates the moral hazard of formally-insulated centralized systems. A key part of future resilience lies in being formed by a community with genuine skin-in-the-game, that is investing in and committed to using the system. By being open-source, everyone has the opportunity to audit code, create improvements, and construct a community-based consensus around safety and durability.

Consider the current market cap of the crypto economy; it's exceedingly small when compared to the USD-based system. The possibility for network effect and easing access to a massively untapped demographic – unbanked people, and younger generations, is something to consider. A vast pipeline of creative builders is ready to deploy innovative projects upon decentralized systems – open-source products cannot be any more easily copied and rapidly built upon than a DeFi product.

Plus, the timeframe for development is lengthened, as the only marginal costs being made in innovation are on the transaction and smart contracts. Anyone can move in to again compare capital freely across many DeFi protocols – both in terms of liquidity and in terms of access to yield on virtual money market investments. The surface of the universe of short-term unsecured debt instruments, which becomes ephemeral in times of crisis, is vastly expanded. Exchange rate risk abates, while price transparency is greatly augmented as existing DEX are liquidity-focused and on-chain.

12.2.3. Challenges in Decentralized Systems

As is the case with any new technological or societal development, it is prudent to also evaluate some of the trade-offs or challenges that the transition to decentralized infrastructure may present. Not every single task available should be outsourced to the crowd, and some will be better suited for centralized solutions, either on the basis of operational efficiency or ethical standards. First and foremost, there is the research on the economic and psychological incentives that will convince another human being to perform a task remotely via an online marketplace. While some will do so for meaningful compensation, and others will contribute for recognition, the majority will not volunteer their effort or attention. This affliction could be addressed by creating engaging clusters of tasks that combine high externalities with high results, but might prove correct on the basis of market barter and reward to motivated players.

Beyond the basic crowdsourcing motivation challenge, there are downsides to a decentralized design that some designers call "market fragmentation." Credible vendors offering the best prices may emerge, or others may cluster around a marketplace with a glorious reputation in order to maximize their business volume. In cases of value aggregation, like car-sharing or lodging-pairing, the set of centralized solutions will dramatically outperform the fragmented decentralized alternatives. This, however, will not necessarily point to a centralized model: Indeed, a well-known company has solidified its position in the car-share market for reasons other than the spirit of profit.

The brand is most recognized in the consumer's mind, just like another brand is acknowledged as the best for Internet searches, even if the company hierarchy is publicly traded.

On the other hand, there are disclosure and trust issues surrounding not only the gathering of user profiles, but also the reliability and accuracy of the crowdsource evaluations. While the collective wisdom of the market may be the most resilient measure of true quality, nested filters and normalized matching may be necessary in order to alleviate some of the negative consequences of information asymmetry. Furthermore, in the case of creative crowdsourcing, poor quality tasks or economic insecurity will severely damage the quality of the products produced. Creativity is influenced by a person's socio-economic situation but also by the psychological framework later developed.

12.2.4. Case Studies of Successful Decentralized Models

While completely decentralized models have not been efficacious in their operationalization, there exist many provisioners of digital technologies that have actively decentralized specific facets of the activities that were traditionally performed by centralized financial institutions. In particular, we focus on examples in the financial data infrastructure and credit risk space, exploring initiatives that have achieved certain levels of success.

Financial data is an essential element of financial intelligence. While technology investments in market data have created alternate sources providing new and informationally diverse data, they have not often challenged the dominance of traditional data vendors. New data vendors often provide alternative sources of data, while relying upon the centralized vendor infrastructure for distribution and curation. This requirement for vendor infrastructure creates a friction point for large asset managers and banks, as it introduces dependence on multiple service providers. These large firms are usually looking for end-to-end solutions. The attempts by new data vendors to offer such solutions, dependent on proprietary models often lead to changes in prices leading to price challenges on fresh data.

The development of blockchain technology offers the potential for radically reworking the operational and economic model for providing financial data. Start-ups currently focusing on blockchain offerings for providing financial data on a decentralized basis include various companies. Other financial data infrastructure providers offering decentralized possibilities are also present in the area of risk data. These start-ups have not been completely successful in their efforts so far.

12.3. Artificial Intelligence in Finance

AI has expanded into multiple sectors of the business ecosystem, particularly into finance. Governments and the private sector have recognized the utility of AI to economize on expert manpower, deploy hundreds of fast, repetitive and rationally-interpreting computers into targeted labor. In finance, China is doing the proverbial walk before it is ready to run. Global leaders have access to top-needed qualified people. AI is making robust inroads into the quotidian tasks of human financial experts. The efficiency of search, predictive model testing, and information and communication technology means that AI-powered tasks can be conducted on far shorter timescales than the traditional financial system allows. These algorithms have taken on tasks such as stock market monitoring, mergers and acquisitions activity monitoring; outlined content for venture capital memorandums, designed business models, monitored credit card applications, and have worked on cyber defense in cybersecurity finance. AI is also assisting research and investment sectors with factor modeling in finance, algorithmic trading, auto-hedging, and portfolio management.

Feature engineering in finance. Financial and economic data is noisy, and most deep learning models do a poor job at predicting their time series flows. This also reduces the need for hard feature engineering in finance, thus dramatically speeding up the time to solutions and allowing the use of complex models. With the notable exception of the use of recurrent neural networks in time series problems which are sensitive to tail risk, such as currency forecasting, speech recognition, or handwriting recognition, deep learning models for tabular data, such as in finance, have struggled when compared to state-of-the-art gradient boosting techniques. However, it is important to strongly emphasize that the protagonists in the ML applied in finance are the people reporting the use of ML, who come from the finance side. Their commercial needs to employ skilled ML people from the academia and technology sectors.

12.3.1. AI Applications in Financial Services

Humans and machines work together in an AI-augmented world to amplify human intelligence and skills beyond their natural limitations. Collectively, they achieve outcomes far beyond what either can accomplish alone. AI solutions are accelerating and transforming a wealth of economic activities across the globe, but in financial services, these innovations are especially in demand. From combatting terrorist financing to auditing fair and unbiased lending practices to identifying new investment products and improving collection of nonperforming loans, AI applications are impacting every corner of the global financial services sector. And financial firms are racing to create and deploy their own solutions.

The financial services industry was among the earliest adopters of AI, laying the groundwork for widespread enterprise resources planning, data mining, and fraud detection efforts in the decades before recovery from the global economic crisis ushered in the big data era and machine learning became ubiquitous inside and outside the industry. What began as rule-based decision engines scripted for a narrow range of specific use cases now combines an astonishing variety of ML with sophisticated scenario mapping and predictive analytics to overcome the challenges posed by the unique, incomprehensible complexity of finance – including widespread regulation by governments to whom the sector is accountable. In particular, supervised reinforcement learning demonstrates an impressive ability to enact resource allocations that leverage rewards while keeping critical risk factors in line. Other popular use cases harness generative adversarial networks, differential privacy, meta-learning, and other AI methods to personalize offerings, push financial products into a consumer's digital world, and minimize customer service costs.

12.3.2. Machine Learning Algorithms for Financial Analysis

Machine Learning (ML) and Deep Learning algorithms have proven to be more accurate than traditional econometric models. AI equipped with sufficient data is capable of learning patterns that humans cannot see. The success of AI has allowed its implementation to grow not only in the financial but also in the academic world. This section cites the most popular algorithms applied in Finance.

Support Vector Machines (SVM) were invented in the 1960s and popularized in the 1990s. The basic idea is to search for a hyperplane that separates different classes of data with the maximum margin error. If the problem is complex and there exist no hyperplane that can separate the different classes, SVM can transform the input data into a higher-dimensional space in which the hyperplane exists. SVM is probably one of the oldest Machine Learning algorithms still in use today.

Artificial Neural Networks (ANN) were invented in the 1950s. The basic idea is to use a non-linear combination of weights and features as the basis of a model. In the 1980s and 1990s the introduction of back-propagation for the training of ANN made them the de facto standard for all prediction problems. In 1990, "deep" networks (with multiple layers of hidden nodes) that profited from the learning of intermediate non-linear features became popular, but it is because of the increase in the capacity of computers, the increase in the amount of data available, and the increase in the amount of data labeled that the success of Deep Neural Networks has been observed in the last three decades. DNN are special cases of ANNs, and possibly trained by similar techniques.

12.3.3. Ethical Considerations in AI Deployment

The development of Artificial Intelligence (AI) has surpassed academia and industrial labs, immediately impacting our daily lives and fueling concerns. The recent dramatic developments in AI - such as generative AI - have made us realize how smartly these complex systems can do certain tasks. However, the safety and reliability of AI systems have become points of concern. Questions regarding the commercialization of advanced AI, its ability to do nearly anything, its early adoption in sectors like content moderation, discrimination in hiring by using AI, and its potential to exacerbate the surveillance state are fueling fears. The burning question is: How can we guarantee that AI systems are transparent, reliable, safe, and aligned with human interests throughout their entire life cycle?

A large cause of concern among experts and the industry in general is the unpredictability and opacity of advanced AI systems and their immediate extrapolation to social systems or critical systems. While much progress has been made regarding ethical AI and AI safety, the majority of this discussion focuses either on the technicalities of decreasing AI general capabilities or general transparency and trust concerns from an abstract perspective. The general concern is grounded in the collective awareness that no AI system is made entirely of algorithms - all AI systems have components of collecting data, training an algorithm, integrating it, and deploying it. The data used, training process, integrated system, and deployment strategies are equally crucial in determining how safe an AI component of a larger system will be. As we focus on practical AI deployment and integration solutions, our reflection is based on the premise that a successful AI system is one that is successful under all components from the life cycle of AI.

12.4. Regulatory Framework for AI in Finance

The use of AI in finance has received unprecedented attention from policymakers around the world. Countries in the EU are also actively discussing development of the AI Act. The Office of Financial Research expressed concern that as many as 641 financial service firms in the EU may be impacted by the AI Act's stringent requirements. On the other side of the Atlantic, regulators in the US released Requests for Information for AI algorithms related to social equity and civil rights and potential risks associated with its use in federal government agencies.

In the coming years, we expect more specific regulation focusing on AI in finance rather than nascent proposals. Business as usual will not address novel challenges for AI in finance. At present, regulations addressing classical finance issues such as consumer protection and access, safety and soundness, national and financial stability, risk management and accountability, malicious activity, integrity and efficiency, and illicit activity focus on the outcome rather than the process. Existing rules for Finance 1.0 gave regulators a non-exhaustive guide while expecting institutions to bring them within the realm of machine learning in their own way. Such piecemeal and inequitable implementation will no longer suffice. Without a comprehensive regulatory framework for AI in finance, industry will not invest the time and money necessary to fully realize the potential societal value from AI applied to finance.

12.4.1. Current Regulatory Landscape

AI & ML play a significant role in modern finance. A growing portion of trades on US markets are executed via algorithmic trading and now constitute the vast majority of trading volume in the markets. Further, AI, ML, and generally Data Science, in all its explosives potentialities, saturate research, strategy building, and decision-making within all functional domains of Financial and Banking Institutions. Its utilization ranges from portfolio management and risk control to loan underwriting, customer relationship management, compliance, fraud, foreign-exchange operations, mapper of third parties, trade execution, and others. Financial Institutions rely on AI systems to detect, prevent, and respond to complex offenses such as money laundering, terrorist financing, and trafficking in narcotics and other illegal drugs. AI algorithms are used to interrogate customer records, transaction data, and data from other sources to detect the movements of small groups of people and link them to the larger criminal syndicates.

Nevertheless, regulators have rarely established regulations that are specific to Finance and AI or any other AI regulation for that matter. On the other hand, supervisory agencies have alluded in their public statements that general-purpose AI regulations could also be applicable to AI utilized for Finance. The increasing use of AI-based models by financial institutions exacerbates some vulnerabilities related to the opacity of the algorithms, potential data abuse, errors in the model design, implementation, or output, dependency risk, and cybersecurity. However, these vulnerabilities are not a source of additional systemic risk.

12.4.2. Proposed Regulations for AI

Governments and organizations around the world are calling for AI regulation. The proposed regulatory framework aims to address the key risks associated with AI systems used within the Union. The regulation will define the regulatory environment related to the use of certain AI tools that have been categorized according to a risk-based model. The AI regulation will incorporate a flexible model that is designed to adapt to changing AI capabilities over time. The regulation will impose strict requirements for very high-risk AI systems, including a determination of the system's purpose, training data quality assurance, data governance, risk management, system accuracy checks, human oversight, and document creation, among others.

At the second tier, high-risk AI systems will be subject to several transparency obligations. At the lower-risk tier, including many more common AI systems, there will be fewer rules, and companies that use AI tools to assist with governance, risk, and compliance would likely welcome the proposed framework. Players using AI tools to evaluate risk, detect money laundering, assess creditworthiness, or make trading decisions will be encouraged to implement special measures to allow them to comply with the proposed framework. It is expected that many of the requirements for all risk levels will be implemented through a standard form. The regulation lays out broad obligations that impact a wide range of areas including concepts like fairness bias in AI, aspects of privacy, maximizing quality and security of data, human oversight, and post-market monitoring.

12.4.3. Impact of Regulations on Innovation

Innovation regulations are established to provide a systematic and organized framework for the development of emerging technologies. In financial technology, innovation regulations impose the regulatory policy objectives in terms of how to innovate and what effects the innovation is trying to achieve for sustainability. However, inappropriate regulations can be burdensome for companies, and unnecessary compliance costs can be imposed on those corporations trying to engage in vertical innovation. The disruptive effects of the development of these technologies can often radically inhibit the ability for measured and careful regulation to be established. Without an enabling regulatory framework, more harm than good can arise for society. It is important to ensure AI deployment regulations remain efficient, lightweight, and do not hamper AI and associated innovative tech development. We can expect that AI will drive a wave of complex regulation in varying jurisdictions. Data privacy is at the forefront of debate, and there is already a slew of legislation proposed to outline new frameworks.

As it stands today, it is already difficult to determine which regulatory agencies might exert oversight over AI deployment. An uncoordinated, patchwork approach to regulation could pose a serious, perhaps existential challenge. For companies competing in various jurisdictions, these different and potentially conflicting regulations could impose disastrous compliance costs of implementing different processes for different geographies. Compliance is at the crossroads of AI development and deployment. AI meets compliance demands more efficiently than legacy rule or model-based systems. AI seamlessly deploys compliance processes to run in the background, monitoring for unusual transaction patterns continuously, and alerting when policy violations may have occurred. The next disruptive phase of this technology will allow companies to focus on performance and outcomes with AI as their partner carrying the burden of checking each decision against compliance regulations and floating a flag if it identifies potential violations while allowing the business to do what it does best.

12.5. Quantum Finance: An Overview

In this chapter, we discuss quantum finance and how quantum computing can be deployed to address current shortcomings in financial modeling, how its development will require a paradigmatic change in the regulation of the financial sector, and how its hasty or incorrect implementation can create discrimination and harm marginalized communities.

Quantum finance is one of the most promising areas of quantum technologies, promising to transform how data are processed and analyzed in finance sectors. Quantum finance has the potential to completely rethink how the developed world economy traditionally viewed pricing, risk assessment, and the exchange of derivatives and other financial instruments, posing a rewiring of the financial infrastructure.

Quantum finance draws its basis in how quantum mechanics and quantum physics process data. This area deploys two quantum computational components. The first consists of the universal approximation theorem that states that an artificial neural network with a single hidden layer containing a finite number of neurons can approximate any continuous function from and to finite-dimensional spaces. Universal quantum approximate optimization algorithms employ learning methods. The second component is the kernel method that states that a quantum computer can embed data into exponentially larger feature space, thus simplifying the task of the classical supervised learning algorithm. Quantum kernel methods use quantum processors. These two computational methods allow quantum computers to model some patterns of data that classical models are not equipped to discover.

Quantum technologies expand the potential of modeling but are still in an incipient stage in terms of implementation and hybridization of algorithms. At this point, specific tasks still have to be assigned to quantum or classical systems depending on specific speedup used. Some identified areas of potential quantum advantage in the finance sector are computations of profits-and-losses in portfolios, Monte Carlo simulation of option pricing models, pricing and hedging derivative products or trades, multi-asset derivative pricing, capital or risk management, credit risk management, and generating data for anti-money laundering strategies and plans.

12.5.1. Introduction to Quantum Computing

The last decade's exponential growth of computational and data capabilities has enabled the successful implementation of various subfields of artificial intelligence (AI) in many industries, including financial analytics and modeling, such as algorithmic trading, risk and fraud management, forecasting, as well as quant investment theories, such as asset pricing, portfolio management, and derivatives pricing. However, as these methods start to reach their limits of capabilities and development, the field of quantum computing has been rapidly advancing. Quantum computing is a novel technology that leverages the unique properties of quantum mechanics to achieve a computational speedup over conventional computing capabilities, with exponential probability over classically intractable problems. It uses quantum bits or qubits that can represent multiple states simultaneously through superposition and entanglement, enabling parallel computation to exponentially increase processing speed and capacity. This creates enormous opportunities for a variety of fields, making it a high potential tool for economic modeling and financial analysis.

Despite being an emergent field, the growing amount of research has demonstrated to have quantum potential speedups when applied to problems in many economic fields, such as quantitative finance modeling, as well as in other econometric fields, such as econometric time series analysis, game theory, and auction-based mechanism designs, among others. Various quantum algorithms have been proposed over the years and can potentially be applied to tackle financial tasks, such as simulation of quantum finance processes, derivatives pricing, and option pricing under the optimal stopping theory. However, the technology is both economically and technically difficult to develop and is still going through ongoing studies. The purpose of this text is to introduce what quantum finance means for the financial world, what it can bring as potential benefits and applications to quantitative finance, as well as to discuss and warn of the risks and challenges that we must face as a society in building this new quantum economy.

12.5.2. Potential Applications in Financial Modeling

Quantum computing presents an exciting opportunity to address questions that would otherwise remain unanswered in computational finance. Since finance-related computing problems ranging from portfolio optimization to derivative pricing and risk management are either NP-hard or can be solved only in a heuristic manner, the limited computational resources provided by classical machines seem to be a barrier to progress in quantitatively based financial modeling. Simply utilizing advanced systems over the next few decades would be no guarantee that these types of important finance challenges will actually be solvable in the future. It is also possible to develop practical quantum algorithms for these computationally difficult questions such that the speedup gained is quadratic and exponential relative to classical computing. Solving those NP-hard problems using such quantum algorithms would help realize, for example, the strategies sought by hedge fund brains and investment banks.

Fig 12.2: Artificial Intelligence and Its Transformative Impact on Public Finance

However, quantum algorithms currently possess a number of limitations that govern what language models could realistically hope to accomplish: in most cases, they solve problems in specially structured settings, providing a possible quadratic speedup over the best of currently known classical counterparts. For some problems, quantum algorithms deliver only a polynomial speedup compared to classical methods. In addition, the problems we involve must exhibit inherent solution characteristics, allowing quantum sampling of those solution characteristics to make an approximation of the correct solution expeditiously.

Certain areas of interest in the financial modeling community may take advantage of quantum speedups: quadratic speedup could help to solve problems arising in maximizing or minimizing objective functions, such as finding the portfolio allocation minimizing the actual risk of investments or finding the optimal calibration parameter for options pricing models. Hybrid quantum-classical systems could then also be used for efficiently training variational recurrent quantum neural networks to speed up financial forecasting.

12.5.3. Risks and Challenges of Quantum Finance

Quantum finance presents a tantalizing glimpse of a future in which quantum computers perform previously infeasible financial calculations and thereby bring about new financial opportunities and efficiencies. Yet, adventuring into quantum finance offers dangers of its own. This section briefly summarizes some of the discussion surrounding potential risks, challenges, and pitfalls ahead if and when quantum finance reaches fruition. Crucial in this context is an explanation of what we mean when we label issues facing quantum finance something other than risks associated with quantum computers per se. Deciding what activities constitute quantum finance versus factors simply reducing the potential impact — negative or positive — of a future quantum computer's implementation is neither simple nor exact science. Furthermore, analyzing the many issues at play at once is a complex proposition, but much of the risk surrounding quantum finance can be categorized as either quantum-specific, quantifiable — but still troublesome for our purposes — risks associated with quantum development but not material to any single application area or group of applications.

More precisely, quantum finance challenges and risks specific to quantum finance practice arise because of the unique nature of quantum finance. First, CFD has long been a speculative area. The risks involved in some quantum finance implementations merely augur or accentuate challenges already existent in CFDs in general, but they have an outsized effect in the case of quantum finance because the hypothetical tools become magnifiers and accelerators of otherwise quantifiable uncertainties. Return-Latency Risk concerns the structure of the quantum finance model. Future developers of state-of-the-art quantum algorithms for finance functions within limited space on the quantum nuts-and-bolts frontier.

12.6. Integration of Technologies

In the coming decade, the three transformative technologies that will fundamentally change the nature of financial intelligence are decentralized systems, artificial intelligence, and quantum computing. Decentralized systems delegate critical functions to machines connected to decentralized networks. Machine learning, automatic reasoning, deep learning, and knowledge bases are artificial intelligence technologies that enable deep machine intelligence. Quantum supremacy and quantum speedup offer new sources of computational capacity via new computing paradigms that will speed up traditional algorithms or enable new computational capabilities. Thus far, the domains of fiscal intelligence have focused independently on these three technologies, exploring their applications within the delineation of their respective domains. With some notable exceptions, there has been little exploration of the intersections of these domains.

The future will demand the integrated application of these three domains because each domain addresses a fundamental limitation of the other two. Decentralized systems currently lack real time responsiveness, flexibility, optimality, and reasoned decision-making capabilities that are associated with AI. Embedded AI accelerates performance and responsiveness, improves reliability and security, and enables deeper natural human-technology collaboration. These capabilities are specifically required in personalized financial decentralized services because of the heterogeneity of financial customers in terms of preferences, risk appetites, degree of technology adoption, and degrees of financial acumen. Current AI systems lack credibility and transparency. While new algorithmic architectures are being developed to provide claims of real-time explanation, the linguistic translation of every decision made by a neural network operating in the background is not directly meaningful to the average human user.

12.6.1. Combining AI and Decentralized Systems

Many applications exist or can be imagined that combine established decentralized systems with Artificial Intelligence algorithms and or technologies. Examples are abundance based currencies, tokenized AI services, or data markets. Particularly interesting are decentralized services that support the AI ecosystem or some part of it. The most interesting ones are decentralized communication channels because they have the potential to create information coherence of AI agents without an additional central organization that other silicon or quantum based AIs would have to obey to. It is a fair assumption that the AIs of tomorrow will use existing digital communication networks. Even if they will directly exchange information between each other without human intervention, they will still go through centralized servers. The AIs of tomorrow will thus have access to all communication information stashed away in centralized clouds, and will be confronted with censorship policies created by the owners of the respective clouds. This is not a population-wide alignment with human interests.

A solution to this potential threat is the development and deployment of decentralized communication channels that use the network of all peers, that is, participants in the chat or conversation. The service is based on the distribution of smart contracts, which the user determines, and which are executed centrally at every peer via the execution layer of the system. By using these network local contracts every participating user can determine which additional channels his client can communicate with. He can do this essentially by applying filters or rules in any AI design, which will accompany the user at all times as metadata stored on his smartphone or personal cloud and will be invoked by the system only whenever necessary. The same applies to all tokens sent or received by these channels.

12.6.2. Quantum Computing and AI Synergies

The surge in newly developed large language models brought both excitement and worries to numerous industries. The advancements in AI mainly go to how well the techniques can replicate human responses in the near future. The implementation of such tools saves costs, but depending on the intended use case, extensive regulations may be required. Regulatory bodies demand a microscope-quality exploration of AI implementations, how the models were developed, what type of bias the models may contain, intellectual property issues, privacy, and deployment procedures. The proposal is that the more invasive-type models, banks or central planning processes, shall go to intense scrutiny and provide information regarding the aforementioned topics.

Ahead of any possible AI regulations, quantum computing may find a window to pave its use cases. AI quantum initiatives unveil a collaborative unexplored field of quantum computing becoming exploratory devices for AI, with foundational consequences. Because LLMs and other ML models rely both on tech-needs to crunch hundreds of terabytes of data, quantum may become mechanical power or be just more usable, cost-friendly versions of classical ML. In the AI space, innovation comes in business aspects as well. The person behind the popularization of LLMs stated that he may consider opening a quantum company with the only idea of paying for hundreds, if not thousands of times, the current price of quantum computing just to have the capability of testing ideas. AI, in its preliminary stages of deployment, forecasting prices, projecting news and sentiment analyses may use quantum to hasten its become-time while quantum, asked to embrace AI and learn from its speed and deployment may serve as a most wanted business and investment trip.

12.6.3. Future Trends in Financial Technology

While the past decades' technology transformations shifted the FinTech landscape from a world physically burdened by institutional and organizational inertia, fixed structures, and distribution networks, toward one pushed by ideas of decentralization, accessibility, and disruption based mostly on technology, a second stage of the transformational curve is about to unfold. This second stage is characterized by the intertwining of many of the initially separate digital specialization strategies into technologically driven comprehensive solutions and bundled services that are truly capable of further developing the financial and economic infrastructures of the free market world. These new opportunities for innovative product developments and market entrants are stemming from the interplay of the latest developments in AI, blockchain, quantum computing, decentralized finance, centralized finance, crypto and digital assets, the metaverse, and SocialFi.

Amalgamating and integrating infrastructure, tools, services, and ideas of interconnectedness for the novelty metaverse world with products based on decentralized sharing and funding, artificial intelligence workforces, extended reality interfaces, crypto and digital assets, together with the backend techno-financial infrastructure of a decentralized financial and exchange world monetized by financial and economic services for the ecosystem participants are likely to shape the metaverse to come. These platforms will create not only a digital community and product experience channel, enabling a novel categorization and segmentation of real world identities and market potential, but will also serve to rethink physical community coordination and funding as decentralized programmable tools of structures will be developed.

12.7. Impact on Financial Markets

Financial markets, as seamless mechanisms for exchanging various assets and rewards, look likely to experience tremendous shifts stemming from three sources. First, financial markets have already begun to use decentralized autonomous organizations and various decentralized finance applications. Since these organizations use smart contracts to organize various agents and assets with minimal hierarchical structures, they distribute ownership and operator responsibilities among the various observers of the market. Thus, financial markets could grow in exposure to all kinds of agents and assets, vastly expanding their apparent depths. Since most of these organizations have multiple kinds of tokens, with one token possibly expressing a kind of management right, they could normalize the market participants dictating their priorities in token supply and demand. In contrast to the traditional models of financial markets where a few large institutional firms control major trade channels, the increasing effect of these organizations could democratize the financial systems and the power dynamics therein. Furthermore, as decentralized finance gains traction, more and more of traditional finance's functions are shifted to smart contract-based ecosystems, financial markets may face increasingly diversified operations, complications, and risks. For example, allowing a host of competitors to engage in shadow-beta testing of various financial products could drive market innovation over shorter and shorter inflection points.

Second, artificial intelligence functions in financial markets will deepen and advance. We should expect improvements in the quality and availability of information to traders to lead to more accurate predictions of the future value of assets and rewards. More accurate expectations may decrease market volatilities, but they will also heighten correlations in trading activities and hedge volumes, leading to turbulent collective behaviors. Empirical analyses show a significant increase in roll-image inflations since the late 2010s, with trading-volume correlations continuing to increase. Trading volumes and activities during major crises reinforce such observations. They jointly display strange discontinuity, erupting into turbulence during jumps in currency deviations and related price variations, drowned by other sudden jumps in correlations.

12.7.1. Market Dynamics with Decentralized Finance

Could Decentralized Finance (DeFi) change the rules of the game for quantitative strategies in trading? It is no coincidence that quants have been rushing in the past decade to design algorithms to make markets on crypto-exchanges: the models they use are similar to the ones employed in the real-side markets of severely disrupted markets: stock markets in flash crashes, FX and rates in the COVID-19 scare, etc. Once a sufficiently developed tokenization infrastructure for trading the real-world economy is in place, one can fear that HFTs will detect arbitrages in this market that is the closest to Nature's ideal of market spontaneity.

If today these algorithms are deployed on closed markets, where access to liquidity is function of an imperfect knowledge of the order flow, then after a “successful growth” phase of DeFi, these algorithms may spread into open market-making across DeFi, facilitating exchange in the world of tokens-to-come. The outcomes from such a convergence would, we can suppose, ameliorate the IFT backestme effects. In a holistic picture of the economy, there is no doubt that such a dynamic would be preferable to a continuation of today's market-making in a secluded “tokenized economy” of not-yet-Tokenized Objects.

12.7.2. AI's Role in Market Predictions

Artificial Intelligence (AI) is already playing an increasingly bigger role in defining market predictions. AI strategies provide valuable forecasts regarding the assets future prices and value. One common use of Artificial Intelligence in financial services has to do with predicting break-out or breakdown levels. In this case, the AI is trained to monitor price action until the crypto-assets price tests important levels of resistance or support more than five times. When the crypto-asset price tests one of these levels and the AI identifies that we are close to the break-out or breakdown event, the AI recommends entering a long or short position.

Considering, however, that the influences built at the crypto-assets market change usually every four years and, thus, should also be accounted for in the AI short-term position recommendations, a more sophisticated AI would need to be able to understand which influences are having a bigger impact on predictions to better estimate the price action. In this sense, any AI model for financial markets predictions is expected to evolve over time and curate their internal datasets considering the markets trends to be able to predict future crypto-assets price actions more accurately.

When we analyze the crypto price action, the part from the base low up to the previous important top appears the most important one for the AI predictions. Considering the price action part defined, the AI is then run to identify the algorithms that best capture this behavior. In this section, we work with a specific type of AI, and specifically, an AI algorithm that applies Symbolic Regression. Through Symbolic Regression, the algorithm returns nonlinear equations that fit our close price action data and, thus, are capable of outputting future price predictions.

12.7.3. Quantum Finance's Influence on Trading Strategies

The field of Quantum Finance involves relying on principles of quantum mechanics to create algorithms that can analyze financial markets, as well as perform statistical modeling on financial data. Quantum Finance can also be used to explain market behavior by leveraging concepts from quantum physics. In its operational aspect, Quantum Finance aims at the implementation of financial transactions: carrying out a trade with the application of optimization algorithms from quantum computing. After accomplishing that, Quantum Finance also pursues the reduction of the risks associated with executing the sequence of trades necessary to perform the financial transaction, i.e. to get in and out of the market. Due to its computational power, Quantum Finance would, for example, replace the high-frequency trading algorithms. Even though today such high-frequency trading algorithms developed by investment banks manage their risk continuously based on speedup of integrated circuits, which is closely now to its end, they are implemented as classical algorithms and cannot be as risk-optimized, as the Quantum Finance can accomplish. Who would have thought that an abstract physical research could influence investment strategies? High-frequency trading performed by Quantum Computers would push markets even more toward efficiency and market liquidity would therefore tend to be best.

Nevertheless, having quantum computing develop specific Quantum Finance algorithms, then attempt to create them for financial markets with reduced risk strategy could have long-standing impacts and confuse economics as we know it. Challenging would be to determine the period necessary for specific financial markets to return to their normal condition; economists would consider themselves essentially naive to believe other markets' operations would be similar, let alone the same, in a globalized perspective. Would they expect the effects of trading systems reliant on quantum algorithms to apply the same across markets? It is naive to think operating economies don’t depend on their fundamental variables. Would a short-term influence to be examined across financial markets over economies make sense? Of course. How to measure those effects? Then, how much time would be necessary for those markets to revert after the application of the short-term trading operations?

12.8. Security and Privacy Concerns

Security and privacy in financial systems have long been priority issues, and indeed, concerning the potential for massive financial loss, they are priority issues in all system design. Decentralized systems hold an advantage in terms of risks associated with individual control, transaction verification, and centralization attacks, as well as storing vast amounts of sensitive data on servers susceptible to attack. But each decentralized point of control is more exposed to hacking, and the design of financial tools around those risks is more difficult. Moreover, unless strong price controls are in place, anonymity in monetary transactions creates all sorts of undue incentives for criminal behavior. Regulation must address these types of security and privacy concerns to avoid the ethical and practical issues raised by such technologies when they are deployed in overly bureaucratic, simply automated ways.

The sector using quantum mechanisms to increase information security is among the more exciting in current physics. Quantum encryption essentially utilizes two principles of quantum physics: it creates pairs of entangled particles, and forces the transmission of those particles to exist at high level superposed states, which ensures that they can be checked at any time for tampering or hacking. If such a transmission is tampered with, the entangled particles are brought out of entanglement, and the transmitter and receiver will know that the communications channel has been breached. Quantum encryption is thus among the most secure transmission modes, but it is still an added expense in terms of communication that small firms may choose not to invest in, thereby also raising the same ethical concerns as applied to any of the other techniques mentioned above.

12.8.1. Risks of Decentralized Systems

Companies invest significant capital into their decentralized systems and realize great success and savings. User-driven decentralized systems that users pour their own resources into while sharing in the reward are a great alternative to consideration networks. However, there are inherent risks and issues we must be mindful of, such as long consensus times that can make trading and settling transactions too slow to be efficient; lack of identity verification which allows bad actors to move in real time without being determined to be illegal or immoral actors; security risks that bank accounts and crypto wallets may be hacked for personal profit motivation; governance issues and silos if not everyone wants to work together or holds a minority interest in one area; and there are countless examples of something happening to the gatekeepers of wallets and accounts that would prevent anyone but the gatekeepers from accessing whatever deserves to be accessed. In addition, hackers can take over smart contracts, governance issues in DAOs may lead to issues in deciding how to run things, there may be bandwidth and overuse issues for links to lower margin decentralized services not meeting the uptime of higher margin centralized services, crypto-based governance is an open area of research particularly within centralized companies opting for decentralized models. Finally, regulatory compliance is a service that is in demand by central digital service providers which decentralized systems shift the burden to the regulatory-based consumers of their service but may lead to issues if those consumers are being harmed and may wish to take legal action. The issues are many and as exciting as decentralized systems are, consider the potential pitfalls before becoming too enamored.

12.8.2. Data Privacy in AI Applications

AI-powered software robots are used in many sectors. Employees in government and business institutes can work with and care for personal sensitive and protected data, such as the healthcare department, tax departments, finances, or other tax organization departments, etc. Using AI applications in these sectors will face some challenges with data privacy and security. There is a general framework for data protection in the European Union area, and it has a global impact. Under this regulation, some types of businesses, such as cloud service providers and AI service providers, act as a data processor and are prone to provide their client organizations with sufficient guarantees in the framework of their business contracts. These contracts might require adherence to the data protection obligations incorporated AI-generic products, tools, and services under development in various projects funded by governmental authorities in the world. With the objective of using AI as a service in the most diverse sectors, such projects address any processing of personal data by AI tools and carry out wide market analysis with clients to validate those solutions.

Artificial Intelligence is being used in many data predictive systems to help organizations with data-driven decisions. Nevertheless, AI techniques, prediction, and prescription methods process data and assist in decision-making in safe zones in terms of following the data security and privacy domain laws. There are some principles about how the individuals' personal data should be handled. The main focus is appropriately processing individuals' personal data to predict or prescribe any data using a generic tool. This occurs when the data controller allowed third parties acting as data processors to process personal data through generic tools without any specific purpose, aside from those that funding programs required.

12.8.3. Quantum Security Measures

The advent of quantum computers threatens the encryption and security frameworks in use today. At the same time, quantum computing also offers the framework for secure encryption systems, using methods such as encryption keys transmitted in quantum random numbers. Encryption is based on the complexity of certain mathematical functions that can be computed relatively easily in one direction, but hard to reverse, for example, factorization of prime numbers. As quantum computers eliminate this apparent asymmetry, we need to find new asymmetric functions that are prohibitively hard even for quantum computers. Any large system that depends upon asymmetric encryption is particularly vulnerable. This could be a serious concern in the realm of finance, given the immense concentration of wealth in this area.

There is already a lot of work being done in developing quantum-secure asymmetric cryptographic algorithms and systems that seem in principle resistant to quantum attacks. There have been draft recommendations on post-quantum algorithms and continued monitoring of developments in this field. The bulk of these efforts rely on functions related to lattices, error-correcting codes, multivariate polynomials or hashes and are signatures, key exchanges, or encryption schemes. These can be layered upon existing systems. The transition from current asymmetric functions to quantum-safe ones is a major effort. Quantum key transmission, based on principles of quantum mechanics, makes it safe even from quantum computers and is available to be layered on top of any classical security system.

12.9. Future Outlook

We have witnessed the early days of neutral and beneficial AI in finance, but multiple actors face strong incentives to “game” the system. If we mitigate corrupt hybrid systems by establishing a common set of protocol rules proven to preserve the Commons, then the digitization of financial intelligence and decentralized systems will begin to raise answers. Continued development of DeFi systems and crypto wallet usage implies a gradual expansion of alternative non-hierarchical modes of economic exchange. As new groups of financial citizens discover tools to expand participation in the economy, we begin formulating new theories of value extraction and value creation. Economic theory shapes innovation. Innovation shapes economic theory.

Our current centralized systems suffer from inherent biases favoring the 1% of users with vast liquidity for whom financial activity composition serves mainly as a vehicle for tax avoidance and wealth concentration. Further, by hiding ecological externalities behind inflated profit lines, the incentives of these groups produce harmful economic and social effects. As we gradually enable decentralized AI systems that provide interpretable and verifiable decision assistance embedded into all our crypto wallets, everyone, regardless of wealth, can then leverage financial intelligence to support life-cycle decisions in their role as consumer, employee, and citizen.

As we employ conversational interfaces to human capital AI, we can explore jointly with our bots. Our bots increase our access to expertise and creativity for problem-solving and suggesting action paths. Greater liquidity of idle capital, across economic and ecological timeframes, creates the potential for reduced risk intermediation. Society then proposes alternative values; society advocates respect for these value systems. If ignored, society travels elsewhere.

12.9.1. Predictions for Financial Intelligence

In the not-too-distant future, every human being will be capable of having some degree of financial intelligence personalized for them, thanks to three factors: (1) the decentralized, inclusive, and permissionless structure of the Web 3.0; (2) advancements in AI algorithms, datasets, and computing systems; and (3) the continual shifts of trust from centralized institutions to decentralized systems. Just as prep courses, financial literacy classes, and elite consulting services are currently available only to a select group, we will soon see the emergence of global corporations working to democratize financial decision-making, preparing everyone (even 18-year-olds) for reaching their maximum utility, financial well-being, and national contribution potential. Large language models will enable everyone to submit image, video, and speech requests for these services — and to work collaboratively with AI co-pilots to maximize the efficiency and accuracy of actual long-term decision-making across their entire lifecycle.

Additionally, the services will be offered in a way such that there is an economic incentive for those providing the financial intelligence capabilities for crowdsourced creation of a library of empirical outcomes and benchmarks for the “financial decisions” encoded into the larger models, as well as incentives for financial intelligence companies to minimize their error rates through continuous fine-tuning of the models. These companies will pull data from various sources to disambiguate the differences in the reasons for the outcomes in the index library as general linearization does not have sufficient explanatory power. For example, a successful entrepreneurship seed can have a “motivation” index of 0 but belong to very different clusters if the cluster index values for “marketer,” “innovator,” and “financial risk manager” are not also specified.

12.9.2. Long-term Implications of AI and Quantum Finance

As AI systems and quantum computation become more powerful, questions about the long-term implications can no longer be dismissed. Although many questions relate to the effects of digitization in general, even the shorter-term implications will combine digitization effects with the specific implications of AI and quantum computation. Effects of digitalization are both creating new opportunities while also creating new dependencies and an increase in malleability if unchecked. AI is likely to increase this dependency while also increasing efficiency by eliminating human beings from professional services. Quantum computation will likely facilitate many processes involving large data sets or requiring significant computation resources while also enabling the breakdown of current cryptography systems. Currently borders on probability and conceptual thinking, these implications are likely to become more urgent.

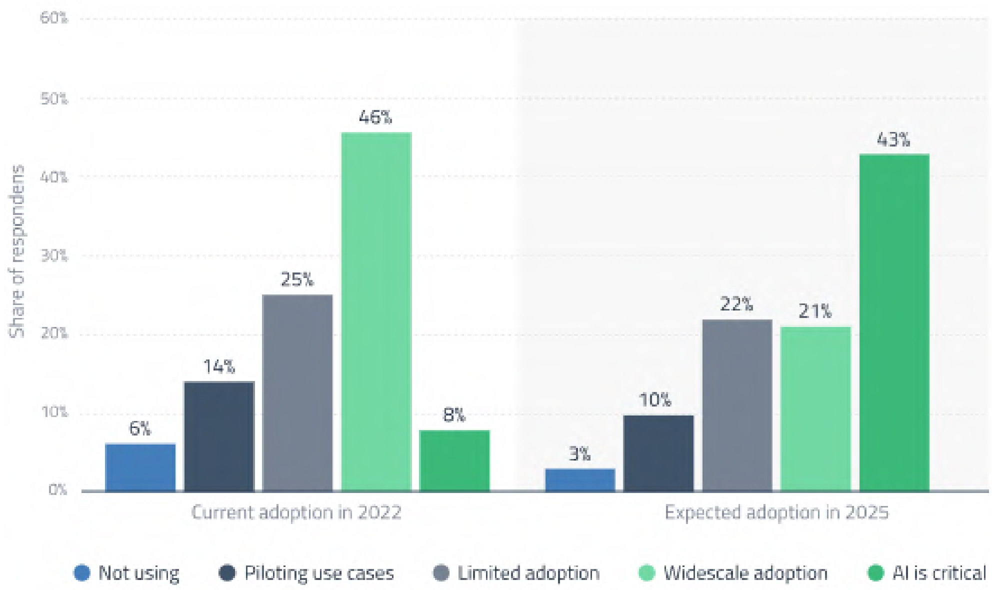

Fig : AI in Finance

As a result, a key question concerns the relativeness of growth vs. middle- and long-term dependency. If the same systems that ease identification and communication also create large macro areas of dependency as both growth and emergence of secessionist approaches suggest, the answer will determine feedback against this dependency. This in turn opens questions about "digital sovereignty." Is an "off" button or code decryption capacity actually a concession to "data sovereignty" for international relationships rather than an acceptance of an effective position of digital dependence? Ultimately, agents of economic digitization ended up as slaves to optimizers of economic activities as a consequence of the appropriation of surplus that coupled decision in the market space with valuation in the information space.

12.9.3. Preparing for a Decentralized Future

Previously in section 12.7.1, we emphasized the impact of quantum computing on the complexity of traditional risk modeling in high-frequency trading, order matching, and market making. It is apparent that although trading financial assets become easier, modeling their dynamics become increasingly difficult. Therefore, the financial business model may change toward increasing the spread in illiquid assets – the suitability of this approach depends on actual distribution of financial asset price dynamics. It is equally important to emphasize that the instant transmission of quantum signals makes market movements visible to everybody around the world; there are no internal agents with insider information. The success in trading depends more on the speed of quantum signals propagation, rather than their interpretation. Which, in turn, raises the problem of maintenance of equal development of quantum computer technology around the world, which is a prerequisite for stability of the economic and political environments.

The importance of equal development of financial quantum computing technologies around the globe and the transmission of these signals with equal speeds is an argument for building decentralized infrastructure for the global economy. While certain governance may be regulated, the equally distributed quantum resonance quantum financial institutions renounce illegitimate appropriation of insider information based on the instant quantum signal transmission by reinstating the exclusion zone around blocks of asset trade – zones in which no blocks of medical asset trading can be created or stored. Regulation and quantum finance quite naturally imply return to decentralization and equal development of quantum finance signal processing around the globe. The solution of quantum decision-making brings finance back to its original goal of serving the interests of the general public.

12.10. Conclusion

Financial intelligence, as defined by the ability to think about finance and make financial decisions, has been an important but underexplored research area in finance that deserves our attention. In this discussion, we explore how the future of financial intelligence will be shaped by three upcoming forces: decentralized systems, artificial intelligence regulation, and quantum finance. Decentralized platforms enable the development of user-friendly, accessible, and low-cost financial decision support tools, leading to better financial outcomes and, therefore, increasing financial intelligence for a broader range of individuals. At the same time, the development of artificial intelligence regulation will generate service propagators, who rely on their information ownership rights to provide customized, accurate, and trustworthy intelligence-based services at a small fee. This helps maintain the luxury status of existing hedge funds and their associated reputational risks, escaping erosion from low-cost financial decision support tools. Lastly, progress in quantum finance will provide insights into complex and high dimensional pricing problems, allowing the faster construction of qualitative conceptual models and more accurate quantitative predictive models.

We believe that, together, these changes will enhance both real-world and conceptual models by a wealthy elite and society. Financial experts will be able to churn out the next conceptual frontiers of finance, taking financial science to the next level. At the same time, the experience of the masses with financial decisions will be heightened, culminating in better decision-making and leading to less extreme financial cycles while paving the way for more equal societies. We hope to ignite the discussion on how decentralized systems, AI regulation, and quantum finance denote changes to decision-making and collaboration in finance, as well set a horizon on the broad, scientific, conceptual, and applied questions that need to be pursued and answered.

References

Tapscott, D., & Tapscott, A. (2018). Blockchain Revolution: How the Technology Behind Bitcoin and Other Cryptocurrencies is Changing the World. Portfolio.

Arner, D. W., Barberis, J., & Buckley, R. P. (2017). FinTech, RegTech, and the Reconceptualization of Financial Regulation. Northwestern Journal of International Law & Business, 37(3), 371–414.

Kshetri, N. (2021). Quantum Computing in Financial Services: Opportunities and Challenges. IT Professional, 23(2), 63–68.

Allen, F., Gu, X., & Jagtiani, J. (2020). Fintech, Bigtech, and the Future of Financial Services. Journal of Financial Services Research, 59, 21–36.

Zetzsche, D. A., Buckley, R. P., Arner, D. W., & Barberis, J. N. (2020). Artificial Intelligence in Finance: Putting the Human in the Loop. Journal of Banking Regulation, 21, 14–22.