

Center for Digital Finance and Technologies



The Center for Digital Finance and Technologies seeks to advance the digital transformation of financial services for higher efficiency and security, increased accessibility, and greater social responsibility

Financial markets are undergoing an unprecedented transformation.

Technological advances have brought major improvements to the operations of financial services, making them quicker, cheaper, and easier to access. Payment systems have become faster, investment advice is now offered algorithmically, and many borrowing/lending platforms are offering cheaper financing options than banks and credit card companies.

Now more than ever, we need to understand the potential of these technologies, barriers to adoption, security mechanisms, and the economic implications of this transformation. The **Center for Digital Finance and Technologies** has been created with this purpose in mind, and through its various teaching, research, and outreach initiatives it aims to change the way academic institutions, regulators, and the private sector think.

An Introduction to Fintech and Blockchain

Fintech and Blockchain: The Digital Transformation of Financial Services

*Graduate Alumni Day
March 3, 2022*

Agostino Capponi
Columbia University

TRANSCENDING DISCIPLINES, TRANSFORMING LIVES

COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science

In this presentation to Columbia Engineering alumni, Center Director Agostino Capponi explains the digital transformation of financial services (1:01:52). Slides available [here](#) .

Time Stamping a Digital Record

- Concatenate
 - The hash of the previous record,
 - The date,
 - The current record (or its hash)
- Hash the result
- Publish the hash widely
- Use the latest hash as input into the next concat

Gur Huberman, professor of behavioral finance at Columbia Business School, presents an introduction to bitcoin and blockchain.

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About

The Center for Digital Finance and Technologies within the School of Engineering and Applied Sciences at Columbia University aims at addressing the societal needs of Fintech companies, and understand the promises of emerging financial innovation. The existing financial system suffers from bottlenecks in efficiency, accessibility, and transparency. Households and businesses do not have cheap financing options, transferring cash or other securities remains costly, and trading assets is expensive. The operating activities of banks and wealth managers are not fully transparent to their clients, and even to regulators. Accessibility to financial services is limited, and a non-negligible fraction of the world population remains unbanked. The digital financial revolution we are experiencing aims at addressing these shortcomings. However, the pros and cons of these financial innovations are not yet understood, and require answering fundamental questions such as: Is the technology ready to support algorithmic investment and fast payment systems? How can financial services be designed and made accessible to underserved communities? How should Fintech companies, crypto tokens, and data sharing, be regulated?

A game changer in the digitalization of finance is blockchain technology. It democratizes finance, revolutionizes how we transact, transfer ownership of assets, and verify transactions. One of the most prominent applications built on blockchain is DeFi. DeFi utilizes open-source smart contracts to provide decentralized borrowing, lending, swapping, and insurance services, which replace the traditional centralized financial intermediaries. The following questions yet remain to be answered. Is the current layered structure of blockchain scalable and sustainable? Is DeFi the most appropriate infrastructure to support the future of finance?

The Center will leverage multi-disciplinary expertise at Columbia in diverse domains such as computer science, engineering, data science, finance, and economics, to answer these questions.

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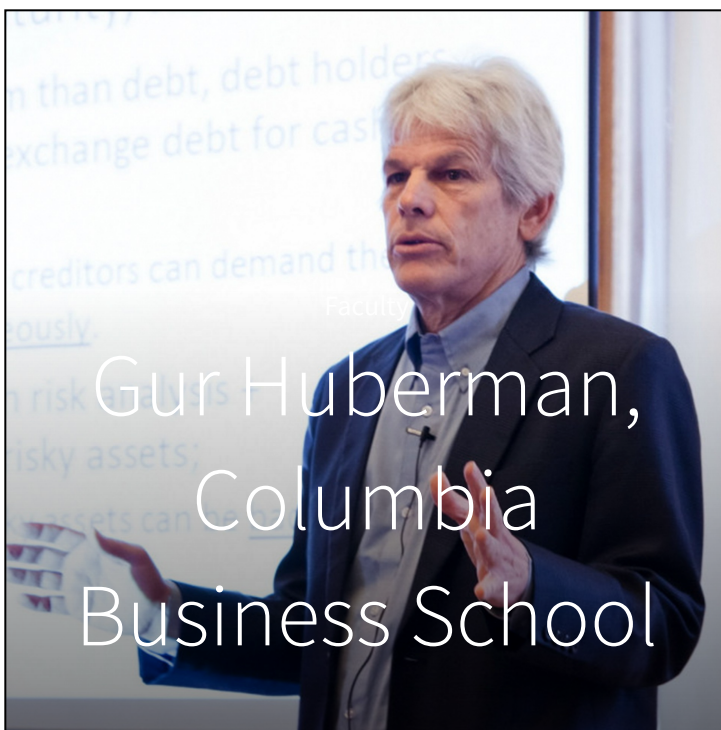
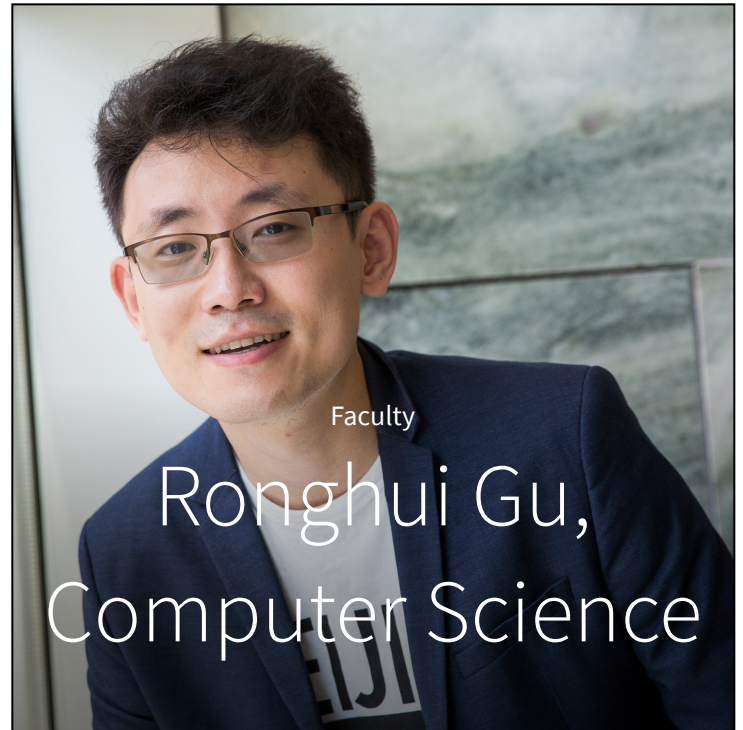
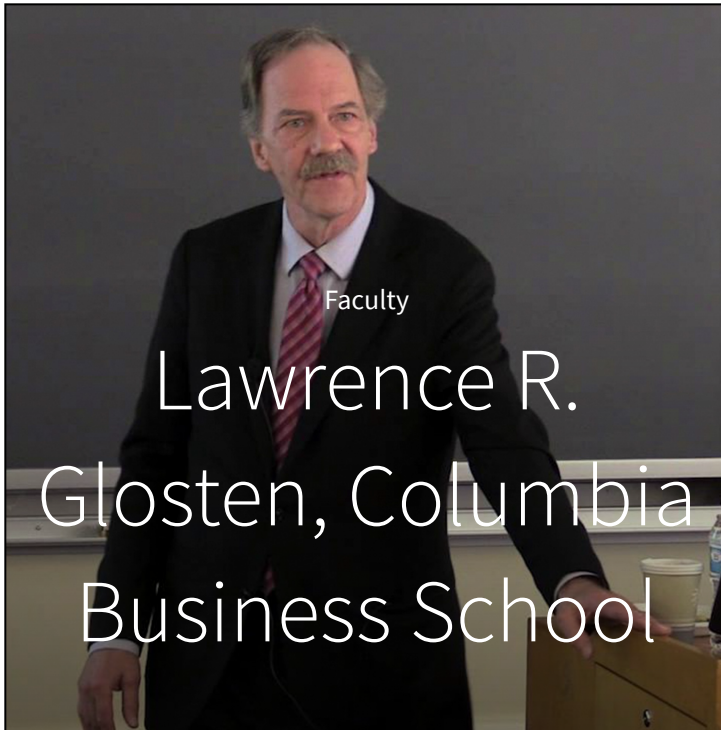
People

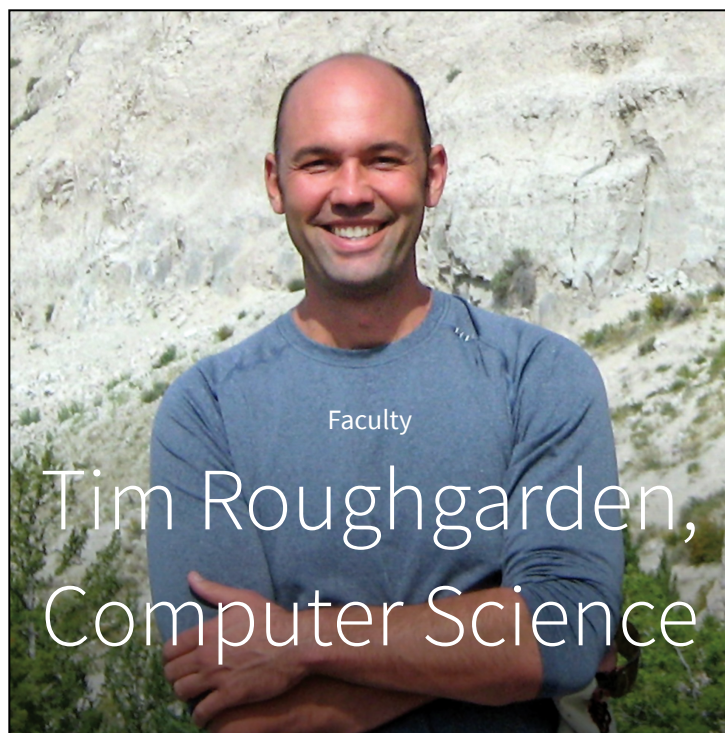
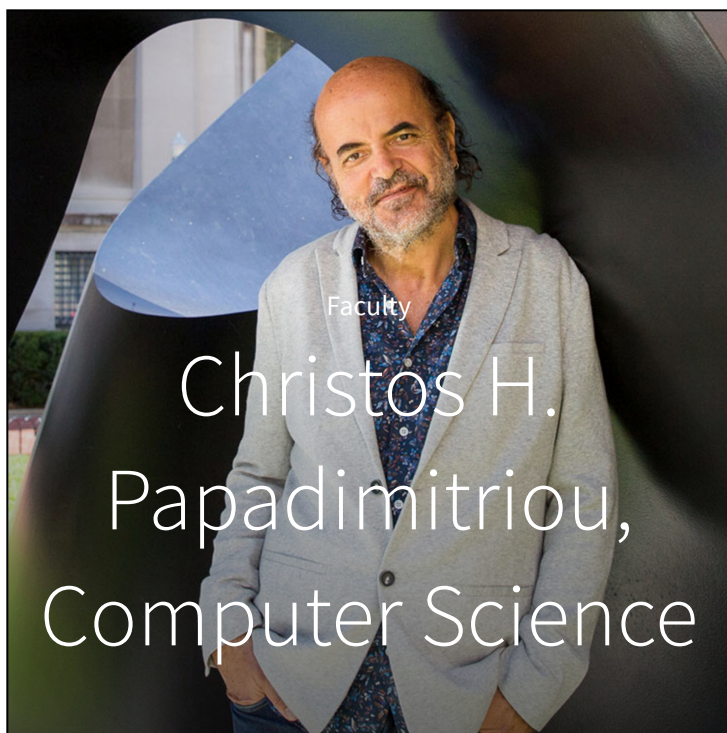
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Information forthcoming.

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Through the Blockchain University Research Initiative, Ripple is generously funding the research activities of the center, targeting the design and adoption of automated market makers.




The Institute is interested in blockchain technology as a platform to improve democratization of financial services by lowering cross-border barriers to payments and transactions.

Capital Fund Management

Capital Fund Management seeks to fund joint academic research projects for PhDs, enabling students to spend time in CFM offices and leverage its large data set.

DeFi Education Fund

The [DeFi Education Fund](#)  educates policymakers around the world about DeFi and advocates for policies welcoming of DeFi and decentralized governance.



The [Stellar Development Foundation \(SDF\)](#) and Stellar seek to unlock the world's economic potential by making money more fluid, markets more open, and people more empowered.

Center supported by the Data Science Institute



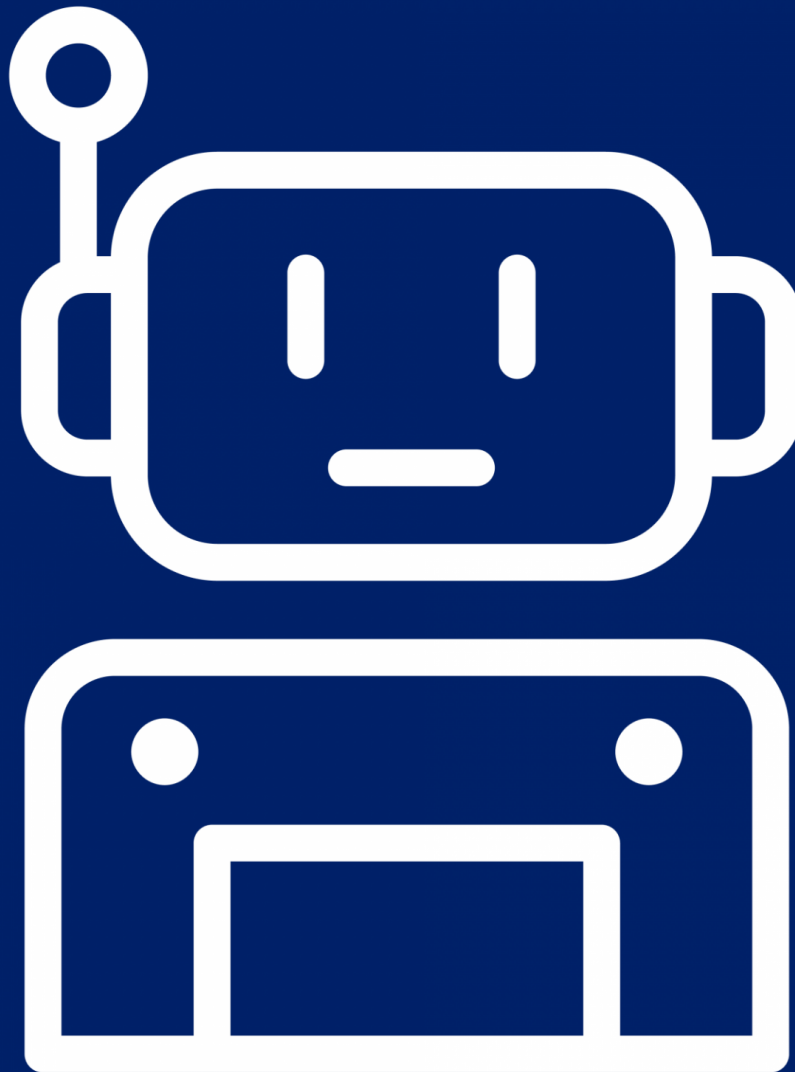
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Research

Research at the Center aims to identify flaws in the existing design and implementation of financial services, and propose novel solutions which maximize the effectiveness and efficiency for the consumer, investor, and broader society. The research will inform regulators and policymakers about the pros and cons of these new financial technologies, and guide the design of policies to promote financial stability.

The center's current research focuses on these areas.

Robo-advising



Robo-advising has grown enormously over the last decade, offering a large range of financial services to investors, ranging from retirement planning to managing checking and saving accounts to meet investment goals. Robo-advisors democratize access to financial services by reducing barriers to entry through the imposition of low fees for assets under management and minimum required investment amounts. Increased adoption will depend on whether the robo-algorithm is able to personalize its recommendations to the risk preferences of users, and whether it can learn the needs and preferences of the clients served. See [Robo-Advising: Learning Investors' Risk Preferences via Portfolio Choices](#) [↗](#) and [Personalized Robo-Advising: Enhancing Investment Through Client Interaction](#) [↗](#) .

Blockchain consensus protocols



Most existing layer-1 blockchain protocols are based on proofs of work and proofs of stake. Those protocols are used to determine which miners or validators will be entitled to update the distributed ledger and earn the fees associated with the transactions in the mined blocks. More research is needed to determine which protocol would ensure the long term sustainability of blockchain and what is the best mechanism design for this protocol. See [Proof-of-Work Cryptocurrencies: Does Mining Technology Undermine Decentralization?](#) [↗](#)

Adoption of decentralized exchanges




Modern blockchains enable the use of smart contracts to implement a broad range of financial services. Those services include borrowing/lending, derivative trading, insurance, and decentralized exchanges. Despite the potential gains of such systems, the adoption of DeFi (decentralized finance) exchanges will present a number of challenges and the need for guardrails. One example is the creation of arbitrage losses for investors trading in blockchain-based DEXs. See [The Adoption of Blockchain-based Decentralized Exchanges](#) .

Validator extractable value



A fundamental problem of second-generation blockchains, which support a broad range of financial services well and beyond cryptocurrency payments, is information leakage. This problem arises due to the public observability of transactions, which can be frontrun by malicious arbitrageurs while pending in the mempool. Frontrunning attacks not only lead to financial losses for traders of the DeFi ecosystem, but also congest the network and decrease the aggregate value of blockchain stakeholders. At the same time, frontrunning opportunities may benefit validators, who extract value

from high transaction-fee bidding frontrunners. This is the so-called validator extractable value problem. The adoption of private communication channels depends upon the incentives provided to the users of the DeFi ecosystem. See [The Evolution of Blockchain: From Public to Private Mempools](#) .


Transaction fee mechanism design



Demand for blockchains such as Bitcoin and Ethereum is far larger than supply, necessitating a mechanism that selects a subset of transactions to include “on-chain” from the pool of all pending transactions. The idiosyncrasies of public blockchains require rethinking mechanism design from first principles, and in particular new notions of incentive-compatibility. Such blockchain-aware mechanism design played an important role in the evolution of Ethereum’s transaction fee mechanism, and in particular the adoption of EIP-1559. See [Transaction Fee Mechanism Design](#) .


Economic analysis of Bitcoin



Bitcoin provides its users with transaction-processing services that are similar to those of traditional payment systems. Its innovative decentralized design allows the payment system to be reliably operated by unrelated parties called miners. Research has found that this decentralized design protects users from monopoly pricing. Competition among service providers within the platform and free entry imply no entity can profitably affect the level of fees paid by users. Instead, a market for transaction-processing determines the fees users pay to gain priority and avoid transaction-processing delays. See [Monopoly without a Monopolist: An Economic Analysis of the Bitcoin Payment System](#) .


Lightning Network economics



Compared with existing payment systems, Bitcoin's throughput is low. Designed to address Bitcoin's scalability challenge, the Lightning Network (LN) is a protocol allowing two parties to secure bitcoin payments and escrow holdings between them. In a lightning channel, each party commits collateral towards future payments to the counterparty and payments are cryptographically secured updates of collaterals. The network of channels increases transaction speed and reduces blockchain congestion. See [Lightning Network Economics: Channels](#) .


Blockchain cybersecurity



The growing adoption of smart contracts and blockchains brings new security risks that can lead to huge monetary losses. Billions of dollars worth of crypto assets have been stolen due to program errors and security vulnerabilities in smart contracts and blockchain systems. More research is needed to provide the correctness and security guarantees for blockchain programs according to their specifications with a reasonable effort, and more importantly, such guarantees should be machine-checkable without the need to trust any third party. See [SciviK: A Versatile Framework for Specifying and Verifying Smart Contracts](#) .


The future of securities markets regulation



Blockchain, and distributed ledger technology (DLT) more generally, have the potential for radically changing how securities markets operate, which would in turn dramatically alter how these markets should or should not be regulated. Interviews with about 100 persons who play prominent roles making these markets work or regulating them reveal a wide range of views on how DLT should or will affect the markets and their structure. While many highlighted the scope for dramatic cost reductions, others expressed skepticism, while still others questioned appetites for making DLT-based changes. See [Distributed Ledger Technology and the Securities Markets of the Future](#) .

Economics of permissioned blockchain

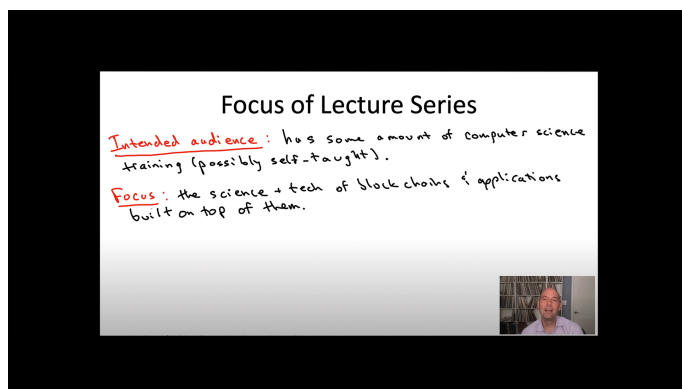


Permissioned blockchains are being used in number of contexts, including supply chains and other related industries. There is, at present, the lack of a framework for understanding the incentives of participants of a permissioned blockchain. Is adoption of blockchain socially beneficial and will such adoption arise in equilibrium? Our research has found that blockchain unequivocally benefits consumers, but that gains for the manufacturing sector are competed away. See [Economics of Permissioned Blockchain Adoption](#)  .

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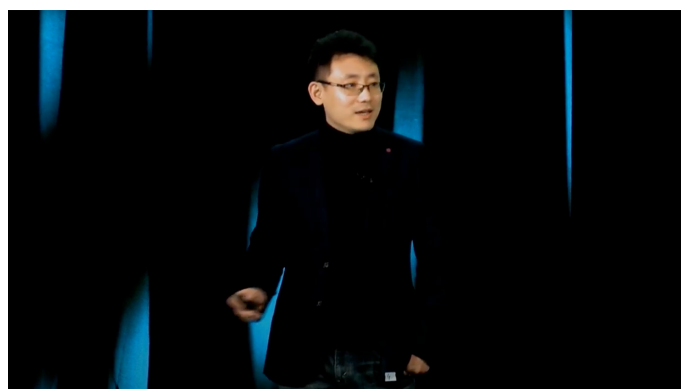
Resources

Video Lectures



Foundations of Blockchain

Tutorials by Tim Roughgarden, Columbia Engineering



Blockchain security

Tutorial by Ronghui Gu, Columbia Engineering