

# Research Statement

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My research is inspired by a large body of work in information economics and financial economics, and mainly focuses on two related areas. First, I study the economics of financial technology and innovation, especially how they affect market outcomes and add to our understanding of economic theory; second, I study information design and agency frictions in dynamic corporate finance and entrepreneurial finance. In addition, I am interested in better understanding the functionalities and imperfections of financial markets and policy, especially in emerging economies such as China, for which I have a few empirically oriented projects.

In what follows, I elaborate on my main agenda for theory research through a non-exhaustive list of my completed and on-going projects.

## 1 Financial Technology and Innovation

In this part of my research agenda, I investigate how the latest technological, methodological, and business innovations shape the landscape of corporate finance, financial intermediation, and asset pricing. Traditionally, academic research in finance and economics has lagged behind technological advances and innovations in business practice for two reasons: first, the phenomena we are interested in are fast-evolving and the learning curve is steep; second, there is only a modicum of canonical research that one can build on, making it challenging to communicate with the audience. As a result, there often lacks a systematic and rigorous understanding of how decentralized ledger systems, crypto-currencies, robo-advisors, smart beta products, and machine learning complement and substitute conventional financial practices and services, even though they hold the potential to transform the world as the Internet did over the past few decades.

My research goal is to take an initial step towards bridging this gap between economic theory and financial technology and innovation. Instead of merely documenting the latest development, I strive to link it to fundamental economic mechanisms, through which we can gain a better understanding of the business practice and general theoretical insights.

### 1.1 Blockchain Technology

Blockchain is believed to have the potential to disrupt business and financial industry in a way similar to how the Internet revolutionized commerce and our daily lives. Yet the plethora of media discussions and industry propaganda are confusing and conflicting, to say the least. Most societies and economies rely on consensus to function properly —protocols of behavior and state of the world that agents with divergent preferences and characteristics act upon as if they were the truth. Instead of having governments, courts, or third-party business arbitrators provide, oversee, and enforce the consensus, blockchains generate, store, and distribute the record of rules and interactions in a more decentralized manner. We have to recognize that even though the

technology is new, the purpose is not alien—to establish a functional trust system that is scalable and decentralized, while achieving consensus among various agents. Achieving all three features is fundamental challenging and much of the industry effort has been devoted towards this end.

Given this, I argue that two natural lines of research naturally arise. The first concerns how blockchains provide such a trust system (internal economy), focusing on equilibrium outcomes under various consensus protocols and the tradeoffs in centralization versus decentralization. The second line examines how given the functions, blockchains affect traditional markets and industries (external economy).

In “**Blockchain Disruption and Smart Contracts**” (with Zhiguo He), we touch on both lines of research. We first identify this universal functionality of blockchains — providing decentralized consensus, which enables low-cost, tamper-proof, and algorithmic executions, consequently enlarging the contracting space through smart contracts. While smart contracts can mitigate information asymmetry and deliver higher social welfare and consumer surplus through enhanced entry and competition, blockchains may also encourage collusion due to the irreducible distribution of information. In general, blockchains can sustain market equilibria with a larger range of economic outcomes, disrupting traditional industrial organization and competition. We further discuss anti-trust policy implications targeting blockchain applications, such as separating consensus record-keepers from users.

In a related paper, “**Decentralized Mining in Centralized Pools**” (with Zhiguo He and Jiasun Li), we examine a non-information based tradeoff in centralization versus decentralization, and highlight the main concern about the rise of mining pools. An open blockchain’s well-functioning relies on adequate decentralization, yet the emergence of mining pools that provide risk-sharing leads to centralization, calling into question the viability of such systems. We show that mining pools as a financial innovation significantly exacerbates the arms race and thus energy consumption for proof-of-work-based blockchains. Moreover, cross-pool diversification and endogenous pool fees generally sustain decentralization — dominant pools better internalize the mining externality, charge higher fees, attract disproportionately less miners, and thus grows more slowly. Consequently, aggregate growth in mining pools is not accompanied by over-concentration of pools. Empirical evidence from Bitcoin mining supports our model predictions, and the economic insight applies to many other blockchain protocols.

Concerning the applications of the technology, we explore in “**Auditing and Blockchains: Pricing, Misstatements, and Regulation**” (with Sean Cao and Baozhong Yang) the implications of blockchains for financial reporting and auditing. Specifically, we study in a unified framework auditor competition for clients, endogenous audit quality and clients’ misstatements, and regulatory policy. We first demonstrate how collaborative auditing using a federated blockchain can improve auditing efficiency for not only transactions recorded on proprietary databases, but also cross-auditor transactions through a zero-knowledge protocol that preserves data privacy. We find such technology adoption disrupts conventional audit pricing: instead of pricing based on client size, auditors charge competitive fees dependent on clients’ counter-parties’ auditor association and corresponding transaction volume. We also find that blockchains adoption reduces clients’ incentives to misreport and that auditors can reduce sampling costs by focusing on off-chain transactions. Importantly, auditors’ adoption of the technology exhibits strategic complementarity, leading to multiple equilibrium outcomes. A regulator can help select an adoption equilibrium that reduces misstatements as well as auditing and regulatory costs.

A discourse on blockchains is incomplete without examining their key applications in support-

ing the creation of cryptocurrencies and crypto-tokens. In “**Tokenomics: Dynamic Adoption and Valuation**” (with Ye Li and Neng Wang), we take an initial step towards a better understanding the fundamental valuation of crypto-assets and the roles of tokens (whether in initial coin offerings or the dynamic evolution of blockchain-based platforms). Specifically, we provide the first dynamic asset-pricing model of (crypto-)tokens that highlight the roles of tokens, taking into consideration the endogenous user adoption and network effect. Tokens intermediate transactions on decentralized networks, and their trading creates an inter-temporal complementarity among users, generating a feedback loop between token valuation and platform adoption. Consequently, tokens capitalize future platform growth, accelerate adoption, reduce user-base volatility, and can improve welfare. Equilibrium token price increases non-linearly in platform productivity, user heterogeneity, and endogenous network size. The model also produces explosive growth of user base after an initial period of dormant adoption, accompanied by a run-up of token price volatility. We further discuss how our framework can be used to discuss cryptocurrency supply, platform competition, and pricing assets under network externality.

In a preliminary project, “**Tokenomics: Dynamic Incentives and Decentralized Contribution**” (with Ye Li and Neng Wang), we endogenize in the above framework the supply of the platform functionality such as decentralized consensus. Tokens provide dynamic incentives in a sharing economy and allow decentralized contributions to a firm or platform. Consequently, traditional corporate finance activities such as financing, labor contracts, investments, and growth take on novel forms.

## 1.2 Innovations in Security or Platform Designs

In addition to technological innovations, financial innovations also take place with existing technologies. Take the Internet for example: it allows dispersed retail investors to lend to one another and to finance entrepreneurial projects on crowdfunding platforms. With innovative designs of the platform, not only do interesting phenomena arise, but they also modify our conventional understandings.

My study on “**Information Cascades and Threshold Implementation**” (with Yizhou Xiao) is motivated by Internet-based crowdfunding, which allows entrepreneurs to reach out to larger crowds. More generally, economic activities often involve sequential interactions, observational learning, and project implementation contingent on achieving certain thresholds of support. We incorporate a design innovation of endogenous all-or-nothing (AoN) implementation—contributions are collected and projects are carried out only after achieving certain thresholds of support—into a classic model of information cascade. We find that early supporters tap the wisdom of a later “gate-keeper” and effectively delegate their decisions, leading to uni-directional cascades and preventing agents’ herding on rejections. Consequently, entrepreneurs or project proposers can charge supporters higher fees, and proposal feasibility, project selection, and information production all improve, even when agents have the option to wait. Equilibrium outcomes depend on the crowd size, and in the limit, efficient project implementation and full information aggregation ensue — a novel result in models with information cascades.

Another form of financial innovation lies in the design of securities or financial products. For example, Exchange-traded funds (ETFs) have proliferated in recent years and have surpassed the hedgefund industry in AUM. They are also the favorite choice of many robo-advising and Artificial Intelligence-based investment platforms and applications. Yet we understand little on

how they are designed and what their impacts are on asset prices and informational efficiencies. We shed lights on these issues in “**Rise of Factor Investing: Asset Prices, Informational Efficiency, and Security Design**” (with Xun Xu). We model financial innovations such as ETFs, smart beta products, and many index-based vehicles as composite securities that facilitate trading common factors in assets’ liquidation values. Through accessing a larger basket of assets in endogenously-chosen proportions, composite securities incorporate greater factor information into asset prices, and attract both informed and uninformed factor investors. Being the first paper to analyze the design of products such as smart-beta funds, we show that the optimal design of composite securities in equilibrium entails selecting liquid and representative assets, and we provide supporting empirical evidence. The model also produces asset-pricing implications consistent with existing empirical findings.

### 1.3 Machine Learning and Unstructured Data Analytics

Fintech startups leverage big/alternative/unstructured data, in particular texts, for originating loans, predicting stock returns, improving customer service, etc. Meanwhile, the interpretability of textual analysis can potentially help us better understand business economics and finance. In “**Textual Factors: A Scalable, Interpretable, and Data-driven Approach to Analyzing Unstructured Information**” (with Tengyuan Liang and Xiao Zhang), we develop a textual-factor framework to analyze large-scale text-based data. Different from existing approaches, our data-driven methodology captures complex linguistic structures without sacrificing computational scalability and economic interpretability. We then demonstrate potential applications of our methodology to issues in finance and economics, such as testing, information transmission, forecasting economic outcomes, and interpreting classical predictive variables based on structured data. In particular, we introduce a text-based factor pricing model in “**Textual Factors and Asset Returns**” (with Tengyuan Liang). By combining the strengths of neural network language models and generative statistical modeling, our textual framework attempts to leverage high-performance computation and strike the balance between model complexity and interpretability, in order to better explain asset returns and interpret existing asset-pricing factors.

Going forward, I plan to continue applying the framework to analyze unstructured data extant tools fail to utilize, in order to help us better understand various topics in financial economics such as startup valuation and transmission channels of macroeconomic news.

## 2 Information and Mechanism Design in Entrepreneurship and Financial Markets

### 2.1 Information Design in Finance

Information design is one of the most active areas of research in information economics over the past decade. It is a confluence of work on Bayes correlated equilibria (Bergemann and Morris 2013) and Bayesian persuasion (Kamenica and Gentzkow 2011), and parallels mechanism design: in the latter, the designer takes the informational environment as given and decides on the rules of the game, whereas in the former the designer determines the information structure but may have no control over the game. Since its inception, information design has been quickly adopted to address issues in banking regulation, online advertising, entertainment, price discrimination, and

traffic congestion, among others. My work contributes to the literature by further developing the theory and applying the analysis to settings in finance.

In “**Persuasion in Relationship Finance**” (with Ehsan Azarmlsa), we apply information design to relationship financing of innovative projects, as is common in bank lending and venture capital, which features incumbent financiers observing interim information before continuation decision. While existing studies typically focus on the borrower’s or entrepreneur’s actions that shape project cash flows and take the interim informational environment as exogenous, we model the entrepreneurs’ endogenous information production and subsequent issuance of securities to both the incumbent insider and competitive outsider investors as persuasion games with heterogeneous receivers and contingent transfers. Entrepreneurs’ experimentation reduces insider investors’ information monopoly, but holds up initial relationship investment. Insider financiers’ own information production and interim competition from outsiders can mitigate the hold-up, and jointly explain the empirical non-monotone patterns linking competition and relational lending. Optimal relationship contracts restore first-best outcomes using convertible securities for insiders and residual claims for competitive outsiders. Our findings are robust under continuum action space and partial commitment to information design.

In another application of Bayesian persuasion to financial markets, “**Dynamic Interventions and Informational Linkages**” (with Steven Grenadier and Yunzhi Hu), we ask how governments should design policy across multiple interventions to mitigate coordination failures in a dynamic economy with strategic complementarity among investors. We show that one intervention can affect another through altering the public-information structure. A stronger initial intervention helps subsequent interventions through increasing the likelihood of positive news, but also leads to negative conditional updates. Our results suggest optimal policy should emphasize initial interventions when coordination outcomes tend to correlate. Neglecting informational externalities of initial interventions results in over- or under-interventions, depending on intervention costs. Moreover, saving smaller funds disproportionately more can generate greater informational benefits at smaller costs. Our paper is thus informative of the interaction of multiple intervention programs such as those enacted during the 2008 financial crisis.

Overall, the literature of information design in finance is just emerging, and the insights gained can be applied to the studies of collective board decisions, disclosure and transparency requirements, and market design, which I continue to explore.

## 2.2 Agency and Learning in Real Options and Entrepreneurial Finance

Given that the solutions to many of the world’s biggest problems such as Alzheimer’s disease, global warming, and fossil-fuel depletion require entrepreneurial financing, long-term experimentation, and effective use of real options, my research aims at utilizing contract theory, security design, and optimal stopping to gain a deeper understanding of how agency issues affect the equilibrium outcomes.

In “**Auctions of Real Options**”, I study the post-auction moral hazard of real option exercise. Auctions of real options are prevalent in licensing and patent acquisitions, leasing of natural resources, real estate development, M&A deals, venture capital and private equity markets, and privatization of large national enterprises. They often entail tremendous financial resources, contingent payments, and timing decisions that are difficult to contract upon sale. I characterize equilibrium bidding and option exercise strategies for standard securities in formal auctions. I find

that the moral hazard associated with uncontractible investment timing inefficiently accelerates or delays investments in an asymmetric manner. A seller has to tradeoff incentivizing efficient option exercise to create a bigger total surplus, and extracting a greater share of the surplus through contingent payments. I use a mechanism design approach to rank securities and derive the optimal security design which involves a combination of upfront “bonus” payments and contingent “royalty” payments. I then take a step further to extend the analysis to informal auctions of real options, such as mergers and acquisitions, where sellers often do not have the commitment power to security design and simply consider the most profitable offer. I show that all auction equilibria are equivalent to cash auctions, and investments are socially efficient. Finally, I provide suggestive empirical evidence supporting the model.

In a related paper, “**Timing of Auctions of Real Options**”, I continue studying auctions of real options, but focus on endogenous auction timing and initiation. In classical studies on auctions, the assets’ values are independent of the agents’ post-auction actions, but real options derive their values from the holders’ timely exercise. While the seller does not exercise the option herself, the irreversible nature of time endows her partial control over the option exercise. Consequently, the revenue-maximizing auction timing deviates from welfare-maximizing or bidders’ preferred timing: As long as the seller does not strongly prefer early exercise, she inefficiently delays the auction; otherwise auction timing is efficient, but option exercises are always inefficiently delayed. When the seller lacks commitment to auction timing and offer finality, bidders always initiate in equilibrium regardless of the divergence in their and the seller’s preferred option exercise. The model also predicts that bidder initiation corresponds to faster option exercise, consistent with empirical evidence from the selling and drilling of oil and gas tracts.

Besides timing decisions in corporate and entrepreneurial finance, I also study how contracting under agency frictions relates to venture-fund performance. Persistent fund performance in venture capital is often interpreted as evidence of differential abilities among managers. In “**Persistent Blessings of Luck**” (with Yizhou Xiao), we present a dynamic model of venture investment with endogenous fund heterogeneity and deal flows that produces performance persistence without innate skill difference. Investors work with multiple funds and use tiered contracts to manage moral hazard dynamically. Recent successful funds receive continuation contracts that encourage greater innovation, and subsequently finance innovative entrepreneurs through assortative matching. Initial luck thus exerts an enduring impact on performance by altering managers’ future investment opportunities. The model generates implications broadly consistent with empirical findings, such as short-term performance persistence and long-term mean reversion, outperforming funds’ appeal to innovative entrepreneurs even with worse terms, and the link between failure-tolerance and innovation. Initial luck may also amplify the effect of innate skill differences. Finally, our findings imply that institutions such as endowments and alternative investment funds that interact with multiple VC firms should take advantage of the inter-contract incentives in managing agency rent and motivating effort from managers.

Moreover, my papers on “**Blockchain Disruption and Smart Contracts**”, “**Persuasion in Relationship Finance**”, and “**Information Cascades and Threshold Implementation**” mentioned earlier are also related to the literature on learning and security design. In on-going work, I continue exploring informational issues in entrepreneurial finance, in particular how information technology has shaped choices to become entrepreneurs and aggravated wealth inequality.