Application Letter

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1. Program Status & Dissertation Committee

Status: Currently Ph.D. Candidate in Economics, Expected Graduation in 2028.
Dissertation Title: *Essays on Financial Bubbles: A Search Model and Empirical Evidence*
Dissertation Committee: Prof. Roberto Samaniego (Chair), Prof. Tara Sinclair, and Prof. Tomas Williams.

2. Research Interest and Overview

Research Fields: Financial Economics, Macroeconomics, Digital Economics & Crypto-Assets, Market Microstructure, Structural Econometrics.

Waves of technological innovation—ranging from the 1990s Dot-com boom to public blockchains and the current expansion in transformative AI—are routinely accompanied by dramatic asset price appreciation and intense trading volume. A central challenge for economists and policymakers studying these emerging sectors is **identification and monitoring**: when asset prices surge, how can we use observable market data—specifically, macroeconomic and transaction-level trading volume—to disentangle **fundamental belief** from self-reinforcing, "ride-the-tide" speculative bubbles?

Existing literature faces three bottlenecks in addressing this question. First, on the theoretical front, macroeconomic bubble models (e.g., Tirole, 1985; Martin and Ventura, 2012; Miao and Wang, 2018) typically characterize smooth transitions to steady states rather than explosive trajectories, whereas classic rational bubble and synchronization models (Blanchard and Watson, 1982; Abreu and Brunnermeier, 2003) rely on exogenous exponential price processes and abstract away from endogenous trading volume. Meanwhile, microstructure models that generate high turnover generally rely on behavioral assumptions such as overconfidence (Scheinkman and Xiong, 2003) rather than strict rational expectations. Second, on the econometric front, reduced-form time-series tests (e.g., Phillips, Shi, and Yu, 2015) date-stamp explosive prices statistically ex-post but cannot structurally recover unobservable asset fundamentals or project collapse turning points from agent optimization. Third, in the digital-asset literature, recent empirical studies focus predominantly on payment rails and settlement flows (Adrian et al., 2025, 2026; Auer et al., 2025) while leaving speculative trading cycles in native digital assets largely unexplored; conversely, traditional equity studies of bubble trading (Brunnermeier and Nagel, 2004; Greenwood and Nagel, 2009) are entangled with cash-flow fundamentals and limited to low-frequency institutional slices.

To bridge these gaps, my research agenda develops a unified toolkit across **4 projects**—the three chapters of my doctoral dissertation and a policy working paper co-authored at the International Monetary Fund (IMF)—demonstrating how search-and-matching frictions and transaction volume data can isolate unobservable fundamentals and monitor speculative fragility:

1. *Chapter 1* builds a rational search-and-matching model that endogenously generates both explosive price paths and complex trading volumes.

2. *Chapter 2* translates this theory into a Simulated Maximum Likelihood Estimator (SMLE) to structurally recover unobservable fundamental values and expected collapse dates from price and volume series.
3. *Chapter 3* analyzes the all-history Ethereum on-chain transactions to verify the model's micro-predictions and construct a price-free early-warning system.
4. *IMF Fund Intern Project* adapts a simplified version of my search-and-matching model to drive an empirical investigation of how geopolitical shocks affect digital-asset transaction activity.

3. Dissertation Chapters and Ongoing Research

***Chapter 1*: A Search Model of Financial Bubbles**

I develop a discrete-time search-and-matching model populated by heterogeneous speculators, where indivisible asset units are traded in an OTC market. In each period, current holders post asking prices and randomly match with potential buyers. After an anticipated horizon $\bar{t}$, holders face a constant probability each period of forced liquidation shock to "fundamental investors" at a baseline price D. Holders' pricing strategies are shaped by two intertemporal forces: (i) posting a higher asking price yields a larger payoff upon sale but reduces the probability of buyer acceptance; and (ii) repeated rejections push the holder closer to the forced liquidation regime $\bar{t}$, although the shock is stochastic and the survival horizon remains unbounded. Matched buyers, in turn, trade off purchasing the asset—thereby stepping into a future holder's position—against taking an outside option from alternative markets. Solving the model via backward induction under a formally proved dynamic separating Nash equilibrium yields two main results: (i) an explosive price path can be sustained only when outside-option returns lie below an analytical threshold; and (ii) the market evolves through three distinct phases—an early expansion driven by a one-way compositional shift in holder types, a middle phase where approaching collapse risk ($\bar{t}$) drives an explosive price surge, and a post-$\bar{t}$ collapse triggered by forced liquidations.

***Chapter 2*: Structural Inference of the Dot-com Bubble: Identification and Prediction**

Chapter 2 translates the theoretical model into a structural estimation framework via SMLE. Linking the model's predicted price and volume trajectories to observed market data allows the joint estimation of behavioral parameters, the unobservable fundamental anchor D, and the expected collapse timing $\bar{t}$. To handle the non-smooth, non-convex likelihood induced by the discrete regime switch at $\bar{t}$, I employ the hybrid optimization algorithm of Forneron (2023), combining derivative-free Gauss-Newton local steps with a global grid search. In a first-stage rolling estimation of the 1994–2004 NASDAQ Dot-com bubble using strictly pre-crash data, the estimator captures the transition from early compositional growth to the accelerating curvature of 1999, endogenously projecting an impending turning point $\hat{\bar{t}}$ aligned with the historical peak in early 2000 and anchoring stably once post-crash data are included.

***Chapter 3*: Ethereum Price Cycles and Patterns of On-Chain Transactions**

Guided by the micro-predictions of my search model (*Chapter 1*), *Chapter 3* examines the complete base-layer transaction history of the Ethereum blockchain from 2015 to 2026 (over 2.5 billion individual transactions across 4,000 days and three macro boom-bust cycles). Isolating genuine "overnight holders", I establish four micro-level stylized facts confirming the search model: (i) sharp liquidation volume spikes (+1.29 SD) on major crash days; (ii) an inverted-U unit volume trajectory that peaks mid-expansion and declines prior to price peaks; (iii) a mid-cycle shortening followed by a late-phase reversal in holding durations alongside “dormant holder” wake-ups; and (iv) a monotonic compression in the ratio of the number of unique buyer-to-seller wallet addresses. Adapting the Kaminsky–Lizondo–Reinhart (1998) signaling framework, I construct a composite early-warning index using purely on-chain quantity, holding-duration, and address-breadth indicators (zero price information), achieving a noise-to-signal ratio of 0.29 and doubling pre-crash detection probability from a 30.0% baseline to 59.5%.

Ongoing Policy Research: Crypto Markets and Geopolitical Conflicts (IMF Working Paper Draft)

During my Summer 2026 Fund Internship Program (FIP) at the IMF, I co-authored an ongoing working paper (currently in internal review) that applies my theoretical framework to policy surveillance. I adapted the heterogeneous search-and-matching model from my dissertation into a two-period comparative-static framework featuring heterogeneous buyer settlement valuations and endogenous seller pricing under net holding costs. In this study, my theoretical model drives the empirical investigation by decomposing how external conflict shocks transmit into on-chain transaction quantities across digital assets with different pricing regimes (stablecoins and unbacked crypto-assets)—explicitly separating direct shifts in participation, outside financial options, and settlement demand from endogenous seller repricing frictions.

4. Future Research Plan

Moving toward my expected graduation in 2028, my research plan focuses on two core extensions that align closely with the NBER Digital Economics and AI community:

1. **Full Joint Price-Volume Structural Recovery of Fundamentals**: In *Chapter 2*, I am expanding the SMLE framework to incorporate the trade volume measurement equation alongside prices and computing formal asymptotic and bootstrap standard errors (Forneron, 2023). Jointly matching price and volume moments provides the identifying variation to structurally recover unobservable fundamental values (D) and test for speculative premia across both technology equity booms and digital-asset cycles.

2. **Entity-Level Digital Ledger Surveillance**: In *Chapter 3*, I am refining the BigQuery data pipeline by integrating entity-level address labels (distinguishing centralized exchanges, DeFi protocols, miners, and individual wallets) and off-chain exchange volumes to build an auditable, mechanism-based surveillance benchmark. Participating in the NBER Digital Economics and AI Tutorial will provide an invaluable opportunity to discuss these methods and explore broader applications of price-volume fundamental identification across digital platforms and AI-driven technology cycles.

Participating in the NBER Digital Economics and AI Tutorial and the subsequent conference meetings at Stanford University would provide an exceptional opportunity to engage with leading scholars in this rapidly evolving field. I look forward to discussing how structural search models and transaction-level ledger analytics can be applied more broadly to separate fundamental beliefs from speculative dynamics across digital platforms and AI-driven technology cycles. Thank you very much for your time, consideration, and support.

Sincerely,

Qingyu Liu