[Elements of Economics, Finance, and Computational Mathematics]

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January 9, 2025

Abstract

We examine an emerging pedagogical realm in which the importance of three major disciplines are considered in synchronicity. The aim is to understand the coherence of an interdisciplinary science formed around modern Economics, Finance, and Computational Mathematics. We recognize the rapidly evolving progress in data encoding techniques and contemplate economic, financial, and societal phenomena that may arise from technology evolving at increasing rates.

Contents

1   Introduction

We will preface this paper with a few notions believed to be true, honest, and scientifically informed to the best of our abilities.

The first fundamental axiom we consider is that recent evolutions in cryptography [10] [20] [25] [1] create new possibilities in many financial, legal, and economic processes allowing for the properties of full transparency and trust-less execution. We make an inherent connection between economic and social prosperity. We also borrow the illustrious concept of *efficient market hypothesis* as famously described by Fama and Samuelson [9] to justify the veracity of market convergence to optimal results given sufficient coverage and volume. We recognize contemporary technology as a potentially pernicious solution to economic processes and their corruption by malicious intent. Semantic junctures between various meanings of the word *corrupt* lend themselves perfectly to our study for one principal reason: we claim that a mathematically incorruptible informational process is the ideal tool for transitioning vital financial processes to a transparent framework designed to protect against malicious human intent (i.e., *corruption*).

2   Recent computational developments

2.1   Zero Knowledge Proofs

Zero Knowledge proofs [10] are a familiar cryptographic concept with recent applicability to scaling financial circuitries [21].

2.2   Machine learning in numerical methods

Machine learning methods allow for greater accuracy in all manner of numerical computation and model interpretation tasks. Interpretability of models allows for easier and more accurate volatility modelling [2] [18] [27] [37] [4].

3   Internet of things

3.1   Kleros [39]

Kleros [39] aims to automate certain commercial mediation processes by use of blockchain technology allowing for financial arbitrage in conflict resolution scenarios.

3.2 Tornado Cash [25] [28]

Tornado Cash is a peculiar blockchain smart contract protocol that allows users to send and receive cryptocurrency payments completely anonymously. The protocol has purportedly been flagged by US authorities leading to very little utilization.

3.3 Cofence [7]

Cofence present a cybersecurity email protection algorithm with integrated human vetting.

3.4 Polymarket [30]

Polymarkets are an interesting phenomenon that, with sufficient volume, may have significant economic effects on an observed event.

3.5 Quantgov [31]

Quantgov seemingly publicises various regulatory documents potentially in the idea to cut red tape.

3.6 TinyURL [34]

TinyURL advertises a useful link shortening tool with added security features along a paid subscription. Modern cryptographic links are long and may seem intimidating especially when domain names change rapidly.

3.7 MyBib [24]

MyBib is a powerful tool for understanding how BibTeX files work, bringing new dimensions to independent research.

3.8 ORCiD [26]

ORCiD provides an easy way for researchers to connect and share work with cutting edge technology at their fingertips.

3.9 ProtonMail [19]

ProtonMail is a popular emailing service based in Switzerland claiming to offer end-to-end encryption. The existence of such services call into question the feasibility of further scaling to internet privacy infrastructure. An analysis [19] on the service's security is offered by Kobeissi.

3.10 The Wikimedia Foundation [36]

The Wikimedia Foundation emerged as a financial supporter of the Wikipedia project, allowing independent researchers to support the movement around freedom of scientific information.

3.11 Data Annotation [8]

Data Annotation is a website that purportedly pays its users to redact and assess AI chatbot prompts and responses.

3.12 Online Museums

Berkeley, University of California publishes art photography online [22] for universal access to ancient scriptures and documents.

4 Blockchain security and pipeline transparency

4.1 Macroeconomic trend prediction using live shipping data

4.2 Commodities markets

4.3 FX option markets

4.4 Commerical legal services

5 Engineering concepts

5.1 Integrating solar panels into protected forestry domain

References

[1] Shahla Atapoor et al. "VSS from Distributed ZK Proofs and Applications". In: *Lecture notes in computer science* (Jan. 2023), pp. 405–440. DOI: 10.1007/978-981-99-8721-4_13. (Visited on 12/05/2024).

[2] Christian Beck, Weinan E, and Arnulf Jentzen. "Machine Learning Approximation Algorithms for High-Dimensional Fully Nonlinear Partial Differential Equations and Second-order Backward Stochastic Differential Equations". In: *Journal of Nonlinear Science* (Jan. 2019). DOI: 10.1007/s00332-018-9525-3.

[3] Fischer Black and Myron Scholes. "The Pricing of Options and Corporate Liabilities". In: *Journal of Political Economy* 81 (1973), pp. 637–654. URL: https://www.jstor.org/stable/1831029?origin=JSTOR-pdf.

[4] Radu Briciu. "Estimating non-linear stochastic functions from generated structured data using multi-layer perceptron models with applications to pricing path-dependent financial derivatives". In: (Dec. 2024). URL: https://github.com/radusbriciu/machine-learning-option-pricing/blob/main/manuscript.pdf.

[5] Aleš Černý. *Mathematical Techniques In Finance: Tools for Incomplete Markets.* 1st ed. Princeton University Press, 2004.

[6] Aleš Černý, Christoph Czichowsky, and Jan Kallsen. "Numeraire-Invariant Quadratic Hedging and Mean–Variance Portfolio Allocation". In: *Mathematics of Operations Research* 49 (May 2023), pp. 752–781. DOI: 10.1287/moor.2023.1374. (Visited on 12/08/2024).

[7] Cofense. *PhishMe Security Awareness Training (SAT) Platform | Cofense.* Cofense.com, 2024. URL: https://cofense.com/phishme-security-awareness-training-(sat)-platform.

[8] *Data Annotation | Your New Remote Job.* www.dataannotation.tech. URL: https://www.dataannotation.tech/.

[9] Thomas Delcey. "Samuelson vs Fama on the Efficient Market Hypothesis: The Point of View of Expertise". In: *OEconomia* 9 (Mar. 2019), pp. 37–58. DOI: 10.4000/oeconomia.5300.

[10] Jens Ernstberger et al. *Do You Need a Zero Knowledge Proof?* 2024. URL: https://eprint.iacr.org/2024/050.pdf.

[11] Christoph Frey et al. *Option Pricing via Machine Learning with Python*. Tidy Finance, 2022. URL: https://www.tidy-finance.org/python/option-pricing-via-machine-learning.html.

[12] Gianluca Fusai, Andrea Roncoroni, and Mark Cummins. *Handbook of Multi-Commodity Markets and Products*. John Wiley & Sons, Feb. 2015.

[13] Henri Gavin. *The Levenberg-Marquardt algorithm for nonlinear least squares curve-fitting problems*. 2024. URL: https://people.duke.edu/~hpgavin/lm.pdf.

[14] Paul Glasserman. *Monte Carlo Methods in Financial Engineering*. Springer Science & Business Media, Mar. 2013.

[15] Steven L. Heston. "A Closed-Form Solution for Options with Stochastic Volatility with Applications to Bond and Currency Options". In: *Review of Financial Studies* 6 (Apr. 1993), pp. 327–343. DOI: 10.1093/rfs/6.2.327.

[16] Willem Hundsdorfer et al. "A Positive Finite-Difference Advection Scheme". In: *Journal of Computational Physics* 117 (Mar. 1995), pp. 35–46. DOI: 10.1006/jcph.1995.1042.

[17] Philippe Jorion. *Value at risk : the new benchmark for managing financial risk*. Mcgraw-Hill, 2007.

[18] Jan Kirenz. *Using Keras for Structured Data – Jan Kirenz*. Kirenz.com, 2022. URL: https://www.kirenz.com/blog/posts/2022-06-17-deep-learning-and-keras-data-preprocessing-with-structured-data/.

[19] Nadim Kobeissi. "An Analysis of the ProtonMail Cryptographic Architecture". In: *Cryptology ePrint Archive* (2018). URL: https://eprint.iacr.org/2018/1121.

[20] Oleksandr Kuznetsov et al. "Enhanced Security and Efficiency in Blockchain with Aggregated Zero-Knowledge Proof Mechanisms". In: *IEEE Access* (2024), pp. 1–1. DOI: 10.1109/ACCESS.2024.3384705. URL: https://arxiv.org/abs/2402.03834.

[21] James Lee-Thorp et al. "FNet: Mixing Tokens with Fourier Transforms". In: *arXiv:2105.03824 [cs]* (May 2022). URL: https://arxiv.org/abs/2105.03824.

[22] *Library Guides: Art History: Encyclopedia & Biographical Sources*. Berkeley.edu, 2024. URL: https://guides.lib.berkeley.edu/c.php?g=478634&p=4684317 (visited on 01/06/2025).

[23] Shuaiqiang Liu, Cornelis Oosterlee, and Sander Bohte. "Pricing Options and Computing Implied Volatilities using Neural Networks". In: *Risks* 7 (Feb. 2019), p. 16. DOI: 10.3390/risks7010016.

[24] MyBib. *MyBib*. MyBib, 2018. URL: https://mybib.com.

[25] Matthias Nadler and Fabian Schär. *Tornado Cash and Blockchain Privacy: A Primer for Economists and Policymakers*. Ssrn.com, 2023. URL: https://papers.ssrn.com/sol3/papers.cfm?abstract_id= 4352337.

[26] ORCiD. *ORCiD*. Orcid.org, 2019. URL: https://orcid.org/.

[27] Terence Parr and James D. Wilson. "Partial dependence through stratification". In: *Machine Learning with Applications* 6 (Dec. 2021), p. 100146. DOI: 10.1016/j.mlwa.2021.100146.

[28] Alexey Pertsev, Roman Semenov, and Roman Storm. *Tornado Cash Privacy Solution Version 1.4*. 2019. URL: https://berkeley-defi. github.io/assets/material/Tornado%20Cash%20Whitepaper.pdf.

[29] Matt Pharr. *GPU gems 2 : programming techniques for high-performance graphics and general-purpose computation*. Addison-Wesley, 2004.

[30] *Polymarket | The World's Largest Prediction Market*. Polymarket. URL: https://polymarket.com/.

[31] QuantGov-Home. *QuantGov*. QuantGov, 2025. URL: https://www. quantgov.org/ (visited on 01/05/2025).

[32] Robert R Reitano. *Introduction to quantitative finance : a math tool kit*. Mit Press, 2010.

[33] Philipp J. Schönbucher. "A Market Model for Stochastic Implied Volatility". In: *SSRN Electronic Journal* 21 (1999). DOI: 10.2139/ssrn. 182775.

[34] *TinyURL.com - shorten that long URL into a tiny URL*. Tinyurl.com, 2019. URL: https://tinyurl.com/.

[35] Anton Vorobets. "Portfolio Construction and Risk Management". In: *SSRN Electronic Journal* (Jan. 2024). DOI: 10.2139/ssrn.4807200. URL: https://papers.ssrn.com/sol3/papers.cfm?abstract_id= 4807200 (visited on 01/08/2025).

[36] *Wikimedia Foundation*. Wikimedia Foundation, 2018. URL: https: //wikimediafoundation.org/.

[37] Bo Yuan et al. *Deep learning interpretability for rough volatility*. arXiv.org, 2024. URL: https://arxiv.org/abs/2411.19317 (visited on 12/15/2024).

[38] Zixuan Zhang et al. "Bi-level optimisation of subsidy and capacity investment under competition and uncertainty". In: *European Journal of Operational Research* 318 (Mar. 2024), pp. 327–340. DOI: `10.1016/j.ejor.2024.03.028`. (Visited on 11/26/2024).

[39] Alesia Zhuk. "Applying blockchain to the modern legal system: Kleros as a decentralised dispute resolution system". In: *International Cybersecurity Law Review* 4 (Apr. 2023). DOI: `10.1365/s43439-023-00086-x`.