

FINM 31000: Cryptoasset Markets

Financial Mathematics Program, University of Chicago

July 12 - August 16, 2022

Tuesday 6:00pm-9:00pm

5727 S. University Ave 112

Instructor: Gina C. Pieters, Ph.D. (gcpieters@uchicago.edu)

Department of Economics, University of Chicago;

Cambridge Center for Alternative Finance (CCAF), Judge Business School, University of Cambridge

Drop-In Meetings: Tuesday 5:00-5:30pm; Wednesday: 4pm-6pm (Saieh 428 or the Zoom link on Canvas), or by appointment (limited).

Credits: 50 credits

“Technical Support” TA: Max Anderson (maxanderson1992@gmail.com)

Office Hours: Thursday 5pm-6pm, Saturday 10:45am-11:45am

See Announcements for Zoom link

Introduction:

The growing global cryptoasset market has steadily gathered interest from the traditional financial sector (TradFi). This course, tailored for students with no prior knowledge of the cryptoasset space, will provide participants with an understanding of the underlying technology, markets, and players. It will also contrast how TradFi analysis tools work, or don't work when applied to cryptoasset markets.

This course is intended as a topic course that provides all participants to apply tools they have learned elsewhere to learn the limitations or successes of those tools in the cryptoasset market space. There may be some rescheduled classes due to speaker availability.

Course Aims and Outcomes

Successful mastery of this elective topic course reflects

- Knowledge of the terminology and structure of the global cryptoasset market, including a non-technical understanding of the underlying distributed ledger and blockchain technology, as well as current topics and recent developments.
- Understanding of the promise, shortcomings, and limitations of data available in this space
- The ability to evaluate the role and market niche a token is intended to fulfill.
- The creation of a potential trading strategy for both an individual crypto and a portfolio of crypto.

Pre-Requisites

There are no formal pre-requisites for this course, but students should have prior training in time series analysis techniques to be comfortable working with provided data series without technical guidance. The standard training in the Financial Math is sufficient. No prior knowledge or experience in cryptoasset markets is expected.

Teaching Method

This class will expose students to the ambiguity and -- because it is new -- the unavailability of decisive, definitive answers. Sometimes the best you can do is apply the tools you know correctly. Class time will be used for student, instructor, and guest presentations, and discussions of results of tool applications. There may be some suggested readings and questions to consider posted to Canvas prior to each class, especially when there are guest speakers, but the primary form of pre-class reading will be reviewing the homework projects of other students, to learn from the efforts of others.

Outline of Class Meetings

Date	Topic
Tuesday, July 12	<u>Foundations 1: Overview of Technology and History</u> <ul style="list-style-type: none"> • Bitcoin; Blockchain; Layers; Proof of Work; Other Proof Systems; Mining Centralization/Decentralization. <ul style="list-style-type: none"> ○ BTC to Altcoins; Long (Island Iced Tea) Blockchain Corp; ICO Frenzy; dApps, DEX, and DeFI; NFTs
Saturday, July 16th	<i>Project 1 due. Group of 4 students (self-selected)</i>
Tuesday, July 19	<u>Foundations 2: Centralized Markets and Crypto-Data</u> <ul style="list-style-type: none"> • Centralized and Decentralized Markets; Comparison to Traditional Financial Markets (Number, Scope, Participants, “Rules”); On-Chain, Off-Chain, and Exogeneous Data. Reliability of reported CEX data. <ul style="list-style-type: none"> ○ Mt. Gox and the Hack; Willy and Markus, Pump and Dump, Bitcoin Untethered, • Spatial and Triangular Arbitrage Trading in Prices and Staking Returns
Saturday, July 23 rd	<i>Project 2 due. Group of 4 students (group leader selection)</i>
Tuesday, July 26	<u>Foundations 3: Decentralized Markets: dApps, DAOs, DEX, and DeFI</u> <ul style="list-style-type: none"> • Smart Contracts; dApps; DAOs; Blockchain Forks; Censor <i>Resistant</i>; Tamper <i>Resistant</i>; “Code is Law”; Oracles and Exogeneous Data; Types of Tokens; TVL; Automated Market Makers, Constant Product Formula; <ul style="list-style-type: none"> ○ Ethereum; ERC-20; ConstitutionDAO, MakerDAO, TheDAO; Uniswap • Yield Farming and Impermanent Loss • Guest Speaker: Lucas Kiely, Yield
Saturday, July 30 th	<i>Project 3 due. Group of 2-4 students (random draw)</i>
Tuesday, August 2	<u>Some Analysis of Crypto>Returns</u> <ul style="list-style-type: none"> • Comparison to Stock Market Returns • Returns and Exposure to Non-Crypto Factors (Currency, commodity, Equity, USA Macroeconomy, Geography, Industry) • Returns and Exposure to “Measurable” Crypto-Specific Factors (Production, Regulation Announcements, Network size) • Predictability of Returns (Momentum, Explanations for momentum) • Guest Speakers: Sebastian Ramirez and Graham Williams (FTX)
Saturday, August 6 th	<i>Project 4 due. Group of up to 4 students (self-selected)</i>
Tuesday, August 9 th	<u>Token’s roles in Projects</u> <ul style="list-style-type: none"> • Project Value vs Token Value • Market Roles and Token Niches <ul style="list-style-type: none"> ○ NFTs, Web3, Governance, Utility, Security, Payment • Perpetual Contracts • Guest Speaker: Jack Anderson and Brandon Goss, Messari
Sunday, August 14th	<i>Project 5 due. Individual.</i>

Assessment

Projects: This course will assess learning using five projects assigned as homework. Projects may have different point values. Most, but not all, of the projects will be done in groups (see course outline). **Each project will be due at 10:00pm, Chicago time on the indicated day.**

- A subset of groups may have the option to present their project result at the weeks course meeting, and may be able to earn additional points based upon that presentation. This option will not be available to all groups.
- Every week, all participants are expected to post their assignment, code or worksheets, and any data they use into a communal course folder that others in the course may reference or use.

- The expected work load is 10 hours outside of class for the average student. You are allowed to reuse code or data you created or received in prior classes, or that are shared in this one.

Academic Dishonesty

Any work you submit must be representative of the understanding held by those whose names are listed on the assignment. This includes use of data or posted code. Any violation of academic will be punished to the fullest extent possible.

Grades

Letter Grade Cutoffs: Letter grades are assigned according to whether a student has achieved a sufficient number of points to meet or exceed the cutoff for that letter grade. Points are received by the on-time completion of the five projects. Each project may be worth a different amount of points.

In the default plan, if a student achieves 92% or more of the total points available they are guaranteed an A.

	A	A-	B+	B	B-	C+	C	C-	D+	D
Default	90%	88%	86%	80%	78%	76%	70%	68%	66%	60%

The course will use one of two curves if necessary to decrease the cutoffs for a given grade.

- Curve 1 determines the cutoff points based on the point distribution in the class (μ is the average, while σ is the standard deviation).
- Curve 2 determines the cutoff points based on the share of students who have a certain number of points (the cutoff for an A becomes the aggregated score of the student at top 20%).

	A	A-	B+	B	B-	C+	C	C-	D+	D
Curve 1: Distribution	$\mu + \frac{5}{4}\sigma$	$\mu + \sigma$	$\mu + \frac{3}{4}\sigma$	$\mu + \frac{1}{4}\sigma$	μ	$\mu - \frac{1}{4}\sigma$	$\mu - \frac{3}{4}\sigma$	$\mu - \sigma$	$\mu - \frac{5}{4}\sigma$	$\mu - \frac{3}{2}\sigma$
Curve 2: Share	Top 20%	Top 25%		Top 50%	Top 55%		Top 75%			

The cutoff score will be determined by letter grade. Whichever of the three plans results in the lowest point requirement will be the one used to determine the cutoff for a letter grade. This means that an “A” grade cutoff can be determined by the default, while the “D” grade can be determined by the distribution.

Canvas

I will use Gradescope to collect and return assignments, Canvas Announcements for course announcements, and Ed Discussion boards for discussions that do not refer to confidential information: these are all accessible through links on the Canvas course page. I will post required reading to Canvas, as well as the project files.

Textbooks and Required Reading

There are no textbooks or reading to purchase for this course. Any papers discussed in the course will be posted to Canvas.

Attendance and Participation

Attendance is expected and participation is encouraged.

Technical Difficulties

I may not accommodate technical difficulties, especially if they are foreseeable. This includes a difficulty in getting code to compile, obtaining desired data, etc.

Email Policy

I respond to all emails within 2 **business days**, and usually faster. If I don’t respond within this time frame it means I did not receive or notice your email so please send a follow-up. It is a course requirement that you check both the email associated with this course and the course discussion board daily. The discussion board can be considered checked if you set up the daily summary email, instead of checking the board directly.

Video Policy

Zoom participants should have their video on unless their internet is slow or unstable. I understand that there may be kids/pets/roommates/chaos in the background, but this way both I and your fellow students can recognize each other if we are at events in the future.

Distributing Audio, Video, or Photograph Policy

Regular meetings will be recorded and distributed using Canvas. Guest speaker presentations will be recorded and distributed only if the speaker gives permission.

If you record a class, discussion section, office hours, or meeting or the Canvas site without permission, or if you share any of the recorded videos without permission, or if you share files associated with the course without permission you be may violating privacy laws, copyright laws, Illinois eavesdropping laws, and/or the FERPA statute. This also applies to any manipulated video, audio, or image file.

Diversity Statement

The University of Chicago is committed to diversity and rigorous inquiry that arises from multiple perspectives. I share this commitment: we have the highest quality interactions and solve problems more creatively when we recognize and share our diversity of perspectives. I expect to maintain a productive learning environment based on open communication, mutual respect, and non-discrimination among students, teaching assistants, support staff, and myself as the lead instructor of the course, even as we may engage in strenuous and critical debates.

Responsible Employees

All University of Chicago faculty and TAs are classified as “responsible employees”; they are required to report any discussions of sexual misconduct, including the identities of the student making the complaint and alleged perpetrator. You will receive an email once a report is filed but are not obligated to meet with anyone or engage in the process. In contrast, Confidential Resource Individuals do not have to share identifying information. Find more information, including phone numbers, [here](#).

Reading Reference List

Data sources are indicated on course slides, web pages for data on the slides are linked to on my website.

Week 1: Overview of Technology and Event History

Academic Papers

Makarov, Igor, and Antoinette Schoar. 2021. "Blockchain Analysis of the Bitcoin Market." Working Paper. Working Paper Series. National Bureau of Economic Research. <https://doi.org/10.3386/w29396>.

Articles, Blogs, Posts, and Reports

Ahiwe, Onyebuchi Valentine. 2020. "Building Your Own Ethereum Based ECR20 Token in Less than an Hour | Codementor." May 17, 2020. <https://www.codementor.io/@vahiwe/building-your-own-ethereum-based-ecr20-token-in-less-than-an-hour-16f44bq67i>.

Andolfatto, David, and Fernando Martin. 2021. "The Blockchain Revolution: Decoding Digital Currencies." Annual Report. Federal Reserve Bank of St. Louis. Federal Reserve Bank of St. Louis. <https://www.stlouisfed.org/annual-report/2021/essay>.

Auer, Raphael, Jon Frost, and Jose María Vidal Pastor. 2022. "Miners as Intermediaries: Extractable Value and Market Manipulation in Crypto and DeFi." *BIS Bulletin* 58 (June). <https://www.bis.org/publ/bisbull58.htm>.

Nakamoto, Satoshi. 2008. "Bitcoin: A Peer-to-Peer Electronic Cash System," 9.

Neto, Moritz. 2017. "How to Issue Your Own Token on Ethereum in Less than 20 Minutes." *Bitfwd* (blog). December 25, 2017. <https://medium.com/bitfwd/how-to-issue-your-own-token-on-ethereum-in-less-than-20-minutes-ac1f8f022793>.

Rauchs, Michel, Andrew Glidden, Brian Gordon, Gina Pieters, Martino Recanatini, Francois Rostand, Kathryn Vagneur, and Bryan Zhang. 2018. "Distributed Ledger Technology Systems: A Conceptual Framework." University of Cambridge, Cambridge Center for Alternative Finance. https://www.jbs.cam.ac.uk/fileadmin/user_upload/research/centres/alternative-finance/downloads/2018-10-26-conceptualising-dlt-systems.pdf.

Shin, Laura. 2022. "Exclusive: Austrian Programmer And Ex Crypto CEO Likely Stole \$11 Billion Of Ether." *Forbes*, February 22, 2022, sec. Crypto & Blockchain. <https://www.forbes.com/sites/laurashin/2022/02/22/exclusive-austrian-programmer-and-ex-crypto-ceo-likely-stole-11-billion-of-ether/>.

Sultanik, Evan, Alexander Remie, Felipe Manzano, Trent Brunson, Sam Moelius, Kilmer, Mike Myers, Talley Amir, and Sonya Schriener. 2022. "Are Blockchains Decentralized? Unintended Centralities in Distributed Ledgers." Trail of Bits. https://assets-global.website-files.com/5fd11235b3950c2c1a3b6df4/62af6c641a672b3329b9a480_Unintended_Centralities_in_Distributed_Ledgers.pdf.

Trail of Bits. 2022. "Are Blockchains Decentralized?" *Trail of Bits Blog* (blog). June 21, 2022. <https://blog.trailofbits.com/2022/06/21/are-blockchains-decentralized/>.

Week 2: Centralized Markets and Crypto-Data

Academic Papers

- Baur, Dirk G., Daniel Cahill, Keith Godfrey, and Zhangxin (Frank) Liu. 2019. “Bitcoin Time-of-Day, Day-of-Week and Month-of-Year Effects in Returns and Trading Volume.” *Finance Research Letters* 31 (December): 78–92. <https://doi.org/10.1016/j.frl.2019.04.023>.
- Caporale, Guglielmo Maria, and Alex Plastun. 2019. “The Day of the Week Effect in the Cryptocurrency Market.” *Finance Research Letters* 31 (December). <https://doi.org/10.1016/j.frl.2018.11.012>.
- Cong, Lin William, Xi Li, Ke Tang, and Yang Yang. 2021. “Crypto Wash Trading.” SSRN Scholarly Paper. Rochester, NY. <https://doi.org/10.2139/ssrn.3530220>.
- Gandal, Neil, JT Hamrick, Tyler Moore, and Tali Oberman. 2018. “Price Manipulation in the Bitcoin Ecosystem.” *Journal of Monetary Economics* 95 (May): 86–96. <https://doi.org/10.1016/j.jmoneco.2017.12.004>.
- Griffin, John, and Amin Shams. 2020. “Is Bitcoin Really Untethered?” *The Journal of Finance* 75 (4): 1913–64. <https://doi.org/10.1111/jofi.12903>
- Hamrick, J. T., Farhang Rouhi, Arghya Mukherjee, Amir Feder, Neil Gandal, Tyler Moore, and Marie Vasek. 2018. “The Economics of Cryptocurrency Pump and Dump Schemes.” SSRN Scholarly Paper. Rochester, NY. <https://papers.ssrn.com/abstract=3310307>.
- Kaiser, Lars. 2019. “Seasonality in Cryptocurrencies.” *Finance Research Letters* 31 (December). <https://doi.org/10.1016/j.frl.2018.11.007>.
- Mbanga, Cedric L. 2019. “The Day-of-the-Week Pattern of Price Clustering in Bitcoin.” *Applied Economics Letters* 26 (10): 807–11. <https://doi.org/10.1080/13504851.2018.1497844>.
- Pennec, Guénolé Le, Ingo Fiedler, and Lennart Ante. 2021. “Wash Trading at Cryptocurrency Exchanges.” *Finance Research Letters* 43 (November): 101982. <https://doi.org/10.1016/j.frl.2021.101982>.
- Pieters, Gina C. 2016. “Bitcoin Reveals Exchange Rate Manipulation and Detects Capital Controls.” SSRN Scholarly Paper. Rochester, NY. <https://doi.org/10.2139/ssrn.2714921>.
- Pieters, Gina, and Sofia Vivanco. 2017. “Financial Regulations and Price Inconsistencies across Bitcoin Markets.” *Information Economics and Policy* 39 (June): 1–14. <https://doi.org/10.1016/j.infoecopol.2017.02.002>.

Articles, Blogs, Posts, and Reports

- “Analysis of Real Bitcoin Trade Volume.” 2019. Bitwise Asset Management. <https://static.bitwiseinvestments.com/Research/Bitwise-Asset-Management-Analysis-of-Real-Bitcoin-Trade-Volume.pdf>.
- Faux, Zeke. 2022. “Did Razzlekhan and Dutch Pull Off History’s Biggest Crypto Heist?” *Bloomberg*, June 30, 2022. <https://www.bloomberg.com/news/features/2022-06-30/how-the-world-s-biggest-bitcoin-btc-hack-at-bitfinex-got-botched>.
- Jeong, Steven Russolillo and Eun-Young. 2018. “Cryptocurrency Exchanges Are Getting Hacked Because It’s Easy.” *WSJ*, July 16, 2018, sec. Markets. <https://www.wsj.com/articles/why-cryptocurrency-exchange-hacks-keep-happening-1531656000>.
- “June 2022 Exchange Review.” 2022. Exchange Reviews. CryptoCompare.
- McMillan, Robert. 2014. “Bitcoin Exchange Mt. Gox Goes Offline Amid Allegations of \$350 Million Hack.” *Wired*, February 24, 2014. <https://www.wired.com/2014/02/bitcoins-mt-gox-implodes-2/>.
- Stucky, Jake Adelstein, Nathalie-Kyoko. 2016. “Inside the Biggest Bitcoin Heist in History.” *The Daily Beast*, May 19, 2016, sec. world. <https://www.thedailybeast.com/articles/2016/05/19/behind-the-biggest-bitcoin-heist-in-history-inside-the-implosion-of-mt-gox>.
- Wieczner, Jen. 2018. “Mt. Gox and the Surprising Redemption of Bitcoin’s Biggest Villain.” *Fortune*, April 19, 2018. <https://fortune.com/longform/bitcoin-mt-gox-hack-karpeles/>.

Week 3: Decentralized Markets: dApps, DAOs, DEX, and DeFi

Academic Papers

- Angeris, Guillermo, Hsien-Tang Kao, Rei Chiang, Charlie Noyes, and Tarun Chitra. 2020. “An Analysis of Uniswap Markets.” *Cryptoeconomic Systems*, November. <https://doi.org/10.21428/58320208.c9738e64>.
- Gu, Wanyun Catherine, Anika Raghuvanshi, and Dan Boneh. 2021. “Empirical Measurements on Pricing Oracles and Decentralized Governance for Stablecoins.” *Cryptoeconomic Systems* 1 (2). <https://doi.org/10.21428/58320208.e27f9a99>.
- Ilyushina, Nataliya, and Trent Macdonald. 2022. “Decentralised Autonomous Organisations: A New Research Agenda for Labour Economics.” *The Journal of The British Blockchain Association*, April, 35367. <https://jbba.scholasticahq.com/article/35367-decentralised-autonomous-organisations-a-new-research-agenda-for-labour-economics>
- Landoni, Mattia, and Gina C. Pieters. 2020. “Taxing Blockchain Forks.” *Stanford Journal of Blockchain Law & Policy* 3 (2). <https://doi.org/10.2139/ssrn.3475598>.
- Makarov, Igor, and Antoinette Schoar. 2022. “Cryptocurrencies and Decentralized Finance (DeFi).” Working Paper. Working Paper Series. National Bureau of Economic Research. <https://doi.org/10.3386/w30006>.
- Qin, Kaihua, Liyi Zhou, Yaroslav Afonin, Ludovico Lazzaretti, and Arthur Gervais. 2021. “CeFi vs. DeFi -- Comparing Centralized to Decentralized Finance.” arXiv. <http://arxiv.org/abs/2106.08157>.
- Qin, Kaihua, Liyi Zhou, Pablo Gamito, Philipp Jovanovic, and Arthur Gervais. 2021. “An Empirical Study of DeFi Liquidations: Incentives, Risks, and Instabilities.” In *Proceedings of the 21st ACM Internet Measurement Conference*, 336–50. <https://doi.org/10.1145/3487552.3487811>.
- Werner, Sam M., Daniel Perez, Lewis Gudgeon, Ariaah Klages-Mundt, Dominik Harz, and William J. Knottenbelt. 2021. “SoK: Decentralized Finance (DeFi).” arXiv. <http://arxiv.org/abs/2101.08778>

Articles, Blogs, Posts, and Reports

- Brian. 2022. “Luna Classic Pricing Error Leads to Mirror Protocol Exploit.” *Cointelegraph*, May 31, 2022. <https://cointelegraph.com/news/luna-classic-lunc-pricing-error-leads-to-mirror-protocol-exploit>.
- Buterin, Vitalik. 2014. “Ethereum: A Next-Generation Smart Contract and Decentralized Application Platform.” https://ethereum.org/669c9e2e2027310b6b3cdce6e1c52962/Ethereum_Whitepaper_-_Buterin_2014.pdf.
- Hackl, Cathy. 2021. “What Are DAOs And Why You Should Pay Attention.” *Forbes*. June 1, 2021. <https://www.forbes.com/sites/cathyhackl/2021/06/01/what-are-daos-and-why-you-should-pay-attention/>.
- Jentzsch, Christoph. 2016. “The History of the DAO and Lessons Learned.” *Slock.It Blog* (blog). August 24, 2016. <https://blog.slock.it/the-history-of-the-dao-and-lessons-learned-d06740f8cfa5>.
- Patel, Nilay. 2021. “From a Meme to \$47 Million: ConstitutionDAO, Crypto, and the Future of Crowdfunding.” *The Verge*, December 7, 2021. <https://www.theverge.com/22820563/constitution-meme-47-million-crypto-crowdfunding-blockchain-ethereum-constitution>.
- Schär, Fabian. 2021. “Decentralized Finance: On Blockchain- and Smart Contract-Based Financial Markets.” *Federal Reserve Bank of St. Louis Review* 103 (2). <https://doi.org/10.20955/r.103.153-74>.
- Simonite, Tom. 2016. “The ‘Autonomous Corporation’ Called the DAO Is Not a Good Way to Spend \$130 Million.” *MIT Technology Review*. May 17, 2016. <https://www.technologyreview.com/2016/05/17/160160/the-autonomous-corporation-called-the-dao-is-not-a-good-way-to-spend-130-million/>.
- Szabo, Nick. 1997. “The Idea of Smart Contracts | Satoshi Nakamoto Institute.” Satoshi Nakamoto Institute. 1997. <https://nakamotoinstitute.org/the-idea-of-smart-contracts/>.

Week 4: Some Analysis of Crypto>Returns

Academic Papers

- Aslanidis, Nektarios, Aurelio F. Bariviera, and Óscar G. López. 2022. “The Link between Cryptocurrencies and Google Trends Attention.” *Finance Research Letters* 47 (June): 102654. <https://doi.org/10.1016/j.frl.2021.102654>.
- Cong, Lin William, Ye Li, and Neng Wang. 2021. “Tokenomics: Dynamic Adoption and Valuation.” *The Review of Financial Studies* 34 (3): 1105–55. <https://doi.org/10.1093/rfs/hhaa089>.
- Liu, Yukun, and Aleh Tsyvinski. 2018. “Risks and Returns of Cryptocurrency.” Working Paper. Working Paper Series. National Bureau of Economic Research. <https://doi.org/10.3386/w24877>.
- . 2021. “Risks and Returns of Cryptocurrency.” *The Review of Financial Studies* 34 (6): 2689–2727. <https://doi.org/10.1093/rfs/hhaa113>.

Week 5: Some Analysis of Crypto>Returns

Academic Papers

- Aslanidis, Nektarios, Aurelio F. Bariviera, and Óscar G. López. 2022. “The Link between Cryptocurrencies and Google Trends Attention.” *Finance Research Letters* 47 (June): 102654. <https://doi.org/10.1016/j.frl.2021.102654>.
- Pernice, Ingolf Gunnar Anton, Georg Gentzen, and Hermann Elendner. 2021. “Cryptocurrencies and the Velocity of Money.” *Cryptoeconomic Systems* 0 (1). <https://doi.org/10.21428/58320208.f212c00e>.
- Shiller, Robert J. 1993. “Measuring Asset Values for Cash Settlement in Derivative Markets: Hedonic Repeated Measures Indices and Perpetual Futures.” *The Journal of Finance* 48 (3): 911–31. <https://doi.org/10.2307/2329020>.
- Soska, Kyle, Jin-Dong Dong, Alex Khodaverdian, Ariel Zetlin-Jones, Bryan Routledge, and Nicolas Christin. 2021. “Towards Understanding Cryptocurrency Derivatives: A Case Study of BitMEX.” In *Proceedings of the Web Conference 2021*, 45–57. Ljubljana Slovenia: ACM. <https://doi.org/10.1145/3442381.3450059>.

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- dcresearch. 2020. “Metcalf’s Law and Bitcoin’s Value.” *Medium* (blog). November 12, 2020. <https://dcresearch.medium.com/metcalfes-law-and-bitcoin-s-value-2b99c7efd1fa>.
- Guttha, Karthik. 2022. “WTF Is an XNFT? And Why Should You Care.” *ItsBlockchain* (blog). June 22, 2022. <https://itsblockchain.com/what-is-xnfts-solana/>.
- Kuhn, Daniel. 2021. “Can This Network Theory Predict If Bitcoin Is Undervalued?” *Coindesk*, July 22, 2021, sec. Markets. <https://www.coindesk.com/markets/2021/07/22/can-this-network-theory-predict-if-bitcoin-is-undervalued/>.
- Marr, Bernard. 2022. “How The Coachella Music Festival Is Using NFTs And Blockchain.” *Forbes*. February 17, 2022. <https://www.forbes.com/sites/bernardmarr/2022/02/17/how-the-coachella-music-festival-is-using-nfts-and-blockchain/>.
- Moore, Simon. 2021. “Might Metcalfe’s Law Govern Bitcoin’s Price?” *Forbes*. March 1, 2021. <https://www.forbes.com/sites/simonmoore/2021/03/01/might-metcalfes-law-govern-bitcoins-price/>.
- Russell. 2022. “Solana Faces the Music with the Lollapalooza NFT Scavenger Hunt.” *NFT Plazas* (blog). July 20, 2022. <https://nftplazas.com/lollapalooza-nft-scavenger-hunt/>.