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Distributed Ledgers Design and Regulation of Financial Infrastructure and Payment Systems

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References

Abel, Andrew B., N. Gregory Mankiw, Lawrence H. Summers, and Richard J. Zeckhauser. 1989. "Assessing Dynamic Efficiency: Theory and Evidence." *Review of Economic Studies* 56 (1): 1–19.

Abreu, Dilip, David Pearce, and Ennio Stacchetti. 1990. "Toward a Theory of Discounted Repeated Games with Imperfect Monitoring." *Econometrica* 58 (5): 1041–1063.

Acemoglu, Daron, and Fabrizio Zilibotti. 1997. "Was Prometheus Unbound by Chance? Risk, Diversification, and Growth." *Journal of Political Economy* 105 (4): 709–751.

Acheson, Noelle. 2019. "Libra Isn't a Cryptocurrency. It's a Glimpse of a New Asset Class." *Coindesk*, July 7. https://www.coindesk.com /libra-isnt-a-cryptocurrency-its-a-glimpse-of-a-new-asset-class.

Adrian, Tobias, and Hyun Song Shin. 2009. "Money, Liquidity, and Monetary Policy." Federal Reserve Bank of New York Staff Report No. 360.

Aiyagari, S. Rao. 1994. "Uninsured Idiosyncratic Risk and Aggregate Saving." *Quarterly Journal of Economics* 109 (3): 659–684.

Alvarez, Fernando, and Francesco Lippi. 2009. "Financial Innovation and the Transactions Demand for Cash." *Econometrica* 77 (2): 363–402.

Alvarez, Fernando, Anan Pawasutipaisit, and Robert M. Townsend. 2018. "Cash Management in Village Thailand: Positive and Normative Implications." MIT Working Paper.

Amberg, Niklas, Tor Jacobson, Erik von Schedvin, and Robert M. Townsend. 2016. "Curbing Shocks to Corporate Liquidity: The Role of Trade Credit." National Bureau of Economic Research (NBER) Working Paper No. 22286.

Angeletos, George-Marios, Fabrice Collard, and Harris Dellas. 2016. "Public Debt as Private Liquidity: Optimal Policy." NBER Working Paper No. 22794.

Aronoff, Daniel J. 2019. "On the Resilience of the Blockchain to Double-Spend Attacks." MIT Working Paper.

ASEAN. 2017. "ASEAN Statistical Leaflet—Selected Key Indicators 2017." ASEAN Secretariat, Jakarta. https://www.aseanstats.org/wp-con tent/uploads/2017/11/ASEAN-Statistical-Leaflet-2017_Final.pdf.

Asian Development Bank. 2017. "Accelerating Financial Inclusion in South-East Asia with Digital Finance." ADB.org. http://dx.doi.org /10.22617/RPT178622-2.

Athey, Susan, Ivo Parashkevov, Vishnu Sarukkai, and Jing Xia. 2016. "Bitcoin Pricing, Adoption, and Usage: Theory and Evidence." Stanford University Graduate School of Business Working Paper 3469. https://ssrn.com/abstract=2826674.

Auclert, Adrien. 2019. "Monetary Policy and the Redistribution Channel." *American Economic Review* 109 (6): 2333–2367.

Banerjee, Abhijit, Emily Breza, Robert M. Townsend, and Diego Vera-Cossio. 2018. "Access to Credit and Productivity: Evidence from Thai Villages." University of California, San Diego, Working Paper.

Bech, Morten, and Rodney Garratt. 2017. "Central Bank Cryptocurrencies." *BIS Quarterly Review* (September): 55–70. https://www.bis .org/publ/qtrpdf/r_qt1709f.pdf.

Bersem, Mario, Enrico Perotti, and Ernst-Ludwig von Thadden. 2013. "Sand in the Wheels of Capitalism: On the Political Economy of Capital Market Frictions." Copenhagen Business School Working Paper.

Bewley, Truman. 1983. "A Difficulty with the Optimum Quantity of Money." *Econometrica* 51(5): 1485–1504.

Bharadwaj, Prashant, William Jack, and Tavneet Suri. 2018. "Can Digital Loans Deliver? Take Up and Impacts of Digital Loans in Kenya." Working Paper.

Biais, Bruno, Christophe Bisiere, Matthieu Bouvard, Catherine Casamatta, and Albert Menkveld. 2018. "Equilibrium Bitcoin Pricing." Toulouse School of Economics Working Paper. BIS (Bank for International Settlements). 2017a. "Distributed Ledger Technology in Payment, Clearing, and Settlement: An Analytical Framework." Committee on Payments and Market Infrastructures Paper No. 157 (February).

BIS (Bank for International Settlements). 2017b. "Distributed Ledgers in Payment, Clearing, and Settlement Carry Promise as Well as Risks." Press release, February 27. https://www.bis.org/press/p170227.htm.

BIS (Bank for International Settlements). 2018. "Cryptocurrencies: Looking beyond the Hype." *BIS Annual Economic Report* (June): 91–109. www.bis.org/publ/arpdf/ar2018e.htm.

Blockdata.tech. 2018. "Stablecoins: An Overview of the Current State of Stablecoins." https://download.blockdata.tech/blockdata-stable coin-report-blockchain-technology.pdf.

Bronstein, Max. 2018. "Mapping the Decentralized Financial System: More Transparent, Open, and Programmable Financial Services." *MaxBronstein.com*, August 7. https://maxbronstein.com/mapping -the-decentralized-financial-system/.

Browning, Martin, Thomas F. Crossley, and Joachim Winter. 2014. "The Measurement of Household Consumption Expenditures." *Annual Review of Economics* 6 (6): 475–501.

Bryant, John, and Neil Wallace. 1984. "A Price Discrimination Analysis of Monetary Policy." *Review of Economic Studies* 51 (2): 279–288.

Budish, Eric. 2018. "The Economic Limits of Bitcoin and the Blockchain." University of Chicago Working Paper.

Budish, Eric, Peter Cramton, and John Shim. 2015. "The High-Frequency Trading Arms Race: Frequent Batch Auctions as a Market Design Response." *Quarterly Journal of Economics* 130 (4): 1547–1621.

Bureau of Economic Analysis. 2017. NIPA Handbook: Concepts and Methods of the US National Income and Product Accounts. US Department of Commerce (November). https://www.bea.gov/sites /default/files/methodologies/nipa-handbook-all-chapters.pdf.

Campbell-Kelly, Martin. 2010. "Victorian Data Processing." Communications of the ACM 53 (10): 19–21.

Cao, Sean S., Lin Cong, and Baozhong Yang. 2018. "Auditing and Blockchains: Pricing, Misstatements, and Regulation." Georgia State University Working Paper. Carlson, Mark, Burcu Duygan-Bump, Fabio Natalucci, Bill Nelson, Marcelo Ochoa, and Jeremy Stein. 2016. "The Demand for Short-Term, Safe Assets and Financial Stability: Some Evidence and Implications for Central Bank Policies." *International Journal of Central Banking* 12 (4): 307–333.

Carlson, Stacy. 2017. "Essays in Financial Innovation and Development." PhD diss., MIT.

Casey, Michael, Jonah Crane, Gary Gensler, Simon Johnson, and Neha Narula. 2018. *The Impact of Blockchain Technology on Finance: A Catalyst for Change*. Vol. 21. Geneva Reports on the World Economy. Geneva: International Center for Monetary and Banking Studies. https://www.cimb.ch/uploads/1/1/5/4/115414161/geneva21_1.pdf.

Cass, David, Masahiro Okuno, and Itzhak Zilcha. 1978. "The Role of Money in Supporting the Pareto Optimality of Competitive Equilibrium in Consumption Loan Type Models." In *Models of Monetary Economies: Proceedings and Contributions from Participants of a December 1978 Conference*, 13–48. Minneapolis: Federal Reserve Bank of Minneapolis.

Chandrasekhar, Arun G., Robert M. Townsend, and Juan Pablo Xandri. 2018. "Financial Centrality and Liquidity Provision." MIT Working Paper.

Chen, Jing, Sergey Gorbunov, Silvio Micali, and Georgios Vlachos. 2018. "Algorand Agreement—Super Fast and Partition Resilient Byzantine Agreement." https://www.algorand.com/resources/white-papers/.

Chiappori, Pierre-André, Krislert Samphantharak, Sam Schulhofer-Wohl, and Robert M. Townsend. 2014. "Heterogeneity and Risk Sharing in Village Economies." *Quantitative Economics 5* (1): 1–27.

Chiu, Jonathan, and Thorsten V. Koeppl. 2017. "The Economics of Cryptocurrencies—Bitcoin and Beyond." http://dx.doi.org/10.2139 /ssrn.3048124.

Chwe, Michael Suk-Young. 1995. "Strategic Reliability of Communication Networks." University of Chicago Working Paper.

Cipolla, Carlo M. 1956. Money, Prices, and Civilization in the Mediterranean World, Fifth to Seventeenth Century. Princeton, NJ: Princeton University Press.

Clower, Robert. 1967. "A Reconsideration of the Microfoundations of Monetary Theory." *Economic Inquiry* 6 (1): 1–8.

Cocco, João F., Francisco J. Gomes, and Nuno C. Martins. 2009. "Lending Relationships in the Interbank Market." *Journal of Financial Intermediation* 18 (2009): 24–48.

Coles, Peter A., and Ran Shorrer. 2012. "Correlation in the Multiplayer Electronic Mail Game." *BE Journal of Theoretical Economics* 12 (1). doi:10.1515/1935–1704.1576.

Columbus, Louis. 2019. "Top 10 Ways Internet of Things and Blockchain Strengthen Supply Chains." *Forbes.com*, January 13. https:// www.forbes.com/sites/louiscolumbus/2019/01/13/top-10-ways-in ternet-of-things-and-blockchain-strengthen-supply-chains/#4fea18a c5e4e.

Cong, Lin, Zhiguo He, and Jiasun Li. 2018. "Decentralized Mining in Centralized Pools." George Mason University School of Business Research Paper No. 18–9.

Cong, Lin William, and Zhiguo He. 2019. "Blockchain Disruption and Smart Contracts." *Review of Financial Studies* 32 (5): 1754–1797.

Crouzet, Nicolas, Apoorv Gupta, and Filippo Mezzanotti. 2019. "Shocks and Technology Adoption: Evidence from Electronic Payment Systems." Northwestern University Working Paper.

Curran, Brian. 2018. "What Is Practical Byzantine Fault Tolerance? Complete Beginner's Guide." *Blockonomi.com*, May 11. https://blockonomi.com/practical-byzantine-fault-tolerance/.

Dandekar, Pranav, Ashish Goel, Ramesh Govindan, and Ian Post. 2012. "Liquidity in Credit Networks: A Little Trust Goes a Long Way." Stanford University Working Paper.

Dasgupta, Partha, Peter Hammond, and Eric Maskin. 1979. "The Implementation of Social Choice Rules: Some General Results on Incentive Compatibility." *Review of Economic Studies* 46 (2): 185–216.

De, Nikhilesh. 2019. "Tether Lawyer Admits Stablecoin Now 74% Backed by Cash and Equivalents." *Coindesk*, May 1. https://www.coindesk.com/tether-lawyer-confirms-stablecoin-74-percent-backed -by-cash-and-equivalents.

De Jaegher, Kris, and Robert van Rooij. 2011. "Strategic Vagueness, and Appropriate Contexts." In *Language, Games, and Evolution*. Lecture Notes in Computer Science, Vol. 6207. Edited by A. Benz, C. Ebert, G. Jäger, and R. van Rooij. Berlin: Springer.

Denison, Erin, Michael Lee, and Antoine Martin. 2016. "What Do Cryptocurrencies Do?" Federal Reserve Bank of New York Conference Paper.

Diamond, Douglas W., and Philip H. Dybvig. 1983. "Bank Runs, Deposit Insurance, and Liquidity." *Journal of Political Economy* 91 (3): 401–419.

Diamond, Peter A. 1965. "National Debt in a Neoclassical Growth Model." *American Economic Review 55* (5) Part 1: 1126–1150.

Doepke, Matthias, and Martin Schneider. 2006. "Inflation and the Redistribution of Nominal Wealth." *Journal of Political Economy* 114 (6): 1069–1097.

Doepke, Matthias, and Robert M. Townsend. 2006. "Dynamic Mechanism Design with Hidden Income and Hidden Actions." *Journal of Economic Theory*, 126 (1): 235–285.

Domeij, David, and Tore Ellingsen. 2018. "Monetary Policy in Incomplete Markets." Stockholm School of Economics Working Paper.

Du, Songzi, and Haoziang Zhu. 2017. "Are CDS Auctions Biased and Inefficient?" *Journal of Finance* 72: 2589–2628.

Duffie, Darrell, Nicolae Gârleanu, and Lasse Heje Pedersen. 2005. "Over-the-Counter Markets." *Econometrica* 73 (6): 1815–1847.

Erlandsson, Frida, and Gabriela Guibourg. 2018. "Times Are Changing and So Are Payment Patterns." Sveriges Riksbank Economic Commentaries No. 6 (May 14).

Falkon, Samuel. 2017. "The Story of the DAO—Its History and Consequences." *Medium.com*, December 24. https://medium.com/swlh/the -story-of-the-dao-its-history-and-consequences-71e6a8a551ee.

Fernandes, Ana, and Christopher Phelan. 2000. "A Recursive Formulation for Repeated Agency with History Dependence." *Journal of Economic Theory* 91 (2): 223–247.

Fernández-Villaverde, Jesús, and Daniel Sanches. 2016. "Can Currency Competition Work?" NBER Working Paper 22157.

Fischer, Michael J., Nancy A. Lynch, and Michael S. Paterson. 1985. "Impossibility of Distributed Consensus with One Faulty Process." *Journal of the Association for Computing Machinery* 32 (2): 374–382.

Foley, Sean, Jonathan R. Karlsen, and Talis J. Putnins. 2019. "Sex, Drugs, and Bitcoin: How Much Illegal Activity Is Financed through Cryptocurrencies?" Review of Financial Studies 32 (5): 1798–1853.

Freeman, Scott. 1996. "The Payments System, Liquidity, and Rediscounting." *American Economic Review* 86 (5): 1126–1138.

Fulford, Scott, and Scott Schuh. 2017. "Credit Card Utilization and Consumption over the Life Cycle and Business Cycle." Federal Reserve Bank of Boston Working Paper No. 17–14.

G20 Research Group. 2013. "The 2013 G20 St. Petersburg Summit Commitments." http://www.g20.utoronto.ca/analysis/commitments-13 -stpetersburg.html.

Gale, Douglas, and Martin Hellwig. 1985. "Incentive-Compatible Debt Contracts: The One-Period Problem." *Review of Economic Studies* 52 (4): 647–663.

Gans, Joshua S. 2018. "The Fine Print in Smart Contracts." University of Toronto Working Paper.

Garratt, Rodney, Antoine Martin, Michael Junho Lee, and Robert M. Townsend. 2018. "Endogenous Liquidity and Interdealer Trading in Over-the-Counter Markets." Federal Reserve Bank of New York Working Paper.

Garratt, Rodney, and Neil Wallace. 2018. "Bitcoin 1, Bitcoin 2, ... : An Experiment in Privately Issued Outside Monies." *Economic Inquiry* 56 (3): 1887–1897.

Geanakoplos, John. 2003. "Liquidity, Default, and Crashes, Endogenous Contracts in General Equilibrium." In *Advances in Economics and Econometrics: Theory and Applications, Eighth World Conference Volume II*, 170–205. Edited by M. Dewatripont, L. P. Hansen, and S. J. Turnovsky, Cambridge: Cambridge University Press.

Geerolf, François. 2017. "Reassessing Dynamic Efficiency." UCLA Working Paper.

Glazer, Phil. 2018. "Decentralized Cryptocurrency Exchanges." *Bit-coinInsider.com*, March 6. https://www.bitcoininsider.org/article/19624 /decentralized-cryptocurrency-exchanges.

Gord, Michael. 2016. "Smart Contracts Described by Nick Szabo 20 Years Ago Now Becoming Reality." *Bitcoin Magazine*, April 26. https://bitcoinmagazine.com/articles/smart-contracts-described-by -nick-szabo-years-ago-now-becoming-reality-1461693751.

Green, Edward J. 1987. "Lending and the Smoothing of Uninsurable Income." In *Contractual Arrangements for Intertemporal Trade*, 3–25. Edited by Edward C. Prescott and Neil Wallace. Minneapolis: University of Minnesota Press.

Green, Edward J. 1999. "Money and Debt in the Structure of Payments." *Federal Reserve Bank of Minneapolis Quarterly Review* 23 (Spring): 13–29.

Green, Edward J., and Ping Lin. 2003. "Implementing Efficient Allocations in a Model of Financial Intermediation," *Journal of Economic Theory* 109 (1): 1–23.

Green, Edward J., and Soo-Nam Oh. 1991. "Contracts, Constraints, and Consumption." *Review of Economic Studies* 58 (5): 883–899.

Green, Edward J., and Ruilin Zhou. 2005. "Money as a Mechanism in a Bewley Economy." *International Economic Review* 46 (2): 351–371.

Greenwood, Robin, Samuel G. Hanson, and Jeremy C. Stein. 2016. "The Federal Reserve's Balance Sheet as a Financial-Stability Tool." In 2016 Economic Policy Symposium Proceedings. Jackson Hole: Federal Reserve Bank of Kansas City.

Griffin, John, and Amin Shams. 2018. "Is Bitcoin Really Un-Tethered?" University of Texas at Austin Working Paper.

Güntzer, Michael M., Dieter Jungnickel, and Matthias Leclerc. 1998. "Efficient Algorithms for the Clearing of Interbank Payments." *European Journal of Operational Research* 106 (1): 212–219.

Halpern, Joseph Y., and Yoram Moses. 1990. "Knowledge and Common Knowledge in a Distributed Environment." *Journal of the Association for Computing Machinery* 37 (3): 549–587.

Harford, Tim. 2017. "What Tally Sticks Tell Us about How Money Works." *BBC.com*, July 10. https://www.bbc.com/news/business-40189959.

Harris, Milton, and Artur Raviv. 1979. "Optimal Incentive Contracts with Imperfect Information." *Journal of Economic Theory* 20 (2): 231–259.

Harris, Milton, and Robert M. Townsend. 1981. "Resource Allocation under Asymmetric Information." *Econometrica* 49 (1): 33–64.

Hart, Oliver, and John Moore. 2007. "Incomplete Contracts and Ownership: Some New Thoughts." *American Economic Review* 97 (2): 182–186. Helix Institute of Digital Finance. 2017. "Agent Network Accelerator Research: Indonesia Country Report." https://www.microsave.net/wp-content/uploads/2018/12/ANA-Indonesia.pdf.

Hendershott, Terrence, and Ananth Madhavan. 2015. "Click or Call: Auction vs. Search in the OTC Market." *Journal of Finance* 70 (1): 419–447.

Hinzen, Franz J., Kose John, and Fahad Saleh. 2019. "Proof-of-Work's Limited Adoption Problem." NYU Stern School of Business Working Paper.

Holden, Richard, and Anup Malani. 2018. "Can Blockchains Solve the Holdup Problem in Contracts?" Becker-Friedman Institute, University of Chicago, Working Paper No. 2018–12.

Huggett, Mark, and Greg Kaplan. 2015. "How Large Is the Stock Component of Human Capital?" NBER Working Paper 21238.

Hussam, Reshmaan, Natalia Rigol, and Benjamin Roth. 2017. "Targeting High Ability Entrepreneurs Using Community Information: Mechanism Design in the Field." Harvard University Working Paper.

Iansiti, Marco, and Karim R. Lakhani. 2017. "The Truth about Blockchain." *Harvard Business Review* 95 (1): 118–127.

IBM. 2019. "Hyperledger Fabric: The Flexible Blockchain Framework That's Changing the Business World," https://www.ibm.com /blockchain/hyperledger.

Ingves, Stefan. 2016. "Efficient Payment Systems and the Riksbank's Approach to Cash Distribution." Money and Banking Conference, Central Bank of Argentina.

Inveniam Capital Partners. 2019. "Update: WeWork, NDSU Housing, Cape at Savona, Impact Africa, and Takenization." YouTube video, 39:16, June 19. https://www.youtube.com/watch?v=DEsQegxLjBk.

IPFS. 2019. "IPFS Powers the Distributed Web." https://ipfs.io/.

Jack, William, and Tavneet Suri. 2011. "Mobile Money: The Economics of M-PESA." NBER Working Paper No. 16721.

Jack, William, and Tavneet Suri. 2014. "Risk Sharing and Transactions Costs: Evidence from Kenya's Mobile Money Revolution." *American Economic Review*, 104 (1): 183–223.

Jack, William, Tavneet Suri, and Robert M. Townsend. 2010. "Monetary Theory and Electronic Money: Reflections on the Kenyan Experience." *Economic Quarterly* 96 (1): 83–122. Jacklin, Charles J. 1987. "Demand Deposits, Trading Restrictions, and Risk Sharing." In *Contractual Arrangements for Intertemporal Trade*, 26–47. Edited by Edward C. Prescot and Neil Wallace. Minneapolis: University of Minnesota Press.

Janin, Simon, Arthur Gervais, and Akaki Mamageishvili. 2019. "File-Bounty: Secure and Efficient File Exchange in a Rational Adversarial Environment." ETH Zurich Working Paper.

Joaquim, Gustavo, Robert M. Townsend, and Victor Zhorin. 2018. "Optimal Contracting and Imperfect Competition among Financial Service Providers." MIT Working Paper.

Kaboski, Joseph P., and Robert M. Townsend. 2011. "A Structural Evaluation of Large-Scale Quasi-experimental Microfinance Initiative." *Econometrica* 79 (5): 1357–1406.

Kaboski, Joseph P., and Robert M. Townsend. 2012. "The Impact of Credit on Village Economies." *American Economic Journal: Applied Economics* 4 (2): 98–133.

Kaplan, Greg, and Giovanni L. Violante. 2014. "A Model of the Consumption Response to Fiscal Stimulus Payments." *Econometrica* 82 (4): 1199–1239.

Karaivanov, Alexander, and Robert M. Townsend. 2014. "Dynamic Financial Constraints: Distinguishing Mechanism Design from Exogenously Incomplete Regimes." *Econometrica* 82 (3): 887–959.

Kareken, John, and Neil Wallace. 1981. "On the Indeterminacy of Equilibrium Exchange Rates." *Quarterly Journal of Economics* 96 (2): 207–222.

Kehoe, Timothy J., David K. Levine, and Michael Woodford. 1990. "The Optimum Quantity of Money Revisited." Federal Reserve Bank of Minneapolis Working Paper 404.

Kestenbaum, David. 2012. "The Accountant Who Changed the World." *All Things Considered*, National Public Radio (NPR), broadcast October 4.

Kilenthong, Weerachart T., and Robert M. Townsend. 2018. "A Market Based Solution for Fire Sales and Other Pecuniary Externalities." MIT Working Paper.

Kim, Kyungmin. 2015. "Summary of 'Money and the Decentralization of Exchange' and Some Comments." Board of Governors of the Federal Reserve System Working Paper. Kimberley, David. 2019. "MAS and Bank of Canada Complete Blockchain Payments Test." *Finance Magnates*, February 5. https:// www.financemagnates.com/fintech/payments/mas-and-bank-of -canada-complete-blockchain-payments-test.

Kinnan, Cynthia, Krislert Samphantharak, Robert M. Townsend, and Diego Vera-Cossio. 2018. "Networks and Risk Sharing in Village Economies." MIT Working Paper.

Kinnan, Cynthia, and Robert Townsend. 2012. "Kinship and Financial Networks, Formal Financial Access, and Risk Reduction." *American Economic Review* 102 (3): 289–293.

Klein, Benjamin. 1976. "Competing Monies: Comment." *Journal of Money* 8 (4): 512–519.

Kocherlakota, Narayana R. 1998. "Money Is Memory." Journal of Economic Theory 81 (2): 232–251.

Krishnamurthy, Arvind, and Annette Vissing-Jorgensen. 2012. "The Aggregate Demand for Treasury Debt." *Journal of Political Economy* 120 (2): 233–267.

Kuussaari, Harri. 1996. "Systemic Risk in the Finnish Payment System: An Empirical Investigation." Bank of Finland Discussion Paper No. 3/96.

Lagos, Ricardo, and Randall Wright. 2005. "A Unified Framework for Theory and Policy Analysis." *Journal of Political Economy* 113 (3): 463–484.

Lagos, Ricardo, and Shengxing Zhang. 2018. "Turnover Liquidity and the Transmission of Monetary Policy." Federal Reserve Bank of Minneapolis Working Paper No. 734.

Lamport, Leslie, Robert Shostak, and Marshall Pease. 1982. "The Byzantine Generals Problem." *ACM Transactions on Programming Languages and Systems* 4 (3): 382–401.

Lehnert, Andreas, Ethan Ligon, and Robert M. Townsend. 1999. "Liquidity Constraints and Incentive Contracts." *Macroeconomic Dynamics* 3 (1): 1–47.

Leong, Nicholas. 2017. "Remittances Are Ripping Off Migrant Workers in ASEAN." *EastAsiaForum.org*, reposted to Eaber.org. November 8. http://www.eaber.org/node/26610.

Levine, David K. 1989. "Efficiency and the Value of Money." *Review* of *Economic Studies* 56 (1): 77–88.

Li, Dan, and Norman Schürhoff. 2012. "Dealer Networks: Market Quality in Over-the-Counter Markets." Federal Reserve Bank of New York Working Paper.

Ligon, Ethan, Jonathan P. Thomas, and Tim Worrall. 2002. "Informal Insurance Arrangements with Limited Commitment: Theory and Evidence from Village Economies." *Review of Economic Studies* 69 (1): 209–244.

Lim, Youngjae, and Robert M. Townsend. 1998. "General Equilibrium Models of Financial Systems: Theory and Measurement in Village Economies." *Review of Economic Dynamics* 1 (1): 59–118.

Lucas, Robert E., and Nancy L. Stokey. 1983. "Optimal Fiscal and Monetary Policy in an Economy without Capital." *Journal of Monetary Economics* 12 (1): 55–93.

Lumenauts.com. 2018. "How the Stellar Consensus Protocol (Federated Byzantine Agreement) Works." YouTube video, 9:43, April 18. https://www.youtube.com/watch?v=X3Gj2nQZCNM.

Lyon, Richard K. 1996. "Optimal Transparency in a Dealer Market with an Application to Foreign Exchange." *Journal of Financial Intermediation*, 5 (3): 225–254.

Makerdao.com. 2017. "The Dai Stablecoin System." White Paper (December). https://makerdao.com/whitepaper/Dai-Whitepaper-Dec17 -en.pdf.

Makerdao.com. 2019. "Dai 1.0: Introduction, Stability, Core, CLI, Query API." https://developer.makerdao.com/dai/1/

Makowski, Louis. 1980. "A Characterization of Perfectly Competitive Economies with Production," *Journal of Economic Theory* 22 (2): 208–221.

Mallett, Jacky. 2009. "Limits on the Communication of Knowledge in Human Organisations." *Studies in Emergent Order* 2: 1–18.

Mallett, Jacky. 2019. Personal correspondence, January.

Manuelli, Rodolfo, and Thomas J. Sargent. 1988. "Longer Trading Periods in a Townsend Turnpike Model." Stanford University Working Paper.

Manuelli, Rodolfo, and Thomas J. Sargent. 2010. "Alternative Monetary Policies in a Turnpike Economy." *Macroeconomic Dynamics* 14 (5): 727–762.

Martin, Antoine, Michael Lee, and Robert Townsend. 2017. Personal correspondence, December.

Martin, Antoine, and James McAndrews. 2008. "An Economic Analysis of Liquidity-Saving Mechanism." *Economic Policy Review* 14 (2): 25–39.

Martin, Antoine, David Skeie, and Ernst-Ludwig von Thadden. 2013. "The Fragility of Short-term Secured Funding Markets." Federal Reserve Bank of New York Staff Reports No. 630.

Martin, Antoine, David Skeie, and Ernst-Ludwig von Thadden. 2014. "Repo Runs." *Review of Financial Studies* 27 (4): 957–989.

Maskin, Eric, and Jean Tirole. 1999. "Unforeseen Contingencies and Incomplete Contracts." *Review of Economic Studies* 66 (1): 83–114.

Mazieres, David. 2016. "The Stellar Consensus Protocol: A Federated Model for Internet-level Consciousness." *Stellar.org*, February 25. https://assets.website-files.com/5deac75ecad2173c2cccbc7/5d f2560fba2fb0526f0ed55f_stellar-consensus-protocol.pdf.

McAndrews, James, and William Roberds. 1999. "Payment Intermediation and the Origins of Banking." Federal Reserve Bank of Atlanta Working Paper No. 99–11.

Miller, Merton H., and Daniel Orr. 1966. "A Model of the Demand for Money by Firms." *Quarterly Journal of Economics* 80: 413–435.

Mills, David, Kathy Wang, Brendan Malone, Anjana Ravi, Jeff Marquardt, Clinton Chen, Anton Badev, Timothy Brezinski, Linda Fahy, Kimberley Liao, Vanessa Kargenian, Max Ellithorpe, Wendy Ng, and Maria Baird. 2016. "Distributed Ledger Technology in Payments, Clearing, and Settlement." Federal Reserve Board Finance and Economics Discussion Series No. 2016–095.

Monetary Authority of Singapore. 2018. "Cross-Border Interbank Payments and Settlements: Emerging Opportunities for Digital Transformation." Project Report. Accessed March 22, 2019. https://www .mas.gov.sg/-/media/MAS/ProjectUbin/Cross-Border-Interbank-Pay ments-and-Settlements.pdf.

Monetary Authority of Singapore and the Association of Banks in Singapore. 2017. "Project Ubin Phase 2: Re-imagining Interbank Real-Time Gross Settlement System Using Distributed Ledger Technologies." Accessed November 15, 2018. https://www.accenture.com /t20171116T081243Z_w_/sg-en/_acnmedia/PDF-66/Accenture -Project-Ubin-Phase-2.pdf.

Monnet, Cyril, and Thomas Nellen. 2014. "The Collateral Costs of Clearing." Swiss National Bank (SNB) Working Paper 4/2014.

Moore, John. 1992. "Implementation, Contracts, and Renegotiation in Environments with Complete Information." In *Advances in Economic Theory: Sixth World Congress, Volume 1*, 182–282. Edited by Jean-Jacques Laffont. Cambridge: Cambridge University Press.

Moore, John, and Rafael Repullo. 1988. "Subgame Perfect Implementation," *Econometrica* 56 (5): 1191–1220.

Moore, John, and Rafael Repullo. 1990. "Nash Implementation: A Full Characterization." *Econometrica* 58 (5): 1083–1099.

Morris, David Z. 2019. "Tether Now Admits It's Not Fully Backed by Dollars." *Breakermag*, March 14. https://breakermag.com/tether -now-admits-its-not-fully-backed-by-dollars/.

Morris, Stephen, and Hyun Song Shin. 1997. "Approximate Common Knowledge and Co-ordination: Recent Lessons from Game Theory." *Journal of Logic, Language, and Information* 6: 171–190.

Moskov, Phillip. 2018. "What Is Bit Gold? The Brainchild of Blockchain Pioneer Nick Szabo." *Coincentral.com*, May 22. https://coincentral .com/what-is-bit-gold-the-brainchild-of-blockchain-pioneer-nick -szabo/.

Muley, Ameya. 2016. "Collateral Reuse in Shadow Banking and Monetary Policy." MIT Job Market Paper.

Myerson, Roger B. 1982. "Optimal Coordination Mechanisms in Generalized Principal-Agent Problems." *Journal of Mathematical Economics* 10 (1): 67–81.

Myerson, Roger B. 1986. "Multistage Games with Communication." *Econometrica* 54 (2): 323–358.

Nakamoto, Satoshi. 2008. "Bitcoin: A Peer-to-Peer Electronic Cash System." White Paper. Accessed October 28, 2018. https://bitcoin.org /bitcoin.pdf.

Narayanan, Arvind, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. 2016. *Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction*. Princeton, NJ: Princeton University Press.

Narayanan, Arvind, and Matt Weinberg. 2018. "Survey of Algorithmic Game Theory Research Questions for Crypto/Blockchain." Lecture presented at "Cryptocurrencies and Blockchains," Becker-Friedman Institute, University of Chicago, November. Ostroy, Joseph M., and Ross M. Starr. 1974. "Money and the Decentralization of Exchange." *Econometrica* 42 (6): 1093–1113.

Palfrey, Thomas R., and Sanjay Srivastava. 1989. "Mechanism Design with Incomplete Information: A Solution to the Implementation Problem." *Journal of Political Economy* 97 (3): 668–691.

Paweenawat, Archawa, and Robert M. Townsend. 2012. "Village Economic Accounts: Real and Financial Intertwined." *American Economics Review* 102 (3): 441–446.

Paweenawat, Archawa, and Robert M. Townsend. 2018. "The Impact of Regional Isolationism: Disentangling Real and Financial Factors." MIT Working Paper.

Payments Canada. 2017. "Project Jasper: A Canadian Experiment with Distributed Ledger Technology for Domestic Interbank Payments Settlement." Payments Canada, Bank of Canada, and R3 White Paper (September 29). Accessed on October 19, 2018. https://www .payments.ca/sites/default/files/29-Sep-17/jasper_report_eng.pdf.

Pesendorfer, Wolfgang. 1995. "Financial Innovation in a General Equilibrium Model." *Journal of Economic Theory* 65 (1): 79–116.

Phelan, Christopher, and Robert M. Townsend. 1991. "Computing Multiperiod Information Constrained Optima." *Review of Economic Studies* 58 (5): 853–883.

Piazzesi, Monika, and Martin Schneider. 2018. "Payments, Credit, and Asset Prices." Stanford University Working Paper.

Prat, Julien, and Benjamin Walter. 2018. "An Equilibrium Model of the Market for Bitcoin Mining." École Polytechnique Working Paper.

Prescott, Edward C., and Robert M. Townsend. 1984a. "Pareto Optima and Competitive Equilibria with Adverse Selection and Moral Hazard." *Econometrica* 52 (1): 21–45.

Prescott, Edward C., and Robert M. Townsend. 1984b. "General Competitive Analysis in an Economy with Private Information." International Economic Review 25 (1): 1–20.

Prescott, Edward S. 2003. "Communication in Private-Information Models: Theory and Computation." *Geneva Papers on Risk and Insurance Theory* 28 (2): 105–130.

Prescott, Edward S., and Robert M. Townsend. 2006a. "Firms as Clubs in Walrasian Markets with Private Information." Journal of Political Economy 114 (4): 644–671. Prescott, Edward S., and Robert M. Townsend. 2006b. "Private Information and Intertemporal Job Assignments." *Review of Economic Studies* 73 (2): 531–548.

Ray, Shaan. 2017. "Blockchains versus Traditional Databases." *Emerging Technology Blog, HackerNoon.com*, November 5. https://hackernoon.com/blockchains-versus-traditional-databases-c1a7281 59f79.

Ray, Shaan. 2018. "Federated Byzantine Agreement." *Emerging Technology Blog, TowardsDataScience.com*, April 8. https://towardsdatascience.com/federated-byzantine-agreement-24ec57bf36e0.

Reese, Frederick. 2017. "Land Registry: A Big Blockchain Explored." *CoinDesk*, April 19. www.coindesk.com/blockchain-land-registry-solu tion-seeking-problem/.

Roberts, John Jeff. "Facebook's Project Libra: 5 Things to Know about the Cryptocurrency." *Fortune*, June 18. https://fortune.com/2019/06/18/facebook-project-libra-crypto-coin-cryptocurrency-how-it-works/.

Robinson, Henry. 2009. "Barbara Liskov's Turing Award, and Byzantine Fault Tolerance." *The Paper Trail Blog*, March 30. https://www .the-paper-trail.org/post/2009-03-30-barbara-liskovs-turing-award -and-byzantine-fault-tolerance/.

Rogoff, Kenneth S. 2016. *The Curse of Cash*. Princeton, NJ: Princeton University Press.

Roth, Benjamin N., and Ran I. Shorrer. 2017. "Making It Safe to Use Centralized Marketplaces: Dominant Individual Rationality and Applications to Market Design." Harvard Business School Working Paper.

Ru, Hong, and Robert M. Townsend. 2018. "Narrowing the GAP: The Costly State Verification Regime in Rural Thailand." MIT Working Paper.

Rubinstein, Ariel. 1989. "The Electronic Mail Game: Strategic Behavior under 'Almost Common Knowledge." *American Economic Review* 79 (3): 385–391.

Samphantharak, Krislert, Scott Schuh, and Robert M. Townsend. 2016. "Integrated Household Surveys: An Assessment of US Methods and an Innovation." Federal Reserve Bank of Boston Working Paper.

Samphantharak, Krislert, and Robert M. Townsend. 2009. Households as Corporate Firms: An Analysis of Household Finance Using Integrated Constructing Financial Statements from Integrated Household Surveys and Corporate Financial Accounting. Econometric Society Monograph Series. Cambridge: Cambridge University Press.

Samphantharak, Krislert, and Robert M. Townsend. 2018. "Risk and Return in Village Economies." *American Economic Journal-Microeconomics* 10 (1): 1–40.

Samuelson, Paul A. 1958. "An Exact Consumption-Loan Model of Interest with or without the Social Contrivance of Money." *Journal of Political Economy* 66 (6): 467–482.

Schilling, L., and Harald Uhlig. 2018. "Some Simple Bitcoin Economics." Becker Friedman Institute for Research in Economics Working Paper No. 2018–21.

Schmandt-Besserat, Denise. 2014. "Tokens: Their Significance for the Origin of Counting and Writing." *UTexas.edu*. Accessed January 29, 2019. https://sites.utexas.edu/dsb/tokens/tokens/.

Schuh, Scott, and Joanna Stavins. 2014. "The 2011 and 2012 Surveys of Consumer Payment Choice." Federal Reserve Bank of Boston Research Data Report No. 14–1.

Schuster, Brian. 2017. "The Ripple Currency Problem: Why Permissioned Blockchains Will Devalue XRP." *Hackernoon.com*, December 4. https://hackernoon.com/the-ripple-currency-problem-why-permissioned-blockchains-will-devalue-xrp-d79aef84c074.

Sharma, Toshendra Kumar. 2019. "Quorum vs. Hyperledger: The Ultimate Guide." Blockchain Council, May 15. https://www.blockchain -council.org/hyperledger/quorum-vs-hyperledger-the-ultimate-guide/.

Shin, Hyun Song. 2018. "Cryptocurrencies and the Economics of Money." Speech given at Bank for International Settlements, Annual General Meeting, Basel, June 24.

Singh, Manmohan. 2011. "Velocity of Pledged Collateral: Analysis and Implications." International Monetary Fund Working Paper.

Skingsley, Cecilia. 2016. "Should the Riksbank Issue e-Krona?" Lecture presented at FinTech Stockholm/Berns, Sweden, November 16.

Spear, Stephen E., and Sanjay Srivastava. 1987. "On Repeated Moral Hazard with Discounting." *Review of Economic Studies* 54 (4): 599–617.

Spector, Mariano, and Robert Townsend. 2019. "Notes on the Townsend Wallace Coordination Problem." MIT Research Notes.

Sprague, Oliver M. W. 1910. "History of Crises under the National Banking System." National Monetary Commission (1910 [1968]), 51st Cong., 2nd Sess., Senate Document No. 538.

Sripakdeevong, Parit, and Robert M. Townsend. 2018. "The Village Money Market Revealed: Credit Chains and Shadow Banking." MIT Working Paper.

Starr, Ross M. 1974. "The Price of Money in a Pure Exchange Monetary Economy with Taxation," *Econometrica* 42 (1): 45–54.

Suri, Tavneet. 2017. "Mobile Money." Annual Review of Economics 9: 497–520.

Sveriges Riksbank. 2018. "Payment Patterns in Sweden 2018." *Riksbank.se* (May). https://www.riksbank.se/globalassets/media/statistik /betalningsstatistik/2018/payments-patterns-in-sweden-2018.pdf.

Swedish Post and Telecom Authority. 2017. "Grundläggande betaltjänster i en digitaliserad framtid [Essential Payment Services in a Digitalised Future]." Swedish Post and Telecom Authority Report No. PTS-ER-2017:20 (December 1). https://www.pts.se/globalassets/start page/dokument/icke-legala-dokument/rapporter/2017/post/grundlag gande-betaltjanster-i-en-digitaliserad-framtid---pts-er-2017_20.pdf.

Szabo, Nick. 1998. "Secure Property Titles with Owner Authority." Satoshi Nakamoto Institute. Accessed February 19, 2019. https:// nakamotoinstitute.org/secure-property-titles/.

Tirole, Jean. 1985. "Asset Bubbles and Overlapping Generations." *Econometrica* 53 (6): 1499–1528.

Tobin, James. 1978. "Discussion." In Models of Monetary Economies: Proceedings and Contributions from Participants of a December 1978 Conference, 83–90. Minneapolis: Federal Reserve Bank of Minneapolis.

Townsend, Robert M. 1977. "The Eventual Failure of Price Fixing Schemes." *Journal of Economic Theory* 14 (3): 190–199.

Townsend, Robert M. 1978. "Intermediation with Costly Bilateral Exchange." *Review of Economic Studies* 45 (3): 417–425.

Townsend, Robert M. 1979. "Optimal Contracts and Competitive Markets with Costly State Verification." *Journal of Economic Theory* 21 (2): 265–293.

Townsend, Robert M. 1980. "Models of Money with Spatially Separated Agents." In *Models of Monetary Economies*, 265–303. Edited

by John Kareken and Neil Wallace. Minneapolis: Federal Reserve Bank of Minneapolis.

Townsend, Robert M. 1982. "Optimal Multiperiod Contracts and the Gain from Enduring Relationships under Private Information." *Journal of Political Economy* 90 (6): 1166–1186.

Townsend, Robert M. 1987. "Economic Organization with Limited Communication." *American Economic Review* 77 (5): 954–971.

Townsend, Robert M. 1988. "Information Constrained Insurance: The Revelation Principle Extended." *Journal of Monetary Economics* 21 (2/3): 411–450.

Townsend, Robert M. 1989. "Currency and Credit in a Private Information Economy." *Journal of Political Economy* 97 (6): 1323–1344.

Townsend, Robert M. 1990. Financial Structure and Economic Organization. Cambridge, MA: Blackwell.

Townsend, Robert M. 2016. "Village and Larger Economies: The Theory and Measurement of the Townsend Thai Project." *Journal of Economic Perspectives* 30 (4): 199–220.

Townsend, Robert M. 2019. "Online Appendix: Distributed Ledgers." http://www.robertmtownsend.net/research/online-appendix.

Townsend, Robert M., and Neil Wallace. 1987. "Circulating Private Debt: An Example with a Coordination Problem." In *Contractual Arrangements for Intertemporal Trade*. Edited by Edward C. Prescott and Neil Wallace. Minneapolis: University of Minnesota Press.

Townsend, Robert, and Juan Pablo Xandri. 2018. "Regulation and the Optimal Design of Financial Markets." MIT Working Paper.

Townsend Thai Project. 2019. In cooperation with the National Bureau of Economic Research. http://townsend-thai.mit.edu/.

Trubek, Anne. 2015. "What the Heck Is Cuneiform, Anyway?" *SmithsonianMag.com*, October 20. https://www.smithsonianmag.com/history /what-heck-cuneiform-anyway-180956999/#dcLC5HSIETSzgobb.03.

Tucker, Paul. 2014. "Are Clearing Houses the New Central Banks?" Over-the-Counter Derivatives Symposium, Chicago.

u/PumpkinFeet. 2018. "What Is the Difference between Normal Byzantine Fault Tolerance and Practical BFT, Asynchronous BFT, Delegated BFT etc.? And Which Coins Use Which One? How Do They Relate to PoW and PoS etc?" *Reddit*, r/CrytoTechnology. https:// www.reddit.com/r/CryptoTechnology/comments/8782mb/what _is_the_difference_between_normal_byzantine/.

Vera-Cossio, Diego A. 2018. "Targeting Credit through Community Members." University of California, San Diego, Working Paper.

Wallace, Neil. 2014. "Optimal Money Creation in 'Pure Currency' Economies: A Conjecture." *Quarterly Journal of Economics* 129 (1): 259–274.

Wikipedia. 2018a. "Informal Value Transfer System." Accessed November 6, 2018. https://en.wikipedia.org/w/index.php?title=Informal _value_transfer_system&oldid=840911091.

Wikipedia. 2018b. "Distributed Data Store." Accessed November 19, 2018. https://en.wikipedia.org/wiki/Distributed_data_store.

Wikipedia. 2019a. "CAP Theorem." Accessed November 17, 2019. https://en.wikipedia.org/wiki/CAP_theorem.

Wikipedia. 2019b. "Synchronization (Computer Science)." Accessed January 28, 2019. https://en.wikipedia.org/wiki/Synchronization.

Woodford, Michael. 1990. "Public Debt as Private Liquidity." American Economic Review 80 (2): 382–388.

Xandri, Juan Pablo. 2016. "Credible Reforms: A Robust Implementation Approach." Princeton University Working Paper.

XRP Ledger. 2019. "Run a Rippled Validator." https://xrpl.org/run-a -rippled-validator.html.

Zhang, Nicolas. 2019. Personal correspondence, August.