Network Dynamics of a Financial Ecosystem

Shahar Somin[1,2], Goren Gordon[2,3], Erez Shmueli[2],
Alex 'Sandy' Pentland[1], and Yaniv Altshuler[1,3]

[1]MIT Media Lab, Cambridge, MA, USA
[2]Industrial Engineering Department, Tel Aviv University, Israel
[3]Endor Ltd.
shaharso@media.mit.edu

Abstract

During the past decade, data-driven research has increased in an unprecedented scale across most scientific disciplines. Specifically, an abundance of research works has focused on the study and modeling of economic ecosystems (*1–5*). However, difficulties in acquiring empirical economic data, due to privacy control and regulatory limitations, pose great impediments to these endeavors. In particular, the scarcity of large-scaled user-level financial datasets hinder the appliance of network theory methods to financial ecosystems. The use of these recently developed methods proved great prominence in modeling behavioral dynamics in a variety of complex systems (*6–13*), suggesting they may also enable accurate modeling of economic markets.

In this work we suggest that the trading of cryptocurrency-tokens (*14–16*) on top of the Ethereum Blockchain (*17*), a publicly available financial dataset encompassing the individual financial activity of millions of different actors trading tens of thousands of varied assets, may be used as a testbed for such analysis. This financial ecosystem, of an overall market cap of 120 Billion USD to-date, is akin to countries like Spain or Italy in terms of number of participants, and to Hungary or the Ukraine in terms of total GPD. The main goal of our work is to establish that this new and evolving cryptocurrency-economy shares important properties and dynamics with the traditional one. We analyze this economy using a network theory approach, and demonstrate it displays an abundance of phenomena, known in existing literature to be characteristic of financial ecosystems, such as a power-law distribution of network degrees (*18–21*) and oscillating dynamics (*22, 23*), as can be seen in Fig. 1.

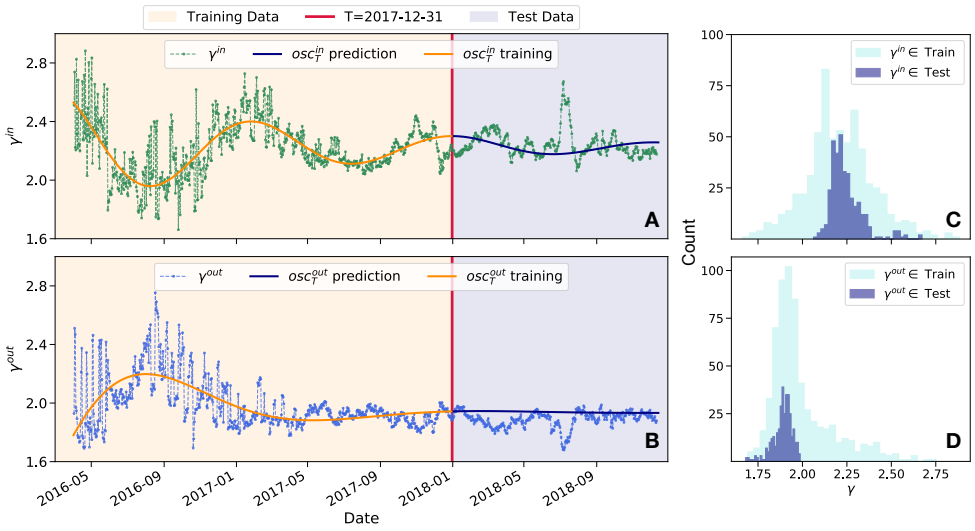

Figure 1: Cryptocurrency network evolution over time, demonstrating the underlying consolidation process the network's topology undergoes. Panels A and B depict the dynamics of incoming and outgoing degree distribution parameters γ_t^{in} and γ_t^{out} over time. Harmonic Under-Damped Oscillator models, OSC_T^{in} and OSC_T^{out}, are fitted to data up until T=31.12.2017 (left part of panels A and B), and their predictions for the following year are displayed in right part of panels A and B. Panels C and D present a comparison between the dispersion of γ_d^{in} and γ_d^{out} along training and test data.

This affinity between cryptocurrency-economy and the traditional economy, suggests that a better modeling of the latter could become possible through the use of high-granularity analytical approach on the former, where data is ample and abundant.

References

1. F. Schweitzer, *et al.*, *science* **325**, 422 (2009).
2. A. Barrat, M. Barthelemy, A. Vespignani, *Dynamical processes on complex networks* (Cambridge university press, 2008).
3. S. Battiston, *et al.*, *Science* **351**, 818 (2016).
4. M. Billio, M. Getmansky, A. W. Lo, L. Pelizzon, *Journal of financial economics* **104**, 535 (2012).
5. A. S. Pentland, *Harvard Business Review* **91**, 80 (2013).
6. R. Albert, A.-L. Barabási, *Reviews of modern physics* **74**, 47 (2002).
7. A.-L. Barabási, Linked: The new science of networks (2003).
8. A.-L. Barabasi, Z. N. Oltvai, *Nature reviews genetics* **5**, 101 (2004).
9. A. Barabasi, *Nature* **435**, 207 (2005).
10. A.-L. Barabási, *et al.*, *Network science* (Cambridge university press, 2016).
11. A.-L. Barabási, The elegant law that governs us all (2017).
12. M. E. Newman, *SIAM review* **45**, 167 (2003).
13. M. E. Newman, *Contemporary physics* **46**, 323 (2005).
14. M. Bartoletti, L. Pompianu, *International Conference on Financial Cryptography and Data Security* (Springer, 2017), pp. 494–509.
15. C. Catalini, J. S. Gans, Initial coin offerings and the value of crypto tokens, *Tech. rep.*, National Bureau of Economic Research (2018).
16. K. Christidis, M. Devetsikiotis, *IEEE Access* **4**, 2292 (2016).
17. V. Buterin, *et al.*, *white paper* (2014).
18. M. Boss, H. Elsinger, M. Summer, S. Thurner 4, *Quantitative finance* **4**, 677 (2004).
19. D. Garlaschelli, S. Battiston, M. Castri, V. D. Servedio, G. Caldarelli, *Physica A: Statistical Mechanics and its Applications* **350**, 491 (2005).
20. G. Iori, G. De Masi, O. V. Precup, G. Gabbi, G. Caldarelli, *Journal of Economic Dynamics and Control* **32**, 259 (2008).
21. E. Shmueli, Y. Altshuler, *et al.*, *International Conference on Social Computing, Behavioral-Cultural Modeling, and Prediction* (Springer, 2014), pp. 359–366.
22. R. Frisch, *et al.* (1933).
23. R. M. Goodwin, *The Dynamics of the Wealth of Nations* (Springer, 1993), pp. 300–310.