

*Assessing the Practicality and Utility of  
Decentralized Finance and Blockchain Technology Series*

**Some of the Challenges Facing DeFi for Mass Adoption**  
(Working Paper 1)

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**Abstract**

This is the first in a series of working papers examining the practicality and utility of decentralized finance and blockchain technology. In this initial paper, the authors present some of the forces driving the move to decentralized finance and blockchain technology as well as some of the challenges it faces for mass adoption. For the most part, the discussion is anecdotal, based primarily on the authors' more than seventy years of combined working experience in the financial services industry. Importantly, this discussion helps lay the foundation for a formal metric system presented by the authors in a subsequent working paper that can be used to assess the pros and cons of DeFi applications more rigorously from a variety of critical perspectives.

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We note at the outset that during the drafting of this first working paper, the cryptocurrency market has suffered a significant meltdown losing nearly \$1 trillion in value in just under a month.<sup>1</sup> However, we do not believe that we have to discuss this at length at this moment. In fact, many of the causes attributed to this collapse as well as the possible consequences are consistent with opinions set forth herein. Moreover, nothing has taken place to refute our options and conclusions. As such, we will address this meltdown in a future working paper after the markets have stabilized and the causes and ramifications are much clearer.

### **Preface**

Since the specifications of Bitcoin were published 2009,<sup>2</sup> decentralized finance (or simply “DeFi”) has received a great deal of attention in the press and academic journals. However, much of this has focused on business opportunities and potential benefits with little attention given to the many operational and technical challenges facing any new financial service paradigm, especially one that appears to be so radical.

In the following series of working papers, we attempt to better understand DeFi by applying a formal metric system to assess its potential utility and practicality as well as potential shortcomings and risks. We currently envision this series to consist of the following working papers:

- Working Paper 1. A qualitative assessment of the many challenges that DeFi applications face in order to achieve mass adoption;
- Working Paper 2. A proposed metric system for rigorously assessing the practicality and utility of DeFi applications from a number of perspectives;
- Working Paper 3. An examination of digital currency, cryptocurrency, and DeFi payment systems;
- Working Paper 4. An examination of DeFi lending applications;
- Working Paper 5. An examination of DeFi trading and investment management applications as well as other business applications;
- Working Paper 6. A general discussion to DeFi applications and blockchain technology from a technical and operational perspective; and
- Working Paper 7. A summary of the findings of the previous working papers with an eye to assessing the likelihood that DeFi will become a major force in the financial services industry.

With respect to working papers 3 through 5, they will generally stick to the following outline:

1. A review of the incumbent financial services in question, including key functionality and performance requirements that such a service must meet (if not exceed) in order to be widely adopted;
2. A review of DeFi applications currently providing such services, including a comparison to incumbent services;
3. A discussion of potential challenges that DeFi applications must overcome in order to be considered a viable alternative to incumbent services; and

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<sup>1</sup> Cf. <https://www.forbes.com/sites/billybambrough/2022/05/12/1-trillion-crypto-meltdown-huge-crash-wipes-out-the-price-of-bitcoin-ethereum-bnb-xrp-cardano-solana-terra-luna-and-avalanche/?sh=3dda4cb045fd> (accessed as May 22, 2022).

<sup>2</sup> Cf. <https://bitcoin.org/en/faq#general> (accessed March 3, 2022).

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4. A discussion of possible issues regarding regulatory oversight, risk management, and governance of such services delivered via a DeFi application.

To be clear, these working papers are not meant to be an exhaustive academic study of DeFi or its underlying technology. Moreover, most, if not all of the opinions, conclusions, and conjectures presented therein are based on the authors' firsthand, practical working experience in the financial services industry rather than rigorous, unbiased research. Regardless, it is our hope is that through these working papers, we can add some formalism to the subject that will provide other researchers and practitioners with a structured platform to help answer many of the questions raised in them.

Before starting, we offer a brief word on nomenclature used throughout these working papers. As with any new field of study, a common language has yet to be fully adopted, and multiple terms are often used to describe the same concepts. Further, there is generally also a significant difference in the language used by academics and financial services industry practitioners. In the case of DeFi, this is exacerbated by the fact that technologists and other DeFi advocates do not seem to be familiar with the terminology commonly used in the financial services industry and, as a result, have used new terminology to express well-established ideas. As a general rule, we have defaulted to the language commonly used in the financial services industry while noting other terminology where appropriate. To help alleviate this problem, we have also defined many of the key terms throughout the text which appear in bold, italic font.

Additionally, there are number of ambiguities in the literature concerning DeFi and blockchain technology. For instance, it is not clear from the literature what exactly the terms "central authority" and "transaction" mean, although these concepts are critical to any definition of DeFi. Even in the same paper they can be used ambiguously. Rather than trying to resolve these problems in these working papers, we have simply pointed out the ambiguity and some ramifications arising from the various definitions.

### **About the Authors**

Jeanette Jin and Peter Vinella have worked together for over twenty-five years and are currently managing directors at the consultancy, PVA Toucan International. Dr. Jin holds a Ph.D. in finance from Drexel University while Dr. Vinella holds a Ph.D. in mathematics from UC Berkeley. Together, they have more than 70 years of combined working experience in the financial services industry as senior executives at major financial institutions as well as consultants to leading financial institutions and government agencies around the world. During their careers, they have been at the forefront of many leading innovations in the financial services industry such as automated trading; quantitative risk management and analysis; complex derivatives; and structured financial products. They also been at the intersection of technology and finance having operated two software development companies and being among the first in the industry to employ distributed computing; relational database management systems and object-oriented programing; and real-time, fault-tolerant processing. Additionally, they have testified before the U.S. Congress and have worked with the Government Accountability Office (GAO) on a number of critical issues including derivatives regulation, the vulnerability of the U.S. financial system to terrorist attacks, and structured financial production. During their careers, they have also led major, multi-million-dollar technology projects for premier financial institutions around the globe including the central banks of Colombia and the Philippines, Citibank, Société Générale, ABM AMRO, Barclays, and Deutsche Bank. Currently, they provide expert testimony in the context of litigation and legal disputes involving major financial institutions, large corporations, and government agencies including several RMBS-, Madoff-, and Lehman Brothers-related matters.

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### **1.0 Introduction**

It is generally agreed that DeFi was born with the publication of Satoshi Nakamoto's seminal paper on cryptocurrency in 2009.<sup>3</sup> Since then, it has received a great deal of attention in both academic and industry literature. On its face, many of the goals of DeFi seem quite admirable – greater access to financial services, a more level playing field, lower costs to consumers, better levels of service, not limited to a specific legal or regulatory jurisdiction, etc. Some proponents have even gone as far as to claim that DeFi has the potential to revolutionize financial systems around the world, displacing many incumbent financial service providers in the process.<sup>4</sup>

Given its apparent potential, it is not surprising that there has been massive investment in DeFi-related opportunities recently. Indeed, in 2021 alone, venture capital funds invested \$30 billion in DeFi service providers, more than all the previous years combined.<sup>5 6</sup> Additionally, numerous academic institutions have launched DeFi/blockchain-related research centers in addition to offering accredited classes on the subject. This includes some of the top business and STEM (science, technology, engineering, and mathematics) universities in the world such as Harvard, MIT, Oxford, Princeton, Stanford, and UC Berkeley.<sup>7</sup>

Despite all of this excitement, DeFi still faces many obstacles before it can truly be widely adopted. Some of these of concern the practicality and overall utility of DeFi as a replacement for incumbent financial services. However, there are still many unanswered questions regarding DeFi suitability to be a true financial services paradigm.

In this initial working paper, we look at some of the motivations and guiding principles behind DeFi as well as some of the challenges it faces for achieving mass adoption with an eye to answering the following four basic questions:

1. Are the goals of DeFi truly desirable?
2. Are they achievable?
3. Will they, in fact, cure the many failings of the incumbent financial system?
4. Is DeFi the best agent for change or are there better service paradigms?

We begin with a brief review of decentralized finance to put this analysis in context.<sup>8</sup>

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<sup>3</sup> *Id.*

<sup>4</sup> For instance, Bitcoin, believed to be the first and most successful DeFi application, was designed explicitly to disintermediate central banks by introducing a global currency absent any government guarantee and, hence, absent any government involvement or oversight.

<sup>5</sup> *Cf.* <https://www.bloomberg.com/news/articles/2021-12-19/ftx-moonpay-axie-lead-crypto-firms-attracting-record-30-billion-in-2021?srnd=markets-vp> (accessed March 10, 2022).

<sup>6</sup> This has created somewhat of a moral dilemma for some, since VC funding conflicts with the democratization ethos of decentralized finance (*cf.* <https://www.denverstartupweek.org/articles/466-three-reasons-venture-capital-and-decentralized-finance-don-t-mix> (accessed March 10, 2022)).

<sup>7</sup> <https://pll.harvard.edu/course/introduction-blockchain-and-bitcoin?delta=0>, <https://dci.mit.edu/courses>, [https://cdn.www.getsmarter.com/uploads/course/info\\_pack/115/oxford\\_blockchain\\_strategy\\_programme\\_prospectus.pdf](https://cdn.www.getsmarter.com/uploads/course/info_pack/115/oxford_blockchain_strategy_programme_prospectus.pdf), <https://www.princeton.edu/news/2022/03/10/venture-forward-gift-launches-initiative-blockchain-and-decentralization-power>, <https://online.stanford.edu/courses/csp-xtech03-introduction-cryptocurrency-and-decentralized-finance-bitcoin-ethereum-nfts>, and <https://haas.berkeley.edu/blockchain/about-us/online-resources/> (all accessed March 10, 2022)

<sup>8</sup> Note that in this initial working paper, we simply introduce some basic concepts and ideas underlying DeFi and finance generally and defer most of the formal definitions until the next working paper.

## 2.0 Elements of Decentralized Finance

Over the past few decades, the many weaknesses in traditional financial systems have become readily apparent. These weaknesses has led to a general distrust in the current financial system on the part of consumers, which has been amplified by the technology-savvy millennials' growing disillusionment of the *status quo* generally. Consequently, it is not surprising that a number of new financial service providers outside of the mainstream have appeared over the past few years offering new services as well as using new ways to deliver existing services. The term, *alternative finance*, is often used to describe such service providers and the products and services they provide.

DeFi is an extreme form of alternative finance which essentially operates outside of the mainstream financial system (as opposed to integrated within it). As such, DeFi represents a disruptive innovation that has the potential to fundamentally change the financial services industry. To be precise, we define *DeFi* as the collection of alternative financial services which have the two distinct properties:

1. They that do not require a *central authority* in order to operate; and
2. They are built and operate on blockchain networks.<sup>9</sup>

We note that there is some ambiguity concerning both of these properties. For instance, some proponents use the term “central authority” to refer to a financial intermediary or some other body which oversees and supervises the delivery and/or use of a DeFi application (*i.e.*, a governing body).<sup>10</sup> Others use the term to indicate that DeFi application has multiple sources of authoritative data as opposed to a single source (*i.e.*, *single source of truth*). Clearly, these are very distinct properties with significantly different ramifications on the nature and delivery of a DeFi application.

Rather than trying to resolve this, for the purpose of these working papers, we simply define a *central authority* as an organization which:

1. Governs the use and operations of a financial service; and/or
2. Processes multiple, public sources of truth for such a service outside the control of a single governing body.

Similarly, it is unclear just to what extent blockchain technology must be used in the delivery of a DeFi application. There is some agreement that blockchain technology should be used to store financial data generated by the application typically in the form of fully replicated, open ledger. However, there are many types of ledgers used in financial services applications, and it is not clear if all of these must be implemented using blockchain technology. Additionally, some applications operate on private networks or hybrids between public and private networks. Again, we defer any discussion on the exact use of blockchain technology in a DeFi application and simply accept that any use of blockchain technology meets the requirement of a DeFi application.

With that in mind, we begin our review of DeFi with look to some of the factors driving its explosion.

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<sup>9</sup> There is some confusion regarding the use of the term, “blockchain.” It is used to describe a type of database architecture, a database management system (“DBMS”) employing a blockchain architecture, the blockchain DMBS along with nodes and network upon which it operates, and even a specific instantiation of the latter (*e.g.*, the Bitcoin blockchain). Where appropriate, we will add the necessary clarification.

<sup>10</sup> Throughout these working papers, we use the term, “delivery” in the context of “service delivery” to mean the actions associated with developing, maintaining, operating, and administrating that service.

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### **2.1 Drivers of DeFi**

There are many catalysts behind growing interest in DeFi. As mentioned above, this is partly due to the many problems that have arisen in mainstream financial systems around the world over the past few decades. Additionally, technology innovation has enabled new services and service delivery methods that appear to be cheaper and more effective than the incumbents, especially those targeting the poor and disenfranchised. In this section, we review a few of these drivers from a purely qualitative perspective.

#### **2.1.1 Consumer Dissatisfaction**

In many ways, the rise of DeFi parallels that of populist political movements of the past decade or so. While diametrically opposed in their overall political views, both the “Tea Party” on the right and “Occupy Wall Street” on the left believed that the average American was being oppressed by the government, large financial institutions, and the “1 percent”, those individuals whose net worth currently exceeds \$45 trillion.<sup>11</sup> And it is true that consumers, especially the poor and disenfranchised, have legitimate cause for believing that the financial system does not work for them, especially in light of ever-growing wealth inequality. As such, it is understandable that consumers simply do not trust the financial system to work in their interest.

Proponents of DeFi have capitalized on this consumer dissatisfaction and general lack of trust in the financial system. Citing from the Ethereum website, some of the cited short-comings of the *status quo* include:<sup>12</sup>

1. Some people aren't granted access to set up a bank account or use financial services.
2. Lack of access to financial services can prevent people from being employable.
3. Financial services can block you from getting paid.
4. A hidden charge of financial services is your personal data.
5. Governments and centralized institutions can close down markets at will.
6. Trading hours often limited to business hours of specific time zone.
7. Money transfers can take days due to internal human processes.
8. There's a premium to financial services because intermediary institutions need their cut.

While some of these are legitimate, on its face, this list is a weird, somewhat random collection of complaints apparently targeting two distinct groups: those with little or no access to traditional financial services and those with a bent toward conspiracy theories, especially those involving government overreach and control. Moreover, it is hard to see how this list of grievances (many of which are misleading or plain wrong) points to significant business opportunities, and certainly none are on par with the excitement that DeFi currently enjoys or the massive investment it is receiving.<sup>13</sup> Be that as it may, it

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<sup>11</sup> The “1 percent” moniker refers to the one percent of the U.S. population that controls nearly one-third of the nation’s wealth (cf. <https://www.cnbc.com/2022/04/01/richest-one-percent-gained-trillions-in-wealth-2021.html#:~:text=The%20total%20wealth%20of%20the%201%25%20reached%20a%20third%2C%20during%20the%20course%20of%20the%20pandemic.?msclkid=ad4c5a5bd08811ec8459164441d2402e> (accessed May 10, 2022)).

<sup>12</sup> Cf. <https://ethereum.org/en/defi/?msclkid=b9a069abd08b11ecb78a1fe4efdd405f> (accessed May 10, 2022).

<sup>13</sup> For instance, point four is a somewhat bizarre claim. While licensed financial institutions mine consumer data for a variety of reasons, they are prohibited by law and regulation from disclosing it (cf. <https://www.fincen.gov/resources/statutes-and-regulations/bank-secrecy-act> (accessed June 17, 2022)). On the

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is important to consider the proponents' view of DeFi as the “outsider” disrupting traditional finance services to understand its current overall appeal.

### **2.1.2 Structural Short-Comings of Incumbent Financial Systems**

Regardless of the specific complaints that consumers have about the current state of the financial system, there is certainly sufficient evidence that most, if not all financial systems around the world are far from perfect. A critical question is to what extent can DeFi lessen, if not altogether cure these shortcomings. In some case, some of the weaknesses are the result of specific laws, policies, and regulations that (intentionally or unintentionally) create various market inefficiencies and inequalities which we discuss in a future working paper. For the moment, however, we review some of the more telling problems that have come to light in mainstream financial systems over the last couple of decades or so.

**Existential Crises.** Over the last twenty-five years alone, numerous financial systems have faced truly existential crises, including (without limitation):

1. The Asian financial crisis in 1997 which lead to the introduction of the term, “financial contagion” (Zhong & Dowling, 2002);
2. The Russian ruble crisis in 1998 which rocked the global financial markets and lead to the collapse of a leading hedge fund, Long Term Capital Management even though Russian economy was quite small at the time;<sup>14</sup>
3. The bursting of the dotcom bubble and following global recession in 2000 (Goodnight & Green, 2010);
4. The terrorist attacks on 9/11 and the near collapse of the global financial system in the weeks immediately thereafter (Government Accountability Office, 2003);
5. The collapse of the Argentine Peso and general economy in 2002 that impacted most of South America (Feldstein, 2002);
6. The Icelandic financial crisis in 2008;<sup>15</sup>
7. The Spanish banking crisis from 2008-2015;<sup>16</sup>
8. The 2008 Global Financial Crisis following the bankruptcy of Lehman Brothers in September of that year (Verick & Islam, 2010);
9. The Irish banking crisis from 2008-2010 (Baudino, Murphy, & Svoronos, 2020);
10. The Great Recession of 2008-2009;<sup>17</sup> and
11. The near shutdown of the global economy due to COVID-19 restrictions starting in 2020 and are on-going (The World Bank, 2022).

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other hand, high-tech companies have faced severe criticism recently for the widely used practice of selling consumer data.

<sup>14</sup> Cf. <https://economics.rabobank.com/publications/2013/september/the-russian-crisis-1998/> (accessed April 21, 2022).

<sup>15</sup> Cf. <https://sevenpillarsinstitute.org/case-study-icelands-banking-crisis/> (accessed April 21, 2022).

<sup>16</sup> Cf. <https://southeusummit.com/europe/spain/revival-spains-banks-creates-recovery-model-europe/#:~:text=The%20History%20of%20the%20Spanish%20Banking%20Crisis%20Spain%E2%80%99s,Recession%2C%20Spanish%20housing%20prices%20rose%20by%20approximately%20200%25> (accessed April 21, 2022).

<sup>17</sup> Cf. <https://www.federalreservehistory.org/essays/great-recession-of-200709> (accessed April 21, 2022).



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We note that even though the direct causes were quite different, 9/11 and the collapse of Lehman Brothers demonstrated the extent to which a disruption in one sector of a particular financial system can quickly spread to the financial systems globally (*i.e.*, financial contagion).<sup>18</sup>

**Major Scandals.** Additionally, financial systems have been hit by a host of major scandals that have cost investors and consumers billions of dollars during that same time period.<sup>19</sup> These include:

1. The collapse of Enron in 2001 which rocked the global energy markets (Healy & Palepu, 2003);
2. The collapse of WorldCom in 2002 which represented some of the worst of the dotcom era (Sidak, 2003);
3. The Tyco accounting scandal which was uncovered in 2003 (Giroux, 2008);
4. The Refco bankruptcy in 2005 (Adams, 2010);
5. The Bernie Madoff Ponzi scheme which ran for years and was finally discovered in 2008 (Rhee, 2009);
6. The collapse of Lehman Brothers in September 2008 (Swedberg, 2010);
7. The government takeover of AIG September n 2008 (Congressional Oversight Panel, 2010);
8. The government takeover of Countrywide in 2008 (Freeman, Wells, & Wyatt, 2014);
9. The FDIC takeover of IndyMac Bank in 2008 (Office of the Inspector General, 2009);
10. The MF Global bankruptcy in 2011 (CRS Staff, 2013);
11. The Libor fixing scandal in 2012 (Hou & Skeie, 2014);
12. The foreign exchange trading conspiracy scandal in 2013 (Attreya, 2015);
13. The 1MDB scandal in 2015 (Md Ali, 2015); and
14. The General Electric accounting scandal which was uncovered in 2018 (Markopolos, 2019).

**Societal Inequalities.** The global financial systems, and the U.S. financial system in particular, have faced severe criticism regarding the lack of diversity, inclusion and fairness. For instance:

1. Market inefficiencies and competitive barriers due to government laws and regulations that give significant advantages to incumbent financial institutions;
2. The consolidation of financial institutions that are “too big to fail” and that thwart competition and innovation;
3. Globalization and its many downsides for poorer populations and countries;
4. The extreme wealth gap between rich nations and poor nations and between the top 1 percent and the rest of the population;
5. The severe lack of diversity in the senior management of major financial institutions;
6. The lack of access to financial services for people of color, women, the poor, the uneducated, and the like;
7. The *customer-competitor paradox* in which financial institutions essentially compete with their own customers; and
8. The heavy reliance on computer algorithms which tends to further disadvantage the already disenfranchised as well as increasing the consumers’ mistrust of the financial system generally.

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<sup>18</sup> For instance, following the collapse of Lehman Brothers, a number of leading financial institutions around the globe were nationalized or received direct and indirect government bailouts (*cf.* (Fratianni & Marchionne, 2010-13), (Ramirez, 2009), and (Baker, 2008)).

<sup>19</sup> Note that as part of the authors’ work providing expert testimony as well as their work with U.S. congress and government agencies, they have been deeply involved in a number of these scandals after the fact.

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**Operational and Technical Failures.** There have also been a number of high-profile operational and technology failures which have threatened financial systems around the globe including the U.S. Examples include:

1. The “Paperwork Crisis” that began in the late 1960’s and led to a massive disruption in post-trade processing in the U.S. (Wells, 2000);
2. The NASDAQ outages in 1987 and 1994 which were both caused by squirrels eating through powerlines;<sup>20</sup>
3. The stock market crash on October 19, 1987, which led to the adoption of circuit breakers at the New York Stock Exchange (“NYSE”) as well as a major improvement in its technology (Carlson, 2006);
4. The terrorist attacks on 9/11 (2001) which resulted in near complete shutdown of the U.S. financial markets for several weeks due in large part to poorly designed backup capabilities (Johnston & Nedelescu, 2005);
5. The Heartland Payment Systems data breach discovered in 2009;<sup>21</sup>
6. The Flash Crashes such as those in 2010, 2014, and 2015;<sup>22</sup>
7. The multiple NASDAQ outages in 2013;<sup>23</sup>
8. The JPMorgan Chase data breach in 2014;<sup>24</sup>
9. The Equifax data breach in 2017;<sup>25</sup>
10. The Capital One data breach in 2019.<sup>26</sup> and
11. The Robinhood Markets outages in 2020.<sup>27</sup>

**Conclusions.** We defer a detailed look into the causes of the failures until a later working paper. For now, however, we can categorize the main ones as follows:

1. Inefficient and ineffective regulatory oversight due in part to a broken and inadequate regulatory framework, especially in the U.S.;<sup>28</sup>
2. A lack of commitment on the part of governments and the financial services industry to prevent such events from occurring and spreading;
3. The absence of a global regulatory framework in the face of growing globalization;

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<sup>20</sup> Cf. <https://www.marketwatch.com/story/nasdaq-outage-a-black-squirrel-event-2013-08-22> (accessed May 13, 2022).

<sup>21</sup> Cf. <https://www.bankinfosecurity.com/heartland-breach-inside-look-at-plaintiffs-case-a-1844> (accessed April 26, 2022).

<sup>22</sup> (CFTC and SEC, 2010), (Levine & Floridi, 2017), and <https://www.investopedia.com/articles/investing/011116/two-biggest-flash-crashes-2015.asp#:~:text=%20The%20Two%20Biggest%20Flash%20Crashes%20of%202015,two%20of%20the%20main%20ones%20in.%20More%20> (accessed May 13, 2022).

<sup>23</sup> Cf. <https://www.marketwatch.com/story/nasdaq-outage-a-black-squirrel-event-2013-08-22> (accessed May 13, 2022).

<sup>24</sup> Cf. <https://www.theguardian.com/business/2014/oct/02/jp-morgan-76m-households-affected-data-breach> (accessed April 26, 2022).

<sup>25</sup> Cf. <https://money.cnn.com/2017/09/16/technology/equifax-breach-security-hole/index.html> (accessed May 13, 2022).

<sup>26</sup> Cf. <https://www.cnn.com/2019/07/29/business/capital-one-data-breach/index.html> (accessed April 26, 2022).

<sup>27</sup> Cf. <https://www.cnn.com/2020/03/04/business/robinhood-outage-explanation/index.html> (accessed May 13, 2022).

<sup>28</sup> For instance, see <https://www.sec.gov/rules/concept/s73202/pvinella1.htm> (accessed May 13, 2022).

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4. The lack of transparency regarding the many conflicts of interests of the typical financial institution acting as a central authority;
5. The nearly unbridled political and economic power of the large financial institutions and the uber wealthy; and
6. Too great a focus on short-term profits and personal wealth that has led to poor management, inadequate oversight, and poorly trained and inexperienced staff at the major financial institutions.

In light of these, it is not clear that DeFi can address or rectify each one of these problems. In fact, on its face, DeFi would seem to exacerbate many of these, which we discuss more fully in Section 3.0 below.

#### **2.1.3 Perceived Benefits for Consumers**

Proponents of DeFi tend to position its potential benefits in somewhat grandiose, idealistic terms.<sup>29</sup> For instance, it is common for proponents to claim that DeFi will democratize finance, presumably transferring financial power from large financial institutions to the common person.<sup>30</sup> Some claim that DeFi will literally change the world (hopefully for the better).<sup>31</sup> Some proponents even have gone so far to claim that DeFi will allow each person to become their own “central bank” by allowing them to create their own personal money whose value is based on the trust that others have in them.

While a little more modest, Ethereum echoes many of these populist beliefs in a comparison it offers between DeFi and traditional financial services. Citing to the company’s website once again:<sup>32</sup>

<i>DeFi</i>	<i>Traditional Financial Services</i>
You hold your money	Your money is held by companies
You control where your money goes and how it's spent	You have to trust companies not to mismanage your money, like lend to risky borrowers
Transfers of funds happen in minutes	Payments can take days due to manual processes
Transaction activity is pseudonymous	Financial activity is tightly coupled with your identity
DeFi is open to anyone	You must apply to use financial services
The markets are always open	Markets close because employees need breaks
It's built on transparency – anyone can look at a product's data and inspect how the system works	Financial institutions are closed books: you can't ask to see their loan history, a record of their managed assets, and so on.

Once again ignoring the accuracy or relevancy of such claims (which is questionable in most of these), it is clear that Ethereum agrees that DeFi has the potential to fundamentally change the very structure of the incumbent financial systems. For the purposes of these working papers, however, we ignore some of the

<sup>29</sup> For instance, see <https://nakamotoinstitute.org/crypto-anarchist-manifesto/> (accessed April 27, 2022).

<sup>30</sup> This is a bit hard to believe given that some of the biggest backers of DeFi are billionaires such as Elon Musk, Peter Thiel, and Vitalik Buterin.

<sup>31</sup> For instance, see <https://blogminds.com/how-DeFi-will-change-the-world/> (accessed April 26, 2022).

<sup>32</sup> Cf. <https://ethereum.org/en/defi/?msclkid=b9a069abd08b11ecb78a1fe4efdd405f> (accessed May 10, 2022).

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more these idealistic aspirations and summarize the some of the more direct benefits of DeFi for the consumer as follows:

1. Participation
  - a. Greater access to financial services;
  - b. No borders or other government restrictions;
  - c. Greater involvement and inclusion in the overall financial system;
  - d. Greater fairness in the delivery and use of financial services (*i.e.*, a more level playing field)
  - e. Greater innovation leading to new types of financial services and service delivery as well as greater competition from non-traditional players;
  - f. Greater diversity of services and service providers;
  - g. Less reliance on large financial institutions whose ethics may be somewhat questionable;
2. Economics
  - a. Lower prices for financial services due greater market efficiency (*e.g.*, lower interest rates, higher risk adjusted returns, etc.)
  - b. Lower fees due to removal of non-value-added intermediaries;<sup>33</sup>
  - c. Higher risk-adjusted returns due to greater diversity and risk-transfer;
3. Operations
  - a. Faster, more efficient, and less error prone processing and reporting (*e.g.*, real-time settlement);
  - b. Quicker availability and greater control of financial assets;
  - c. Greater transparency and auditability;
  - d. Greater convenience and ease of use via smart devices;
  - e. Customizable financial services tailored to their needs;
  - f. Greater data security and the security of financial assets;
  - g. The immutability of financial records.

(We note that greater transparency is also touted a significant benefit of switching to a DeFi application. However, such transparency is actually very limited to transactions in which the identity of the counterparties are not disclosed. It is not clear what use this is without a central authority to disclose the parties. It is the opinion of the authors that greater transparency is warranted as demonstrated by the collapse of AIG and Lehman Brothers. Given the importance of transparency, we will discuss this more fully in later working papers).

Given the fact that DeFi applications have only been available for a brief period, it is difficult to find hard evidence that decentralized financial services are even beginning to bring such significant changes to the status quo. Moreover, many of the perceived benefits of such services arise from the belief (true or not) that these services will lead to truly democratized financial system free from the control of an established central authority. We address some of the challenges of accurately measuring the benefits of DeFi in a subsequent working paper.

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<sup>33</sup> In economic terms, the fee paid to a non-value-added intermediary (*i.e.*, the agency cost) is an economic rent, *i.e.*, an unnecessary expense from the consumer's perspective and an excess profit from that of the intermediary.

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### **2.1.4 Perceived Opportunities for Service Providers and Investors**

DeFi represents a significant opportunity for both emerging and incumbent service providers alike, as well as investors in such service companies. For instance, some of key DeFi business drivers from the perspective of emerging service providers include:

1. The consumers' general cynicism and lack of trust in the existing service providers and the overall financial system (*i.e.*, the financial system is rigged in favor of the "1 percent");
2. Access to new markets and services, especially those targeting disenfranchised, underserved, and/or disillusioned consumers;
3. Technology innovation leading to new financial products, services, and service delivery;
4. Greater integration and interoperability of financial services and core technologies;
5. Lower barriers of entry through the use of technology leading to greater access, less intermediation, better service delivery, and lower cost of delivery;
6. The consumers' greater use of social media and their growing appetite for digitally delivered services generally;
7. The consumers' greater reliance on smart devices and mobile technology which are the primary user interfaces for DeFi applications; and
8. The availability of massive investment capital coupled with the promise of massive payouts.

Similarly, DeFi offers incumbent financial service providers possible improvements in their current service delivery models, including:

1. Significant cost savings due to a reduction in staff and associated costs (*e.g.*, direct costs, benefits, real-estate, equipment, services, etc.);<sup>34</sup>
2. Greater customer reach using smart devices and mobile technology;
3. Better competitive positioning and greater flexibility;
4. Less reliance on manual processing;
5. Lower error rates and associated costs; and
6. Less operational and financial risk due to removing intermediaries, achieving real-time settlement, and pushing much of the operations and administration of a given service to the blockchain.

Finally, DeFi startups present early-stage investors with an enormous potential upside, given such factors as:

1. A large population of disenfranchised, underserved, and/or disillusioned consumers eager for new financial services and new financial service providers;
2. The worldwide adoption of smartphone and other digital devices opening up new, technology-based markets for financial services;
3. Massive amounts of available capital couple with lower returns from more traditional investments;
4. The poor track record of business and technology innovation from incumbent financial service providers;
5. The current excitement and market hype that DeFi is generating; and
6. The recent history of big IPO payoffs for fintech companies.

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<sup>34</sup> For instance, *see* <https://www.jpmorgan.com/news/jpmorgan-central-bank-digital-currency-report> (accessed June 17, 2022).

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Given all this, we cannot forget that at the height of the dotcom bubble, there was a growing consensus that brick-and-mortar banks were moribund. This led incumbent banks to begin to shutter branches in favor of ATM's and online services. New online-only banks sprang up, apparently posing an existential threat to traditional banks due their lower operating costs and greater geographical reach.

However, none of this came to pass. Rather than disappearing, traditional banking continues to thrive. In fact, many banks have expanded their digital footprint and ATM's networks in addition to maintaining large branch networks, especially in more affluent neighborhoods.<sup>35</sup> Moreover, the massive political power that banks and other financial institutions wield remains almost entirely unchecked despite their role in the Great Recession and subsequent scandals (*cf.* Section 2.1.2 herein).

## **2.2 DeFi Applications**

Now that we have briefly examined some of the forces driving the popularity of DeFi, we now explore some of the general concepts of DeFi applications, keeping these drivers in mind. Here, we offer only enough technical detail to put some of the concerns about DeFi raised in Section 3.0 in context and postpone a more detailed discussion of the technical aspects of DeFi applications for a later working paper.<sup>36</sup>

### **2.2.1 Guiding Principles**

Although it is still in infancy, there is growing consensus regarding a small number of principles guiding the development of DeFi applications.<sup>37</sup> In no particular order, some of these principles include:

1. Every user has an identical, locally resident copy of the application and its data (*i.e.*, there is no single source of truth);
2. Peer-to-peer transactions take place directly without the need of intermediation;
3. Validation and confirmation of transactions are made by a cryptographic consensus mechanism as opposed to a central authority;
4. The application and its data are open and transparent with the full auditability of all financial records and software;
5. The applications and its data are virtually unhackable and immutable;
6. Users are identified by pseudonym, requiring virtually no personal information;
7. Financial transactions are settled in real-time settlement without the need of an intermediary;
8. There is no need for the custody of financial assets by a third-party (*i.e.*, the application is self-custodying); and
9. The application is self-governing, requiring no external regulators or other central authorities.

Importantly, by following such principles, trust in DeFi services is simply a natural outgrowth of the technology itself (at least in theory). Rules which govern the delivery of such services can be created and modified by a consensus of users. These rules can then be encapsulated directly in open source code available for anyone's inspection, review, and virtually unfettered use. Additionally, automated safeguards based on these rules can be implemented to ensure the ethical behavior of all parties, while

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<sup>35</sup> However, you only have to drive through a poorer neighborhood to see that, indeed, banks did forgo physical locations in favor of ATMs in these areas.

<sup>36</sup> For a brief introduction to blockchain technology, *see* (Mills, et al., 2016) and (Priyadarshini, 2019).

<sup>37</sup> The website of the Satoshi Nakamoto Institute links to a number of articles which set forth some of these principles along with the philosophical and ontological rationale for such principles (*cf.* [nakamotoinstitute.org/literature/](http://nakamotoinstitute.org/literature/)). Additionally, *see* (Dos Santos, 2017).

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audit trails can be used to resolve any disputes that might arise with little or no third-party involvement.<sup>38</sup> Moreover, the technology can be improved based on experience using artificial intelligence with a special emphasis on improved performance and reliability.

The guiding principles notwithstanding, there is some ambiguity regarding what constitutes a central authority with respect to a DeFi application. As we mentioned earlier, a central authority is defined as an entity which

1. Governs the use and/or delivery of the service, and/or
2. Acts as the single source of truth.

Until now, we have considered central authorities in a business context such as financial institutions acting as intermediaries, governments passing laws and adopting policies, tax authorities, regulators setting policies and supervising financial institutions, courts resolving disputes, and the like. However, given the governance model of the typical DeFi application discussed immediately above, the application itself meets the definition of a central governing authority set forth in point one above.

Additionally, we have to consider the fact that a computer application itself may be subordinate to a different sort of central authority than we have considered so far. For instance, the administrator (or a super user) of an application could act as a central authority by deciding (at least implicitly) who can use the program, how it operates, and who has access to the results and data. Likewise, the developer of the code or its owner could be considered a central authority since they could restrict its use. Even the code itself can be considered as the central authority if its results cannot be disputed.

Rather than trying to resolve this dilemma in these working papers, we will adopt a fairly broad definition of what constitutes a technology-based central authority and central authorities generally. Consequently, at one end of the spectrum are DeFi applications which merely employ a distributed ledger implemented using a blockchain network which essentially operates like traditional software in many ways.<sup>39</sup> On the other end of the spectrum are applications which completely lack any form a central authority including those that administer the application, governs its use or operation, or even own it.<sup>40</sup>

### **2.2.2 The Elements of a DeFi Application**

For the purpose of these working papers, we define a *DeFi application* as a computer program complying to some degree with the guiding principles set forth in Section 2.2.1 above that delivers one or more financial services using a blockchain as its foundation. Here, we define a *blockchain* as:

1. A network of equi-privileged, equipotent nodes;<sup>41</sup>
2. A fully replicated, distributed ledger in the form of a chain of blocks of data (*i.e.*, a linked-list) resident on each node and accessed via a cryptographic hash protocol;<sup>42</sup>
3. A base cryptocurrency which can be used as a medium of exchange, unit of account, and store of value within the context of the application;<sup>43</sup>

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<sup>38</sup> This is essentially a new self-governance model as discussed in Section 3.1.4.4 herein.

<sup>39</sup> This architecture is commonly referred as *distributed ledger technology* or *DLT*.

<sup>40</sup> These are often referred as a *decentralized application* or *dApp* (a.k.a. *Dapp*, *DApp*, and *dapp*).

<sup>41</sup> This can be public or private network, although some purists require it to be private.

<sup>42</sup> We will provide a much more technical description of the technical features of the blockchain along with benefits and drawbacks in a later working paper.

<sup>43</sup> This may or may not be the base cryptocurrency of the blockchain.

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4. A consensus protocol governing the validation and confirmation of new blocks which typically employs some form of cryptography;
5. Rules governing the creation and transfer of cryptocurrency which are encapsulated directly in code;
6. A programming or scripting language which can be used to develop new applications that run on the blockchain; and
7. Utilities such as a digital wallet and block explorer which make the blockchain user-friendly.

Under this definition, a blockchain itself can be a DeFi application. For instance, the Bitcoin blockchain is a payment system which facilitates the transfer of bitcoins from one user to another. Additionally, a blockchain's programming language (or other languages) can be used to create other DeFi applications, as well as encapsulate the various rules governing the modification and use of the application. These typically take the form of collection of immutable *smart contracts*, which are essentially code stored on the blockchain.<sup>44</sup> This often takes the form of "if then else"-based algorithms and incapsulates the various rules governing the processing a given transaction. Consequently, each smart contract and its current state resides on all nodes on the network at all times and is executed on each node based on the occurrence of a given event.

Through the use of a special form of a smart contract known as a *token*, it is possible to create virtually any financial product. This extends DeFi applications from the crypto-world to financial service generally. For instance, it is possible to peg a cryptocurrency to a national currency such as the U.S. dollar using a token known as a *stablecoin*.<sup>45</sup> Using a stablecoin, it would be possible to build a DeFi application on a blockchain to transfer U.S. dollars between two parties in much the same way as PayPal or Venmo.

### **2.2.3 Business Applications (a.k.a. Use Cases)**

If we view a smart contract as an "object" in the computer science sense, it is possible to program virtually any financial service which can be fully automated.<sup>46</sup> This is especially true for incumbent services which involve a non-value-added intermediary or in the situation in which the central authority no longer has the consumers' trust. With this in mind, some of the business activities currently supported by DeFi applications include:

1. Cryptocurrency and stablecoin payment systems which remove the need for central banks and depositories;<sup>47</sup>
2. Lending systems in which borrowers interact directly with lenders thus removing the need for banks and loan servicers;<sup>48</sup>
3. Cryptocurrency and token trading via decentralize exchanges (a.k.a. *Dexs*);<sup>49</sup> and

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<sup>44</sup> As even proponents have acknowledged, smart contracts are neither smart nor contracts as those terms are commonly used.

<sup>45</sup> For example, "DAI" is a well-known stable coin pegged to the U.S. dollar (*cf.* <https://coinmarketcap.com/currencies/multi-collateral-dai/> (accessed June 17, 2022)).

<sup>46</sup> Of the course, there may performance limitations arising to the blockchain architecture that make such an application impractical.

<sup>47</sup> For instance, *see* <https://defiprime.com/payments?msclkid=8bbd1551cfd011ec8a063936b93fb792> (accessed May 9, 2022).

<sup>48</sup> For instance, *see* <https://moneymint.com/top-defi-lending-platforms/?msclkid=557b9288cfd011ecb19549467b831c5b> (accessed May 9, 2022).

<sup>49</sup> For instance, *see* <https://www.blockchainappsdeveloper.com/top-10-defi-exchange-platforms?msclkid=f37dda35cfd011ecbc265c3e70ce6510> (accessed May 9, 2022).



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### 4. Token-based insurance.<sup>50</sup>

Again, it is important to realize that DeFi is only in its infancy and this list will surely grow longer as more DeFi applications are developed and used by consumers.

### **3.0 Challenges for Mass Adoption**

On its face, there are many reasons to doubt that DeFi will radically change the current landscape of financial services in the near future, and it is possible that it never will. This is especially true in those countries with highly developed financial systems like the U.S. Ignoring this existential question for the moment, it is also unclear if specific DeFi applications can successfully compete with or displace incumbent services outside of niche markets. Therefore, in this section, we look at some of the major obstacles facing DeFi that have the potential of stopping it from becoming a widely accepted alternative to incumbent financial services.

In such an analysis, we consider the following factors:

1. **Performance** – does a particular DeFi application perform as good as or better than a comparable incumbent service;<sup>51</sup>
2. **Economics** – is the DeFi application as cost effective or even more so;
3. **Regulatory response** – what adverse actions regulators might take to limit access to or use of the application;
4. **Barriers to entry and competitive response** – what actions we might expect competitors to take;
5. **Sociological factors** – what impact various consumer attributes may have on the speed of adoption (*e.g.*, income, age, location, education, etc.); and
6. **Psychological factors** – what impact various consumer attitudes may have the adoption rate (*e.g.*, fear, resistance to change, distrust of the new, patriotism, etc.).

Since performance issues or any expected regulatory response are closely tied to the nature of a particular financial service, we defer discussing these factors in detail until later working papers. In the case of performance, we do examine the fundamental question: are central authorities actually bad? As for the sociological and psychological factors, we limit the discussion at this point only to the need for a DeFi application to build trust with potential consumers and defer a deeper analysis until future working papers.

Note that we are not saying or even implying that all DeFi applications will fail or that there is no place for DeFi in the financial system. Surely some will be successful. This is especially true for those offering new or expanded financial services to underserved and/or poorly served consumers, as well as those applications that are well aligned with the performance characteristics of blockchain technology. The question at hand is not whether a specific DeFi application or a specific class of applications will become successful. Rather, it is whether DeFi will truly revolutionize and transform the financial services industry or merely become a bit player in the incumbent financial system. We begin to answer this existential question by examining the role of central authorities in a traditional financial system.

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<sup>50</sup> For instance, *see* <https://www.benzinga.com/money/best-crypto-and-defi-insurance/?msclkid=1d713fa6cfd111ec9f44bed9ccd5e5> (accessed May 9, 2022).

<sup>51</sup> For the moment, we purposely leave the definition of “performance” to be somewhat vague. We will consider a number of concrete performance measures in a subsequent working paper as part of a formal metric system.

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(Note that we defer a look at some of the obvious performance-related challenges facing DeFi applications until later working papers).

### **3.1.1 Performance – are Central Authorities Truly Bad?**

Ignoring the performance characteristics of particular DeFi applications until a future working paper, a core tenet of decentralized finance is that financial services can be ably delivered without the need for a central authority (whether acting as a governing body, the single source of truth, or both). However, it is not clear that simply replacing a central authority with a blockchain-based computer application will provide at least comparable levels of service as incumbents, much less a greater one. Moreover, it is not clear that a DeFi application can actually replace all the roles that a central authority plays in terms of maintaining the health and integrity of the financial system (as well as the overall economy), much less the ensure the quality and risk exposure of a given service.<sup>52</sup> Lastly, it is not clear that transitioning to a DeFi application is the best way to instill the consumers’ trust even when they have little or no trust in an incumbent service. We look at some of these questions immediately below.

#### **3.1.1.1 Acting on Behalf of the Greater Good**

Financial systems are not monolithic. Various stakeholders can (and often do) have differing expectations with respect to the types of financial services as well as the levels service they receive. Consequently, it is not surprising that they often have differing opinions regarding the state of a given financial system and, in particular, differing opinions regarding possible changes that might benefit one cohort at the expense of another. Without strong central authorities, such decisions would be left solely to unbridled market forces which, based on history, could lead to greater inequalities between the haves and the have nots.<sup>53</sup> Importantly, a number of incumbent central authorities are tasked specifically with protecting the health and integrity of the overall financial system. In this role, they not only protect the interests of consumers, but also consider the impact of various services on society as whole. Such central authorities includes governments and central banks, supranational organizations, courts and arbitration panels, regulators, and financial utilities.<sup>54</sup>

**Governments and Central Banks.** Through their fiscal and economic policies, governments (which are, by definition, central authorities) typically look to enact laws, regulations, and policies that benefit their nations and the welfare of their citizens as a whole (albeit, sometimes to differing degrees). Of course, government administrations also try to achieve certain political objectives in order to stay in power and often enact laws and policies to benefit a certain class of constituents, sometimes to the detriment of others. This is a natural dialectic between the interests of a nation and the interests of a national government currently in power. This dialectic notwithstanding, few would advocate for a financial system that was completely devoid of government influence and oversight (*i.e.*, removing such a central authority).<sup>55</sup>

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<sup>52</sup> In the next working paper, we will proffer a number of metrics which can be used to measure the health and integrity of a financial system. For now, we will simply define this as: a) liquidity, b) the efficiency of financial markets, c) market volatility, and d) the amount of systemic risk in the system.

<sup>53</sup> Let us not forget the old adage, “power is money and money is power.”

<sup>54</sup> At this time, we only highlight these organizations’ role as a central authority and defer a more in depth discussion of their overall role in the financial system until a later working paper. We also note the most extreme proponents of DeFi believe that all the organizations discussed in this section are unnecessary based on the democratic principles and governance backing DeFi.

<sup>55</sup> There are proponents of DeFi that argue exactly for the abolishment of government control of the financial system as an expression of personal liberty. However, this is a philosophical, not economic position.

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Recognizing this natural conflict between the interests of a country and that of a particular administration, most countries have enacted laws making their central bank independent of the government administration. In this role, central banks are generally responsible for setting the monetary policy with specific goals in the national interest as opposed to the interest of the current administration. Consequently, such policies are generally intended to bring overall stability to the financial system as well as promote sustainable and stable economic growth.<sup>56</sup> Additionally, central banks typically implement such policies through various actions they carry out directly and indirectly in the financial markets. This can take the form of setting interest rate targets to buying and selling currencies directly in the market. Lastly, central banks are typically the principal regulator of their country's financial system. In this role, they are typically responsible for setting targets for key operational parameters for the country's financial system as well as supervising the financial health and integrity of individual financial institutions and the financial system as a whole.

This model of responsible government involvement in the financial system coupled with a strong, independent central bank has proven to be highly effective in not only strengthening a nation's financial system, but also in improving the nation's overall well-being as well.<sup>57</sup> And the current success of cryptocurrencies notwithstanding, we have seen nothing in the literature showing that a financial system without responsible government involvement or a strong, independent central bank is preferable, much less viable, or that a nation's citizens would be better off without one.

**Supranational Organizations.** Understanding that financial systems around the globe are highly integrated, a number of developed countries have come together to create supranational organizations specifically tasked with helping develop and guide the economies of developing countries. Such organization include the World Bank, International Monetary Fund ("IMF"), the Bank of International Settlements ("BIS"), and the International Organization of Securities Commissions ("IOSCO"). Beyond providing lending, grants, and other financial assistance, these organizations also offer recommendations and guidance regarding monetary policies and regulatory oversight, as well as technical assistance and other advice with the goal of reducing poverty, building stronger local economies, and building lasting economic stability worldwide.<sup>58</sup> However, in order to participate, developing countries must enact specific policies dictated by such organizations and, in some cases, agree to their oversight and supervision. Consequently, such organizations are central authorities under our definition of DeFi as defined on page six herein even though they are intermediaries in the strict sense. While there are a host of valid criticisms that can be leveled at some of the organizations, few can argue with their overall mission, and it is not clear how replacing them with a DeFi application (if at all possible) will improve the situation.

**Courts and Arbitration Panels.** Many, if not most, incumbent financial services are delivered pursuant to one or more legal agreements between the service providers and consumers. Consequently, a court or arbitration panel may act as central authority if it adjudicates a dispute between the parties should one

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<sup>56</sup> For instance, the Fed has three principal policy goals as set by congress: maximizing employment, price stability, and achieving moderate long-term interest rates (cf. <https://www.federalreserve.gov/aboutthefed/files/the-fed-explained.pdf#page=24>).

<sup>57</sup> No social program is perfect and some sectors of the citizenry benefit more than others. However, incremental improvements can be made overtime without abandoning the overall model entirely.

<sup>58</sup> It should be noted that despite such lofty goals, these types of organizations have received quite a bit of criticism for promoting specific policies and financial services that tend to advantage the richer countries at the expense of developing nations.

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arise. This is also true should a financial regulator or law enforcement bring a civil or criminal action against one of the parties.

**Regulators.** Financial regulators set policies, procedures, and guidelines governing the operations of one or more financial markets. As such, they monitor and assess the safety and health of those markets and intervene when necessary to maintain their stability and liquidity. Additionally, regulators are often responsible for licensing and supervising financial institutions and utilities that operate in the markets that they are tasked with overseeing. One of their principal mandates is to protect consumers and the overall financial system from the failings of individual institutions. In this role, they typically perform annual audits, investigate possible infractions; and prosecute possible wrong-doers. Regulators are generally classified as follows:

1. Government agencies including law enforcement
2. Self-regulatory organizations (“SRO”) which are industry bodies which promulgate and enforce regulations and rules such as the Financial Industry Regulatory Authority (“FINRA”) in the U.S.; and
3. Industry trade groups which often set policy and operational standards in addition to lobbying on the industry’s behalf, such as the Securities Industry and Financial Markets Association (“SIFMA”) and the International Swap and Derivatives Association (“ISDA”).

**Financial Utilities.** Similarly, many financial utilities, which typically act as central authorities, were created specifically to help ensure the stability of financial systems. This includes listed exchanges which guarantee best execution price for their members as well as ensure safe and secure markets; central clearinghouses and central securities depositories which spread settlement risk across member firms; and communication services such as the Society for Worldwide Interbank Financial Transactions (“SWIFT”) and the Automated Clearing House (“ACH”) which provide secure communication of payment instructions and other financial messages. In all of these cases, the financial utility is both a central authority governing the actions of its members when using its services, as well as a single source of truth. Again, we have seen nothing in the literature showing that a financial system without such financial utilities acting as central authorities is preferable, much less viable.

Therefore, it is questionable that competing DeFi applications can replace such central authorities without offering the same benefits to society at large. This must be an important consideration when assessing the actual value of a particular DeFi application.

### **3.1.1.2 The Big Picture**

While a particular DeFi application may indeed be a more attractive option than a specific incumbent financial service, it is important to consider what impact moving to such a DeFi application may have in the context of the full financial system (*i.e.*, the bigger picture). This is comparable to removing a large column in the center of large room. While the room may look better without it, the column has to be considered in the context of the overall architectural integrity of the house before making the decision to remove it. Making radical changes to a financial system as the proponents of DeFi suggest is no different. In order to fully understand the impact of moving to a particular DeFi application, it has to be considered in terms of the societal goals of the financial system and not simply the financial service being replaced (World Economic Forum, 2013).

By design, banks and other depository institutions are the backbone of virtually all financial systems. And, by design, they typically act as a central authority in their various roles they play. To a large extent,

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this is simply a recognition of the fact that most of the world's money supply is created by bank lending, and it is through such lending that most economies grow.

In addition to promoting lending, governments enact laws and statutes to help promote various policy objectives to better the financial condition of their citizens and the country as a whole. Often such laws intentionally give depositories significant advantages over non-depositories both in the types of services that they can deliver and how they may be delivered. Additionally, depositories often receive various forms of financial and operational support that simply is available to non-depositories. Intuitively, this seems justifiable since by conforming with these laws, banks are serving the greater good.

To better understand this, consider the average individual living in the U.S. Their greatest source of wealth (and equally important, *transferrable* wealth) is typically their home equity. In the U.S. (and in many other countries as well), individuals typically purchase a home using a mortgage loan issued and serviced by a licensed financial institution such as bank. Recognizing this, the U.S. government has enacted a number of laws, programs, and policies to encourage home ownership, especially for the poor and disadvantaged. Unsurprisingly, many of these are intended to incent banks to issue mortgage loans.<sup>59</sup>

For instance, the U.S. government has enacted laws under which only licensed depositories, such as banks, savings and loans, and credit unions, can accept and hold customer deposits. Importantly, such deposits become part of the depository's general operating capital (essentially, it becomes the depository's money and the depository has an obligation to repay the depository on demand, hence the term, *demand deposit account* or *DDA*). Since the cost of obtaining such deposits are essentially zero, they can be lent to home buyers, thereby virtually guaranteeing a greater profit (*i.e.*, a greater *net interest spread*) than non-depositories. This is a significant competitive advantage.

Additionally, the U.S. government has established a number of agencies and government sponsored enterprises (GSE) to provide depositories with:

1. Access to cheap capital,
2. Increased liquidity, and
3. Risk transfer.<sup>60</sup>

Clearly, these organizations give depositories a significant competitive advantage over non-depositories, which they justify by the fact that these advantages incent depositories to lend.

However, there is a *quid pro quo* that these financial institutions agree to in return for the market advantages that receive. As licensed businesses, depositories must comply with burdensome government regulation and supervision that is generally intended to ensure safety and soundness for the overall financial system. Through such regulatory oversight, governments can use licensed financial institutions to help police the financial system by implementing controls intended to prevent and detect criminal acts in addition to following sound business practices.<sup>61</sup>

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<sup>59</sup> Residential mortgages (a.k.a. retail mortgages) make up one of the largest, if not the largest, asset class on a bank's balance sheet (for instance, see <https://www.forbes.com/sites/greatspeculations/2018/06/27/a-breakdown-of-the-loan-portfolios-of-the-largest-u-s-banks-2/?sh=715118f3126b> (accessed April 22, 2022)).

<sup>60</sup> Such organizations include the Federal Housing Authority (FHA), the Federal Home Loan Banks ("FHLBs"), the Federal National Mortgage Associations ("Fannie Mae"), the Federal Home Loan Mortgage Corporation ("Freddie Mac"), and the Government National Mortgage Association ("Ginny Mae.") This are discussed more fully in second working paper in the series.

<sup>61</sup> Such controls include "know-your-customer" and anti-money laundering monitoring and reporting, among others.

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Putting aside whether such lofty policy goals such as increased home ownership and crime prevention can actually be met, most would agree that such goals are praiseworthy in the context of the big picture and that licensed financial institutions (often in the role of a central authority) are serving the greater good in this scenario.

There is no doubt that financial institutions such as commercial banks deserve their many criticisms, which we discuss at length in subsequent working papers. However, some of this criticism is simply a consequence of the advantages that financial institutions receive for helping to maintain the health and integrity of the financial system which, *by design*, requires them to act as central authorities.

Consequently, it is essential to consider the role that incumbent financial institutions play in the context of this big picture when assessing the impact of replacing them with a DeFi application.

### **3.1.1.3 Systemic Risk**

Central authorities (in their role as a governing body) play an essential role in reducing *systemic risk* in the financial system, which we define as the risk of the failure of one component of the financial system resulting in the collapse entire financial system or the economy as a whole. For example, consider the role of a central clearinghouse such as the National Securities Clearing Corp (“NSCC”). Once a trade has been executed on an U.S. stock exchange (such as NYSE), it does not settle directly between the buyer and seller. Rather, the buyer and seller remain anonymous, and each settle their portion of trade with NSCC as the counterparty of record (*i.e.*, the buyer is obligated to deliver funds to the NSCC and in return, receives shares from the NSCC while the seller delivers shares to the NSCC and receives money from the NSCC).<sup>62</sup> If the either the buyer or seller fails on their obligation to deliver money or shares, respectively, the NSCC is still obligated to settle with other party nonetheless, thereby protecting the performing party from any financial harm. Essentially, the *settlement risk* has be transferred to the NSCC, thereby indemnifying both the buyer and seller from a settlement fail by the other party.

More importantly, settling through the NSCC significantly reduces the risk that a single settlement failure could result in a “daisy chain” of settlement failures that could spread throughout the financial system (*i.e.*, *financial contagion*). For instance, assume that the buyer above fails to deliver funds to the seller. Further assume that the seller had entered into a second trade to purchase some other stock using the proceeds from the first trade. Without the NSCC acting as the counterparty to the initial trade, the seller would not have received funds from the buyer and might potentially fail on its second trade. It is not hard to see that without some sort of intervention, this could ripple through the entire U.S. stock-related markets.

While this may seem a bit extreme, in fact, the authors experienced this firsthand immediately following the collapse of Lehman Brothers in September 2008.<sup>63</sup> At the time, the authors were the CEO and COO of Wilmington Trust Conduit Services (“WTCS”), a subsidiary of Wilmington Trust Corporation, the holding company of the nationally chartered bank, Wilmington Trust Company. WTCS offered a suite of corporate trust/fund administration services to issuers and managers of and investors in structured financial products backed by pools of loans such as mortgage-backed securities (“MBS”), collateral debt obligations (“CDO”), and the like.

As of September 2008, WTCS had about \$16 billion of assets under administration, mostly in the form of collateralized loan obligations (“CLO”), a form of CDO backed by commercial loans. In accordance with

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<sup>62</sup> This act of transferring the settlement responsibility to the NSCC is known as novation.

<sup>63</sup> The government takeover of AIG is more well-known example of the same phenomenon, which we discuss this at length in a future working paper.

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the convention at the time, most CLO paid noteholders quarterly on March 15, June 15, September 15, and December 15. Because the payment dates of the underlying commercial loans do not generally match those of the CLO, it was common practice at the time to enter into a swap agreement with a large investment bank to provide bridge financing to ensure sufficient liquidity on CLO payment dates.<sup>64</sup> A subsidiary of Lehman Brothers, Lehman Brothers Financial Products (“LBFP”), was a major counterparty to such swaps, and about \$12 billion of our CLO had swap agreements with LBFP. On September 15, Lehman Brothers Holdings (the parent of the U.S. broker-dealer) filed for bankruptcy. However, the U.S. broker-dealer, as well a number of other separately capitalized Lehman Brothers subsidiaries, were allowed to continue to operate.

When the bankruptcy was announced, it was unclear if LBFP was one of the Lehman entities that was part of the bankruptcy or if it were still operating and would be able to make its scheduled swap payments. The legal agreements governing the operations of the CLO typically set forth that noteholder payments had to be made no later than five business days after the scheduled payment date. A failure to receive such payments within the five day limit typically would result in an event of default, thereby causing the liquidation and termination of the CLO. It turned out that LBFP was, indeed, still operating and it was able to make its payments as scheduled. I was told at the time that LBFP swap agreements with various CLO’s totaled close to \$150 billion, virtually all of which would have defaulted had LBLP been part of the bankruptcy. This would have a devastating impact on the credit markets and financial systems around the world.

Any peer-to-peer market in which settlement takes place directly between counterparties (such as the swaps market) is vulnerable to financial contagion by its very nature. As such, it is not surprising that following the collapse of Lehman Brothers, many regulators and academics called for the creation of central exchanges and clearinghouses to replace many over-the-counter (“OTC”) markets.<sup>65</sup> This is precisely the antithesis of DeFi, which calls for the move *to* peer-to-peer markets and the abolishment of central authorities. Such a move can only lead to an increase systemic risk in the overall financial system, and it is not clear at this point in time what the proponents of DeFi recommend to reduce it without some form of central authority.

### **3.1.1.4 Recourse and Adjudication**

An actor (whether a company or individual) providing financial services to a consumer is generally responsible for delivering those services pursuant to some standard. For instance, such a standard may be negligence or gross negligence if the delivery of the services are governed by a legal agreement. At a minimum, the delivery of services must comply with applicable laws and statutes as well as regulations, rules, and guidelines promulgated by government or industry regulators. Such a standard may also be generally accepted customs, practices, and standards of care. However, without a consumer’s ability to act should the services fail to meet such standards, any agreement under which the services are delivered are basically worthless.

For instance, consider that an individual wants to wire money from a traditional bank, and assume that the bank fails to do it correctly. If this were due to acts or omissions on the part of the bank acting as an intermediary, the customer could demand that the bank pay them for any harm that they may have

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<sup>64</sup> Such swaps are commonly referred to as perfect swaps.

<sup>65</sup> For instance, a group of fifteen well-known economists drafted a report entitled, “The Squam Report: Fixing the Financial System” in the fall of 2008. One of their major recommendations was the creation of such exchanges and central clearinghouses for a type of swap known as credit default swap or simply CDS (*cf.* “The Squam Report: Fixing the Financial System”, chapter 9).

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suffered. Should the bank refuse, the individual may take the matter to arbitration or even to court.<sup>66</sup> If the bank acted illegally, the individual could refer the matter to the local district attorney for investigation. At minimum, the individual could report the incident to one or more regulators for possible investigation.

Now consider a peer-to-peer DeFi application without a central authority and assume that it is extra-legal in the sense that it is not subject to any legal authority. Further, assume that there is a dispute between the sender and receiver regarding the transfer. Who adjudicates the dispute? Who represents the various parties, and how is evidence presented? Who is the finder of fact? Even if there are provisions in the use license to settle such disputes, who enforces them or enforces any damage payments? If the DeFi application itself takes on this responsibility, then it becomes a central authority governing the use of its application, thereby violating one of core tenets of DeFi. If it is left up to the user community, there is no reason to believe that they will want to participate in resolving the situation or that they will act competently and fairly (juries of one's peers have been known to make mistakes). Essentially, the developer of the DeFi application will have to develop an effective dispute resolution capability in order to provide the protections that were provided by the central authority.<sup>67</sup> To our knowledge, there has been no truly rigorous work in this area without the use of external central authorities such as arbitration boards and courts.<sup>68</sup> This is a significant issue that must be addressed in order for DeFi applications to become truly mainstream.

#### **3.1.1.5 Fraud and Other Criminal Acts**

It is not surprising that various components of financial systems have been the target of criminal acts or used to carry them out.<sup>69</sup> Given this, lawmakers and regulators have drafted a number of laws and regulations intended specifically to prevent criminal acts from taking place in the financial system. Many of these controls are directed to financial institutions since they are the most accessible gateway into a financial system. Essentially, lawmakers and regulators recognized and exploited the role of financial institutions as central authorities.

In the U.S., for instance, licensed financial institutions must perform what is commonly called “know your customer” or “KYC” vetting of any unknown individual or corporation that wishes to open accounts with or receive money that institution. In addition to performing KYC vetting, banks must also report money transfers over \$10,000 as well as any suspicious activity. These controls are part of a financial institution's overall program to prevent and detect fraud and other criminal activity, which is often (and mistakenly) referred to anti-money laundering or AML.<sup>70</sup> Many of these programs stem from the Bank Secrecy Act passed in 1970 and then from U.S.A. Patriot Act passed 2001.

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<sup>66</sup> In reality, financial institutions make it extremely hard to take them to court. However, this is problem of execution, not design.

<sup>67</sup> There has been some work in literature trying to extend the dispute resolution methodologies use by various e-commerce service providers (such as eBay) to more general forms of disputes which is commonly referred to as online dispute resolution or ODR. For instance, *see* <https://www.sciencedirect.com/science/article/pii/S2351667415000074>.

<sup>68</sup> Much of the available literature simply suggests that user community will somehow resolve disputes organically. Human history shows that this is naïve in the extreme.

<sup>69</sup> Some of these components were discussed in Sections 3.1.1.1 and 3.1.1.2 herein.

<sup>70</sup> Pursuant to the text of the prevailing regulations, such programs are not limited to anti-money laundering but criminal acts generally.



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Additionally, financial institutions often have been the victim of insider fraud, conspiracies, and other criminal acts themselves.<sup>71</sup> In fact, many of the generally accepted controls implemented by financial institutions are a response to past criminal acts conducted by employees and contractors.<sup>72</sup> Examples of such controls include:

1. The segregation of various operational groups involved in performing and recording transactions (*i.e.*, the segregation of duties);
2. Documented delegation of authority policies and procedures;
3. Independent compliance and internal audit organizations;
4. A dedicated investigations group within the operations organization;
5. Four eye approval (*i.e.*, two individuals confirming instructions to move money or financial products);
6. Callback confirmation of instructions;
7. Daily account balance and transaction reconciliation;
8. Proactive system and physical security protocols;
9. Transaction history logs; and
10. Tiered approval protocols.

It is naïve to believe that all users of a DeFi application will be well-behaved and well-intended or that technology alone can prevent crimes without some oversight. Consequently, an important question to consider is to what degree (if any) will a DeFi application implement crime prevention controls that were previously provided by the central authority it is intended to replace.

### **3.1.2 The Economics – there are no Free Lunches**

One of the most attractive aspects of DeFi is the promise of lower costs to the consumer.<sup>73</sup> While there is really no hard evidence for this at the moment, replacing an intermediary with essentially free software logically should reduce the cost to the consumer by the fees charged by the intermediary.<sup>74</sup> However, this logic is fundamentally flawed for several reasons.

**Value for Money.** For instance, rather than simply comparing direct costs, we first need to consider overall value of the service (*i.e.*, its *value for money*) based the following three factors:

1. The scope of the services (*i.e.*, are they truly equivalent services);
2. The quality of the services (*i.e.*, are quality of the delivery and that of the ultimate results equivalent); and
3. Risk of a financial loss associated with using the services.

This last point is somewhat nuanced. We not only have to consider the likelihood of problem occurring, but we also have to consider the likely the size of loss given such an occurrence, which must include nuisance cost if problems frequently occur. Moreover, we have to consider the long-term viability of the service provider which, in the DeFi space, is not very likely given the performance of DeFi service providers to date. All of these factors are especially important to consider when assessing the value of

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<sup>71</sup> A bank examiner from the Fed told the authors that as much as ten percent of member bank's operating expenses could be attributed to insider fraud.

<sup>72</sup> These controls also have proven to be effective in preventing outsider fraud as well.

<sup>73</sup> Cf. <https://coinconfidential.com/what-is-defi/#:~:text=And%20the%20great%20thing%20about%20DeFi%20and%20decentralisation,the%20world%20a%20fairer%20place.%20It%E2%80%99s%20a%20win-win> (accessed June 5, 2022).

<sup>74</sup> In economic terms, replacing the intermediaries removes any economic rent (*i.e.*, excess profit).

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DeFi application in the situation where the consumer has no recourse due to the absence of a central authority such as a regulator or the courts.

**Full Cost of Ownership.** Additionally, we have to consider the full cost of using the service (*i.e.*, the **full cost of ownership**) which includes all direct and indirect costs associated with using it. For instance, even if the service is provided at no direct cost (essentially for free), we still need to consider the cost of the equipment and other infrastructure needed to run the software, the network usage costs, the time needed to master the application, customer support costs, the costs of migrating to the DeFi application, and the like. In other words, we cannot simply conclude that a DeFi application is more cost effective than that of an incumbent service even if the DeFi application is free to use given the various technology- and data-related cost likely incurred to use it.

**Hidden Costs.** Importantly, users of a particular DeFi application may have to pay hidden costs to use the service in addition to known service fees such as miner incentives. For instance, consider Bitcoin. Miners are incented to validate and confirm transactions in return for newly minted bitcoins. This, in turn, reduces the spending power of the existing bitcoin. In other words, users are directly subsidizing miners, most without even noticing it, which is essentially a use fee.<sup>75</sup> Additionally, the blockchain may adopt monetary policies which are also inflationary, thereby reducing the wealth of average users.

**Cost and Risk Transfer.** Based on the experience of the authors, many proponents of DeFi have a rather superficial understanding of finance and the financial services industry. They tend to think of the industry in terms of processes, often at the expense of the underlying financial theory. This is especially true in the context of disintermediation and cost and risk transfer.

Proponents of DeFi generally portray financial institutions as non-valued-added intermediaries that charge excessive fees for their services. This criticism ignores the fact that financial institutions spend tens of billions on technology and operational staff to deliver those services.<sup>76</sup> Without the use of such intermediaries, these costs would have to borne by the blockchain and ultimately the users.

Additionally, through such intermediation, consumers also transfer most if not all the financial risk associated with using a particular service to these intermediaries. For instance, through novation, counterparties transfer the settlement risk of a trade to the central clearinghouse as discussed in Section 3.1.1.3 herein. In other words, the central clearinghouse not only provides processing (essentially on an outsourced basis), but it also provides significant risk protection for consumers.

As another example, consider lending. Some proponents of DeFi advocate for directly matching borrowers and lenders on the blockchain without the need for a financial institution in the middle.<sup>77</sup> They claim that the net effect would be drastically lower lending rates. This is naïve in the extreme and ignores some basic laws of finance.

Under the scenario of a single borrower obtaining funds from a single lender, one hundred percent of the credit risk (*i.e.*, the risk of loss due the borrower's inability or unwillingness to meet their obligations) is

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<sup>75</sup> Even ardent proponents of DeFi acknowledge that once this incentive ends, users will have to eventually pay a base fee to miners in addition to incentive fees. This is discussed more fully in a later working paper.

<sup>76</sup> For instance, *see* <https://www.statista.com/statistics/871049/world-it-spending-financial-services-firms/> and <https://www.forbes.com/sites/ronshevlin/2019/04/01/how-much-do-banks-spend-on-technology-hint-chase-spends-more-than-all-credit-unions-combined/?sh=1e2a27a9683a> (both accessed June 17, 2022).

<sup>77</sup> *Cf.* <https://coinconfidential.com/what-is-defi/#:~:text=And%20the%20great%20thing%20about%20DeFi%20and%20decentralisation,the%20world%20a%20fairer%20place.%20It%E2%80%99s%20a%20win-win> (accessed June 5, 2022).

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borne by that lender. Assuming that the lenders are rational, this has several important consequences, including:

1. Lenders will only be willing to lend a modest amount of their wealth;
2. Lenders will demand higher interest rates for less creditworthy borrowers; and
3. Lenders will have to perform some sort of qualitative and/or quantitative analysis to assess the creditworthiness of potential borrowers.

Now consider a DeFi lending application which matches borrowers directly with lenders such that borrowers post amounts they wish to borrow (and possibly other terms) and lenders post indications of rates they are willing to lend at. In order for such a marketplace to be efficient, also assume that the application provides sufficient analysis to adequately assess the creditworthiness of all potential borrowers.

It is easy to see that the amount of lending would be constrained by the total amount each individual lender would be willing to risk in addition to any capital limitations. Of course, the amount that a lender is willing and able to lend would go down if they experience losses due to less capital and a greater aversion to risk. In certain situations, lenders might not be willing to lend to risky borrowers at all (this is somewhat ironic since this is one of the main criticisms of current financial systems). One way to overcome this limitation is to pool the lending so that a single lender's risk exposure to a particular borrower is reduced. Even if a few borrowers default, the return on the total pool may make such lending attractive. This is essentially the idea behind syndicated lending and securitization, as well as the traditional banking model in which banks lend pools of consumer assets.

Given its peer-to-peer operating model, pooled lending seems like a perfectly reasonable application for DeFi which would disintermediate incumbent lending institutions and other central authorities.<sup>78</sup> However, there are number of critical issues to consider before we can conclude that such an application can and will replace incumbent consumer lending. First is the willingness or ability of lenders to lend. Lending institutions are in the business of lending, individuals are not. Lenders may have other uses for their money or simply lose interest in lending. A second important factor constraining such a lending application is simply fact that the size of the lending pool is limited by the wealth resident in the blockchain. For instance, at the time of this writing, there was approximately \$650 billion worth of bitcoin.<sup>79</sup> Consequently, any lending pool would be significantly less than this. The amount of consumer debt in the U.S. alone as of March 2022 was estimated to be over \$4 trillion.<sup>80</sup> From these numbers, it is clear that a DeFi application is not going to replace incumbent consumer lending anytime soon.

**An Example: Robinhood Markets.** While Robinhood Markets (“Robinhood”) is not a DeFi application, it does highlight the fact that there are generally no free lunches in the financial services industry.<sup>81 82</sup> Robinhood burst on the scene in 2014 positioning itself as a mobile trading app (as opposed to a retail broker) that executed trades for (what it claimed to be) free.<sup>83</sup> It quickly attracted a significant number of

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<sup>78</sup> This is essentially the business model of the alternative lender, KIVA (*cf.* <https://www.kiva.global/> (accessed June 5, 2022)).

<sup>79</sup> *Cf.* <https://coinmarketcap.com/currencies/bitcoin/> (accessed June 5, 2022).

<sup>80</sup> *Cf.* [https://www.federalreserve.gov/releases/g19/HIST/cc\\_hist\\_mt\\_levels.html](https://www.federalreserve.gov/releases/g19/HIST/cc_hist_mt_levels.html) (accessed June 5, 2022).

<sup>81</sup> *Cf.* <https://www.investopedia.com/robinhood-review-4587919> (accessed June 5, 2022).

<sup>82</sup> In the interest of full disclosure, the authors provided expert testimony adverse to Robinhood in pending litigation.

<sup>83</sup> *Cf.* <https://www.businessofapps.com/data/robinhood-statistics/> (accessed June 5, 2022).

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customers, many of whom had never had a brokerage account before. As of Q1, 2022, Robinhood had nearly sixteen million trading accounts.<sup>84</sup>

However, the claim of commission-free trading was a bit misleading. Rather than submitting customer orders to an established exchange such as the NYSE for execution, Robinhood sold consumer orders to a handful of market makers such as Virtu and Citadel Securities.<sup>85</sup> These market makers, which also tended to be the biggest players in HFT, had the option to execute the Robinhood customer orders directly or subsequently bundled them and send to an exchange for execution.

While selling order flow is legal in the U.S. and has been practiced for decades (a.k.a. *payment-for-order-flow*), there is a measurable risk that the orders will not execute at the then best price, which was unknown to Robinhood's customers early on.<sup>86</sup> Further, Robinhood can only support financial products that the market makers support (these tend to be exchange traded products such as stocks, listed options and futures, exchange traded funds ("ETF") and the like). Additionally, Robinhood built most of its systems itself rather than utilizing proven products from existing fintech providers. Consequently, Robinhood's customers were subject to the growing pains typically associated with new technology.<sup>87</sup> To make matters worse, at the time of these technology-related problems, Robinhood did not have other means to communicate with its customers such as text messages, email, telephone, or in-person communications.

In other words, the tradeoff for commission-free trades was that Robinhood's customers were exposed to risks that they would not have otherwise been had they used an incumbent broker. It is also worth noting that incumbent brokers quickly eliminated trading-based fees once Robinhood began to garner meaningful market share. This quickly removed Robinhood's primary competitive advantage and deprived its customers of any meaningful risk premium for trading with Robinhood.

### **3.1.3 Barriers to Entry and Competitive Response**

Like any new service paradigm, DeFi must overcome a number of challenges in order to achieve mass adoption. These challenges include a significant response from incumbent service providers which will not simply sit by and give up market share. For instance, as essentially a technology-delivered service, there will likely be significant upfront costs and longer times to market. Additionally, users typically take some time to adjust to, learn, and trust new technologies. Putting aside these rather generic technology-related issues for the moment, let us look at some of the challenges that apply to DeFi specifically as a new financial services paradigm.<sup>88</sup>

**The Size and Complexity of Incumbent Financial Systems.** One of the biggest hurdles facing DeFi is the sheer size and complexity of the typical financial system. They are huge almost beyond comprehension. Every one of the nearly eight billion people in the world has the potential to participate in

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<sup>84</sup> Cf. <https://www.statista.com/statistics/822176/number-of-users-robinhood/#:~:text=The%20number%20of%20users%20of%20the%20commission-free%20trading,up%20to%2022.8%20million%20as%20of%20March%202022> (accessed June 5, 2022).

<sup>85</sup> The authors have provided expert testimony on behalf of Citadel in past litigation.

<sup>86</sup> In fact, the regulator, FINRA, fined Robinhood \$1.25 million in 2019 for failing to disclose that it sold customer orders and ensure that they received the best execution price (cf. <https://www.bloomberg.com/news/articles/2019-12-19/robinhood-fined-1-25-million-over-how-it-routed-customer-orders> (accessed June 5, 2022)).

<sup>87</sup> Cf. <https://www.fool.com/investing/2020/09/26/heres-the-biggest-problem-robinhood-users-have-and/> (accessed June 5, 2022).

<sup>88</sup> We will look at these technology-related challenges in a future working paper.

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one or more financial systems.<sup>89</sup> Other than possibly Facebook, there are no technology platforms capable of reaching such a large, geographically dispersed user community.<sup>90</sup> On top of this, the net global wealth as of 2020 was estimated at more than \$430 trillion with financial assets accounting for nearly sixty percent of that (Boston Consulting Group, 2021). In the U.S. alone, the net wealth exceeded \$122 trillion with financial assets accounting for nearly \$100 trillion.<sup>91</sup> In terms of banks in just the U.S., the FDIC lists nearly 4,800 individual institutions made up of more than 82,000 branch offices with assets totaling nearly \$25 trillion.<sup>92</sup> The largest U.S. bank, JPMorgan Chase, alone has more than sixty million retail customers in the U.S.<sup>93</sup>

Conversely, even the biggest DeFi applications, Bitcoin and Ethereum, have only 15,000 and 6,100 nodes, respectively, as of this writing.<sup>94</sup> These are virtually insignificant compared the near two billion users that logon to Facebook daily or the fifty-one million digital customers that JPMorgan Chase had as of 2019.<sup>95</sup>

We also note that the financial system did not evolve entirely organically in response to market forces and competitive pressures. Rather, they have been somewhat engineered through government laws and statutes, as well as policies, rules, and regulations promulgated by government agencies, industry regulators, and supra-national institutions such as the World Bank, the IMF, the BIS, and IOSCO. These, in turn, may be integrated into well-established and widely accepted industry practices, customs, and standards of care. Given the highly integrated nature of financial systems across the globe, DeFi applications will have to initially co-exist and, in most cases, interoperate with incumbent financial services rather than immediately displacing them as current DeFi applications such as even Bitcoin have shown.<sup>96</sup>

It is completely reasonable (and likely) to assume that some DeFi applications will be successful in the near term and maybe even over the long haul. However, given the size and complexity of financial systems around the world, it is naïve to believe they will have any significant impact on incumbent service delivery mechanisms over the next five to ten years, much less revolutionize them.

**Not Everyone has, is Comfortable using, or Trusts a Computing Device.** An important assumption (at least implicitly) is that software is the consumer's preferred delivery means as opposed to those used by incumbent providers such as in person, telephonic, and other manual means. Not everyone has access to computing devices with sufficient computing power and network speeds to trust the entirety of their financial activity to DeFi.<sup>97</sup> Even if they do have access to such technology, they may not be happy or

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<sup>89</sup> Cf. <https://www.worldometers.info/world-population/> (accessed May 24, 2022).

<sup>90</sup> Cf. <https://www.statista.com/statistics/264810/number-of-monthly-active-facebook-users-worldwide/> (accessed June 5, 2022).

<sup>91</sup> *Id.*

<sup>92</sup> Cf. <https://banks.data.fdic.gov/bankfind-suite/bankfind> (accessed May 24, 2022).

<sup>93</sup> Cf. <https://www.jpmorganchase.com/news-stories/tech-investment-could-disrupt-banking> (accessed May 24, 2022).

<sup>94</sup> Cf. <https://www.ethernodes.org/nodes> (accessed May 24, 2022).

<sup>95</sup> Cf. <https://www.businessinsider.com/jpmorgan-chase-digital-investment-lead-to-strong-q3-engagement-2019-10#:~:text=As%20of%20Q3%202019%2C%20JPMorgan%20Chase%20has%2051.8,growth%20was%20also%2012%25%20YoY.%20Business%20Insider%20Intelligence> (accessed June 17, 2022).

<sup>96</sup> For instance, as of the drafting of this working paper, only a small number of service providers accept bitcoins as payment for goods and services. Consequently, Bitcoin users still have to convert their bitcoins to traditional money and rely on incumbent services providers to custody and process it.

<sup>97</sup> Many proponents point to the number of mobile communication devices there are in the world, especially in those countries which lack robust and fair financial systems. However, it is unlikely that the entire blockchain

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have the necessary skills to properly use it. This is especially true of many of the groups that typically lack access to traditional financial services (*e.g.*, the poor, the elderly, the poorly educated, rural dwellers, etc.). However, even people who use computers or smart devices everyday often have only enough understanding of a given application to just get by as opposed to mastering it. Moreover, many people prefer human interaction, especially when it comes to their finances. This is due, in part, to a general lack of trust regarding automated services which, to a large extent, is based on personal experience.

Quite simply, even the “smartest” software does only what it is programmed to do.<sup>98</sup> As such, it is not very flexible, especially as compared to interacting with other people, and this has often led to significant user frustration. Further, all computer-based applications have bugs and other points of failure no matter how rigorous the testing.<sup>99</sup> Most people would rather simply speak directly with a customer service representative rather than suffering through an endless selection of options only to get dropped when you do finally get a human on the line.

**Incumbent Service Providers have faced similar Challenges Before and Won.** Quite often, proponents of DeFi point to a particular financial service provided by one or incumbent providers as an opportunity for a competing DeFi service. For instance, many retail consumers complain about the excessive fees that banks charge for various services such as checking accounts, wires, and ATMs, as well as the time it takes for deposits to hit their accounts, both of which disproportionately hurt the poor and disadvantaged. A DeFi application offering similar services, but with lower fees or reduced deposit processing time might be able to successfully compete and replace incumbent service providers.

However logical this may seem, it is highly unlikely that incumbent financial service providers will simply rollover and give up market share to DeFi providers. Based on the authors’ experience, nothing could be further from the truth, and we only need to look at the dotcom bubble of the late 1990’s for evidence of this.<sup>100</sup>

At that time, many pundits were claiming that dotcom companies would quickly outcompete brick and mortar financial institutions given the rapid growth of high speed internet capacity along with the growth in the number of personal computers and intelligent mobile devices. And it is true that a number of dotcoms were extraordinarily successful, particularly alternative payment services such as PayPal. Additionally, a reasonable share of financial activity began to be carried out digitally, with it now accounting for a significant amount of the economic activity. Despite such successes, the dotcoms ultimately did not displace the incumbent financial institutions. Rather, these institutions either acquired dotcom providers and/or launched their own online services, all-the-while coupled with expanding ATM services and their overall digital footprint. Moreover, while some institutions initially began to close offices, in the long run, many opened additional offices and expanded both their digital and physical

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can reside on such a device anytime soon. Consequently, such users will be exposed to the vulnerabilities of cellular networks and communication device as well as having to rely on intermediaries with full access to the entire blockchain.

<sup>98</sup> Even learning algorithms do not possess human intelligence. Rather, they simply execute the instructions that they were programmed to follow. For instance, *see* <https://www.wsj.com/articles/why-artificial-intelligence-isnt-intelligent-11627704050> (accessed June 5, 2022).

<sup>99</sup> As physical and information systems, computer-based applications are subject to the laws of entropy. For instance, *see* (Gray, 2011).

<sup>100</sup> For instance, JPMorgan Chase has made a major commitment to blockchain delivered applications (*cf.* <https://www.jpmorgan.com/insights/technology/blockchain> (accessed May 24, 2022)).

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presence.<sup>101</sup> Despite the billions of dollars of investment in dotcoms, the largest financial institutions not only retain their market share, but they also got larger.<sup>102</sup>

### **The Incumbent Service Providers have almost Unlimited Financial and Political Power.**

Additionally, incumbent financial institutions have virtually paralleled financial power. For instance, JPMorgan Chase, the largest U.S. bank had a net income of over \$38 billion in 2021 alone on assets totaling over \$3 trillion.<sup>103</sup> Moreover, the top twenty-five banks in the U.S. had net incomes over \$1.5 billion on assets totaling more than \$150 billion.

As discussed in Section 3.1.1.1 herein, incumbent financial service providers also receive a tremendous amount of governmental support. In many cases, this support intentionally gives them significant advantages over non-financial institutions, whether it is through enacted laws, regulations, or tax incentives. For instance, only state and federal depositories in the U.S. can accept customer deposits, and laws are on the books which allow licensed financial institutions to use these funds essentially interest free.<sup>104</sup> Additionally, state and federal lawmakers have enacted laws that allow licensed financial institutions to charge excessive fees, generate pure profit on float balances, or prohibit non-licensed institutions for certain business activities. For instance, in the U.S., the federal government issues securities only through a small group of financial institutions known as *primary dealers* who then sell them in the secondary market typically at a profit.<sup>105 106</sup>

On top of this, the financial services industry is arguably the most powerful industry in the world politically, even greater than the oil industry in terms of its influence on government policies and laws. For instance, the financial services industry spent an estimated \$500 million in 2021 and over \$10 billion since 1998 on lobbying in the U.S. alone.<sup>107</sup> As such, financial institutions often have an outsized influence on government policies and statutes, essentially using this political power to benefit private interests over those of the public.<sup>108</sup>

Even in the face of the DeFi's potential radical change of the financial services industry, incumbent financial institutions continue to grow larger and more powerful. And as they did during the dotcom boom, they are investing heavily in blockchain-delivered services. While the overall early stage investment in DeFi services topped \$33 billion in 2021,<sup>109</sup> JPMorgan Chase (the largest U.S. bank) has

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<sup>101</sup> Cf. (Hannan & Hanweck, 2008)

<sup>102</sup> Cf. (Corbae & D'Erasmio, 2020)

<sup>103</sup> Cf. <https://www.usbanklocations.com/> (accessed May 24, 2022).

<sup>104</sup> As of the end of 2021, JPMorgan Chase has deposits totaling more than \$2.5 trillion (*id.*).

<sup>105</sup> For a brief description of primary dealers and their role in the U.S. financial system, see <https://www.investopedia.com/terms/p/primarydealer.asp#:~:text=A%20primary%20dealer%20is%20a%20bank%20or%20other,bank%20to%20their%20clients%2C%20creating%20the%20initial%20market> (accessed June 16, 2022).

<sup>106</sup> One of the authors sat on the desk of a primary dealer and in their experience, the Treasury Department believed that the primary dealers help maintain orderly and liquid markets. Even faced with a number of scandals including the Salomon auction scandal in 1991 (cf. <https://www.latimes.com/archives/la-xpm-1991-09-01-op-2246-story.html>), the Treasury Department has continued to issue U.S. treasury securities through the primary dealers.

<sup>107</sup> Cf. <https://www.opensecrets.org/federal-lobbying/sectors/summary?cycle=2021&id=F> (accessed May 23, 2022). Note that these figures do not include campaign contributions.

<sup>108</sup> Cf. <https://voxeu.org/article/finance-and-politics-new-insights> and <https://voxeu.org/article/lobbying-and-financial-crisis> (both accessed May 23, 2022).

<sup>109</sup> Cf. <https://blockworks.co/report-vcs-invested-33b-in-crypto-and-blockchain-startups-in-2021/> (accessed June 17, 2022).

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been extremely active in various blockchain technology-based initiatives during the same time period.<sup>110</sup> JPMorgan Chase's annual technology budget topped \$12 billion in 2021 supporting a staff of around 50,000 technologists.<sup>111</sup>

In short, incumbent service providers are not going to simply rollover and cede their businesses to DeFi startups. These incumbents have more than enough money to build DeFi-like applications themselves as well as fund and/or acquire DeFi providers. Moreover, they have enough political power to have the government erect significant legal and regulatory barriers in addition to the government's own interests to maintain the power to tax, issue debt, and print money. In other words, DeFi service providers not only have to compete with incumbent financial institutions who have immense financial resources at their disposal, but they also have to battle the government as well, and this is no easy task (for a brief discussion of the government's role in the financial system, *see* Section 3.1.1.1 herein).

### **3.1.4 Sociological and Psychological Factors – Building Trust**

Proponents of DeFi rightfully cite the consumers' general mistrust of the incumbent financial system as a key motivator for change. However, people also are naturally resistant to change, especially those that the incumbent financial system has benefited or at least not materially harmed. Also, older people, who tend to resist change generally, typically have a greater fear of technology-based services that have little or no human interaction, which is exactly DeFi's operational paradigm. In other words, it is not reasonable to simply assume that the consumers' mistrust of the incumbent financial system will overcome their mistrust of any replacement. They will need some sort of proof in order to overcome their fear and inertia.

In the following section, we examine some of sociological and psychological reasons for consumers' mistrust of the new with a special emphasis on the apparent benefits of blockchain technology over incumbent financial services.

#### **3.1.4.1 Are DeFi Applications Inherently Trustworthy**

An underlying assumption of DeFi is that a DeFi application is more *trustworthy* than a comparable incumbent financial service. Since incumbent service providers can also deliver their services using blockchain technology, we have to be careful to differentiate trust in the actual services as opposed to trust in blockchain technology.

For instance, proponents point to a number of problems with incumbent financial services (both real and imagined) which are generally aligned with those on the Ethereum website discussed above in Section 2.1.1 herein.<sup>112</sup> However, most of these arguments boil down to the basic claim that DeFi services are free from government and corporate interference and control. Cryptocurrency are issued essentially by the

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<sup>110</sup> For instance, *see* <https://www.bloomberg.com/news/articles/2020-12-10/jpmorgan-using-blockchain-to-move-billions-in-repo-market-trades#xj4y7vzkg>, <https://blockworks.co/jpmorgan-chase-strategically-invests-in-blockchain-focused-trm-labs/>, <https://www.jpmorgan.com/onyx/blockchain-launch.htm>, and <https://www.cnbc.com/2020/10/27/jpmorgan-creates-new-unit-for-blockchain-projects-as-it-says-the-technology-is-close-to-making-money.html#:~:text=Venture%20capital%20funding%20for%20blockchain%20start-ups%20dropped%2035%25,whose%20proponents%20believe%20that%20mainstream%20adoption%20is%20nearing> (all accessed June 17, 2022).

<sup>111</sup> *Cf.* <https://www.jpmorganchase.com/news-stories/tech-investment-could-disrupt-banking> (accessed May 24, 2022).

<sup>112</sup> These also happen to be generally aligned with many libertarian values (*cf.* <https://www.libertarianism.org/what-is-a-libertarian>).



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blockchain ecosystem and are exchanged directly by users without the need of a government or corporate central authority. No personal information is required to use the services and user identities are protected. New financial products and services can be created and used by anyone in the ecosystem.

But is this paradigm inherently *more* trustworthy than incumbent financial services?

To answer this question, we first need to agree on the meaning of “trustworthy.” The Merriam Webster Dictionary defines “trustworthy” as “worthy of confidence, dependable.”<sup>113</sup> Applying this to DeFi, it appears the proponents are claiming that a consumer can have more confidence that a DeFi application will serve their interests without offering material advantages to one cohort over another and that the performance of the application is dependable.<sup>114</sup> However, it is very hard to apply this definition in practice to a particular DeFi application.

For instance, proponents of DeFi can point to the many problems with incumbent services, some of which are listed in Section 2.1.2 herein. However, opponents can just as easily point to high failure rate of DeFi service providers and the extreme volatility of cryptocurrency markets. They can also point to the fact that an estimated eighty percent of DeFi applications are scams resulting in over \$10 billion in losses to consumers in 2021 alone.<sup>115 116</sup>

In a future working paper, the authors propose a formal metric system for measuring the practicality and utility of a particular financial service to make the exercise more objective and concrete. Using such a metric system, we can measure various advantages and disadvantages of a given service paradigm such as performance, cost, societal benefits, and the like. Importantly, with such a metric system we can estimate both a service’s hypothetical and actual capabilities (*i.e.*, what is designed to achieve versus what it actually achieves). For now, however, we only consider the following metrics related specifically to trust:

1. **Reliability** – the degree to which the application performs as expected;
2. **Safety** – the extent to which each user’s financial assets will be protected from loss or harm due to any aspect of the delivery of the service;
3. **Security** – the extent to which personal user data resident in the service for any amount of time will be adequately protected;
4. **Auditability** – the degree to which transactions and changes of state are transparent, immutable, fully logged, archived, and reviewable by the parties to the transactions; and
5. **Financial Risk** – a measure of
  - a. the probability of the occurrence of a material service failure;

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<sup>113</sup> Cf. <https://www.merriam-webster.com/dictionary/trust> (accessed May 27, 2022).

<sup>114</sup> Of course, this ignores the fact that nothing backs cryptocurrency other than the users’ trust. Commodities have some intrinsic value since they can be used for something other than as a unit of exchange or value. Fiat currencies are backed by the government’s ability to tax.

<sup>115</sup> An Investopedia article describes various DeFi scams (*cf.* <https://www.investopedia.com/articles/forex/042315/beware-these-five-bitcoin-scams.asp>) while another Investopedia article estimates that as much as eighty percent of the ICOs as of April 2, 2018, were scams and less than eight percent eventually went operational (*cf.* <https://www.investopedia.com/news/80-icos-are-scams-report/>). The website, [coinopsy.com](https://www.coinopsy.com), lists 2404 non-operating DeFi applications as of this writing that they refer to as dead coins (*cf.* <https://www.coinopsy.com/dead-coins/scam/>). Most of these are listed as “scams or other.” The website, [99bitcoins.com](https://99bitcoins.com), estimates that there are 1705 dead coins as of April 6, 2022 (*cf.* <https://99bitcoins.com/deadcoins/>). Regardless of the exact number, this is an astonishingly high number given that the first DeFi applications (Bitcoin) was only introduced in 2009 (*cf.* <https://www.investopedia.com/articles/forex/121815/bitcoins-price-history.asp>) (all accessed June 17, 2022).

<sup>116</sup> Cf. <https://www.cnn.com/2021/11/19/over-10-billion-lost-to-defi-scams-and-thefts-in-2021.html> (accessed May 27, 2022).

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- b. the possible harm a user may incur in event of such a failure; and
- c. the extent to which that user will have recourse for equitable remuneration.<sup>117</sup>

Additionally, we also apply the standard of “commercially reasonable” to these metrics which, for the purposes of these working papers we define as: “fair, done in good faith, and corresponding to commonly accepted commercial practices.”<sup>118</sup> Here we note that by “commercial practices”, we typically mean “generally-accepted financial services industry customs, practices, and standards of care.”<sup>119</sup> We also note that as defined, the above rubric is somewhat subjective. Again, this is addressed in a future working paper.

**Reliability.** Reliability is a key success for any computer-based application, especially one that processes and records money and other financial assets. However, based on first-hand, personal experience, software development may be one of the hardest human endeavors.<sup>120</sup> It requires a deep understanding of the customs, practices, and standards of care of the business coupled with a deep understanding of applicable technical architectures and paradigms. Moreover, as stated earlier, software is not flexible and only performs what it is programmed to. Errors can result from misunderstand requirements, choosing the wrong technical paradigm, logic and calculation errors, and simple programming mistakes. The cause of such errors can be obvious, or only manifest given a very particular set of conditions. And, to make matters worse, software is not self-correcting. Bugs and other discrepancies have to be manually verified and corrected, which can take significant time.

Besides errors, users are often frustrated by an application’s user interface, which are often unintuitive and awkward. Consequently, such user interfaces have to be carefully thought out, user tested, and well implemented to increase the adoption rate and overall utility.

None of this is easy, and software engineers have spent considerable time and resources developing tools and procedures to make software development more successful and dependable.<sup>121</sup> As such, there are myriad development methodologies and frameworks which span the gambit, from well-established software development life cycles to those supporting continuous development, which is commonly used by big social media companies. Regardless of the particular software development paradigm, they typically employ some sort of independent oversight and testing, which is an anathema in the eyes of DeFi as discussed in Section 3.1.4.4 below.

Another critical issue is experience, or more accurately, the lack thereof. Based on the authors’ experience, the vast majority of DeFi startups lack managers and staff with any meaningful financial services experience. In fact, technical skills are often much preferred to industry experience. This is dangerous for several reasons, not the least of which is the financial services industry reliance on the oral tradition.

Much of the processing performed in the financial services industry today evolved from manual processing associated with a particular financial market or type of financial institution. U.S. equities have different processing conventions than those in the U.K. The processing of equities is typically different than that of fixed income securities. Banks typically have different processing standards than those of

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<sup>117</sup> These parallel the well-known risk metrics: the probability of default (“PD”), the exposure at default (“EAD”), and the loss given default (“LGD”) (Bandyopadhyay, 2016).

<sup>118</sup> Cf. <https://www.merriam-webster.com/legal/commercially%20reasonable> (accessed May 27, 2022).

<sup>119</sup> The authors note that this is the standard they generally apply when giving expert testimony.

<sup>120</sup> The authors have owned and operated fintech software development companies.

<sup>121</sup> For a good overview of software development, see <https://www.ibm.com/topics/software-development> (accessed June 6, 2022).

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brokerages and so on. Moreover, these difference generally have been codified in various statutes and regulations. As such processing was integrated into single software platforms (*i.e.*, ones that could process U.S. and U.K. equities, fixed-income securities, bank-related businesses and brokerage-related business), much of the arcane, market-specific processing conventions was incorporated into the code with little or no documentation.

For instance, financial markets in the U.S. operate on different business calendars. The equities markets are open on many federal holidays while the bond markets are closed.<sup>122</sup> Similarly, financial markets typically have different operating hours and an individual market may have one or more “early closes” such as the day following Thanksgiving.<sup>123</sup>

As another example, equities may trade on an *as agent* basis in which a broker places an order on behalf of customer but does not commit its own capital. If the trade is executed, a commission is added to the settlement price to compensate the broker. On the other hand, the bond market does not have such a convention since it is an OTC market. Here, a broker executes a customer bond trade with a third party using what is known as a *back-to-back trade*. This consists of two simultaneous trades (typically with the same settlement date) the first being between the broker and the third party and the second between the broker and the customer. In this second trade, the broker is acting as a *riskless principal* (indicating that none of his capital is at risk), and the settlement price is adjusted to reflect a commission.<sup>124</sup>

These are only two of the literally tens of thousands of arcane and little known standards that are incorporated into incumbent financial service delivery platforms, many following a failure of the platform to process the standard correctly. Consequently, having to build DeFi applications essentially *de novo* dooms many of them to repeat the same mistakes from the past as the applications mature. This will be little (if anything) to build trust in such applications.

**Safety, Security, and Auditability.** Proponents of DeFi point to the extensive use of cryptography, consensus mechanism, and replication (all native to blockchain technology) as testament to its safety, security, auditability. However, they generally ignore the other elements of the application ecosystem such as public networks and nodes which interact with the blockchain and which have proven vulnerable to hackers. Additionally, they dismiss out of hand the possibility that 51 percent of users could conspire to take advantage of the other 49 percent and generally seem to ignore that there are bad actors out there.<sup>125</sup> They also ignore the huge losses to fraud that users of DeFi applications have already suffered as well as the risks associated with the lack of government oversight and access to the courts. All of this on its face, makes DeFi applications appear to be riskier than incumbent services, at least in theory.

Putting aside these anecdotal arguments (many of which are misleading or plain wrong), there simply is little or no hard evidence that DeFi applications are actually safer, more secure, and have better auditability the incumbent services at this time.

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<sup>122</sup> Cf. <https://www.marketbeat.com/stock-market-holidays/> and <https://www.marketbeat.com/bond-market-holidays/> (both accessed June 6, 2022).

<sup>123</sup> *Id.*

<sup>124</sup> Some may question why all this necessary for bond trades and not simply apply the same conventions as the equity markets. The answer is simple: to protect anonymity. Since equity trades novate to a central clearinghouse, the true counterparties remain unknown to each other. However, bonds settle directly between counterparties, and anonymity can only be achieved by keeping the broker in the middle.

<sup>125</sup> While this may seem farfetched, the Bitcoin fork that took place in 2017 created essentially two different Bitcoin blockchains (cf. <https://www.bitdegree.org/crypto/tutorials/bitcoin-fork> (accessed June 16, 2022)).

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**Financial Risk.** Above we considered three aspects of the financial risk consumers face when using a given financial service. The first of these was the likelihood that service will suffer some material failure. Such a failure could be localized to a specific user or user community, or it could be service-wide. Due to the nature of software development, it is widely accepted that newly released software is more prone to failure than seasoned code. Of course, adhering to proven software development customs, practices, and standards of care can greatly improve the performance of new software, but it is natural that more discrepancies will come to light when it is used in true production environment. Consequently, it is reasonable to believe that DeFi applications will represent more operational risk than incumbent services, which often have backup capabilities and alternative means of delivery.

The second aspect of risk that we listed was the potential harm that consumers may suffer in the event of a failure. For instance, it is common for newer code to have lots of little bugs that are more of an annoyance than anything else, while the occurrence of failures in seasoned code tend to be much less common, but more arcane and harmful when they do occur. However, there have already been a number of high-profile DeFi application failures that caused quite a bit of harm, in addition to showing some of the weaknesses of smart contracts.<sup>126</sup>

Perhaps the biggest problem that DeFi faces when it comes to trust is the lack of recourse. Users simply have no means to seek remedy of any harm they may have suffered due to problems with the delivery of a particular service.<sup>127</sup> It is hard to see how the general population will trust a service, especially a financial service, if they have no protection of financial loss in the event of system malfunction or outright failure.

Lastly, it is worth noting that DeFi represents an entirely different and substantially greater risk than incumbent services. No matter how flawed they might be, there are no regulators, government agencies, corporate boards, auditors, courts, law enforcement, or any other forms of supervision and oversight that people have relied on to protect their interests. Without replacing this with something more practicable than smart contracts and self-governance, it would be naïve and wrong to simply assume that DeFi applications are inherently more trustworthy. Rather, each application must be assessed individually using a rigorous and unbiased metric system before making any claims regarding its trustworthiness.

### **3.1.4.2 Change for Change's Sake is Not Always for the Good**

As discussed in Section 2.1.2 above, there is ample justification for the general lack of trust in the current financial system on the part of consumers, and change is needed, especially for the disenfranchised. However, change alone is no guarantee it will be for the better. While DeFi may displace some sectors of the incumbent financial system, it is not clear what benefits (or harm) will actually result. Replacing one despot with another changes nothing in the long run and could possibly make matters worse.

For instance, it is generally accepted that automated order processing and execution is a significant improvement over voice markets. It has also helped make financial markets more accessible and equitable for the general consumer. Further, it is also clear that such automation has benefited the financial system as a whole since it has increased liquidity and reduced systemic risk overall. However, it has also helped

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<sup>126</sup> For instance, *see* <https://payspacemagazine.com/blockchain/3-famous-smart-contract-fails/> and <https://applicature.com/blog/blockchain-technology/smart-contract-mistakes-bugs-pitfalls> (both accessed June 16, 2022).

<sup>127</sup> This brings up an interesting legal question: does operating outside of a corporate entity expose developers and particular classes of users to legal jeopardy as individuals since they are no longer protected by the corporate veil? For a deeper discussion on this topic, *see* <https://corpgov.law.harvard.edu/2018/05/26/an-introduction-to-smart-contracts-and-their-potential-and-inherent-limitations/> (accessed June 16, 2022).

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to create significant advantages for a handful of financial institutions engaged in a very specialized form of electronic trading known as *high-frequency trading* (“HFT”).<sup>128</sup>

Although the theory underlying HFT is outside the scope of these working papers, properly executing such a strategy virtually guarantees an extremely small profit from each trade. However, to be economically viable, these trades must be made very frequently (hence the name) in exceptionally large volumes requiring sub-second execution times. As such, the typical HFT strategy requires the use of complex mathematical models to identify profit opportunities and extremely expensive computer equipment to process and submit orders.<sup>129</sup> This is beyond many professional investors, much less the average investor. As such, it is clear that HFT created an even greater inequity despite the fact that electronic execution may have helped democratize the securities markets. The lesson here is that changes to the financial systems that benefit one cohort or even the entire financial system may unintentionally disadvantage others.

Putting this lesson aside for the moment, one of the most obvious failings of DeFi is that it assumes (at least implicitly) that incumbent services providers are the cause of many, if not most of the problems found in current financial systems. Consequently, replacing them with a DeFi service will cure such problems. But this is based on two critical assumptions:

1. Blockchain technology *in-and-of-itself* can solve many of the problems caused by incumbent service providers and delivery methods *without* causing others; and
2. Where it cannot, DeFi users will act in good faith to solve them equitably and fairly.

While we discuss both of these assumptions in a future working paper, each of these seem fundamentally flawed and naïve at best. The authors are not aware of examples of merely automating or self-governing a manually intensive process curing its ills. While technology can make many processes more efficient and less error prone, not every process or procedure lends itself to automation, especially those of which involve a great deal of human interaction and creative thinking. And even if technology could be universally applied to the delivery all financial services without the need for human interaction, technology introduces new classes of risk and uncertainty as discussed throughout this working paper.

We note that a critical question is whether DeFi is the best agent for change if changes to the financial system are warranted. This is discussed at length in a future working paper.

### **3.1.4.3 Is it Worth Investing in DeFi?**

As discussed in Section 3.1.3 above, in order for DeFi to truly revolutionize the financial system, it will have to successfully compete with established incumbent service providers across a broad array of services. This will require a significant number of DeFi applications servicing millions of consumers. This, in turn, will require a substantial investment in both time and money, and a basic question is: is such an investment worthwhile?

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<sup>128</sup> While as much as 55 percent of trading volume in U.S. equity markets is due to HFT, it is thought that only a couple of dozen firms frequently exchange in HFT. For instance, the CFTC/SEC report discuss the flash crash of May 6, 2010, lists only twelve firms engaged in HFT at the time after a review of FINRA reports (CFTC and SEC, 2010).

<sup>129</sup> Many HFT trading shops locate their computer equipment in the same building that house the exchange’s systems, thereby avoiding the use of wide-area networks (WAN) which are typically much slower than a local-area networks (LAN).

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Despite the amount of money invested in cryptocurrency and the amount capital being invested in early stage DeFi startups, DeFi is only in its infancy, and it is far from certain that DeFi will be successful beyond a few niche applications. Moreover, unlike the typical fintech company which fits a traditional, well-accepted startup model, the economics of launching and operating a DeFi application are fuzzy at best. Even the concept of ownership and legal status is an issue since many DeFi applications have no owners and operate as software, not a company with traditional ownership (Lehmann, 2020). Consequently, it is not clear what developers and early stage investors can reasonably expect in the way of returns from launching a DeFi application.

To better understand this, an early-stage investor's primary concern is typically the internal rate of return ("IRR") on their investment. This calculation basically a discounted cash flow of revenues less expenses associated with starting up and operating the business up to an expected exit time with expenses typically dominating the early years. Investors usually receive equity in the venture as well as other considerations for their investment. As the service matures, profits are used to repay the investors either directly or through some exit event such as initial public offering (IPO) or sale of some or all of the company.

Another important investment consideration is the amount of investment risk. Specifically, what is the risk that the investment will not meet the investor's IRR target? This is typically estimated using a formal business plan and an associated *pro forma* financial projection as baseline. Following the well-accepted principals of security analysis, a key risk mitigant is the quality of management team and the commitment of ownership.<sup>130</sup> Quite simply, it is generally believed that an experienced management team with skin in the game will do a better of meeting or exceeding expectation. A second mitigant is the experience of the development team, along with the efficacy of the development methodology and the project management. Again, it is generally believed that an experienced development team using proven development tools facilitated by sound project management will be more successful than a loosely organized group of developers, no matter how good they might be individually.

Now consider the most extreme case espoused by proponents of DeFi, in which the service is not a legal entity, but merely software. Typically, such software is developed and operated under a *permissive open source* license with virtually no restrictions on what unrelated parties can do with the code (Whitesource, 2022). Additionally, such software typically does not have owners and therefore does not need to generate profits. If the service is fully decentralized, there is no need for employees, equipment, facilities, or other costly elements of the typical commercial enterprise. Further, it can run over an existing blockchain such as Ethereum to further reduce startup and operating costs. Moreover, the service can essentially print tokens or cryptocurrency to pay for mining, software development, network costs, and other required services. This essentially passes these costs onto holders of the native token or cryptocurrency. Since it is fully decentralized, the service will not require highly paid management. Rather, it can be run by a consensus of users much in the same way that the blockchain is maintained. Consumers will be incited to use such services since they will receive quality services at the lowest price. Moreover, as users, they will have a say in the management of the service, even more so if they are also a developer of the application's open source code.<sup>131</sup>

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<sup>130</sup> For the landmark text on security analysis, *see* (Graham & Dood, 2008).

<sup>131</sup> This is not as farfetched as it seems since it is essentially the Bitcoin model. For instance, *see* <https://fee.org/articles/the-ideological-origins-of-bitcoin/#:~:text=The%20Philosophy%20Behind%20Bitcoin%20Operating%20as%20an%20open-source,a%20network%20of%20nodes%20and%20protected%20through%20cryptography> (accessed May 23, 2022).

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Putting aside whether such a scenario is actually realistic for the moment, this extreme case presents a chicken and egg dilemma. Software typically has a high startup cost. However, in the case of pure DeFi applications, there are no operating profits generated by the business to compensate early-stage investors. Consequently, many DeFi startups have issued initial coin offerings (“ICO”) and initial token offerings (“ITO”) to attract outside investment.<sup>132</sup> Essentially, coins and tokens are issued at discount to entice buyers, particularly those who might use the service. In other words, the payback to early stage investors is in the form of the appreciation in the value of the native token or cryptocurrency due to market forces.

However, estimating the future value of an as-yet to be issued token or cryptocurrency is extremely difficult, since their value are driven mostly by speculation than anything else. This is especially problematic given the current appetite for anything DeFi, which has the effect of inflating value. Additionally, there is no reasonable assurance that the venture will become operational, much less succeed. In fact, some estimates are as low as eight percent that a DeFi application will be successful enough to pay off its initial investors, and up to 80 percent are scams (Dowlat, 2018).<sup>133</sup> Given this, it is hard to envision significant investment continuing in DeFi startups once the current hype fades away.

### **3.1.4.4 Governance and Risk Management**

By their very nature, DeFi applications require a governance model that is significantly different from those used in the incumbent financial services industry and the financial system generally. This is especially concerning given the many new and expanded risks that DeFi represents as discussed throughout this working paper. In the configuration many proponents promote, a DeFi application would lack central authorities of any kind, not just intermediaries. Specifically, it would have virtually no corporate, government, regulatory, or other forms of third-party oversight over its development and subsequent use. Consequently, any governance of the development, delivery, and use of that application would have to be left to its developers and users. This is essentially a pure self-governance (a.k.a. self-regulation) model in which the team developing the service and the user community are also (and solely) responsible for ensuring its quality and safety. In particular, there are no dedicated control organizations that are typically found in an incumbent services provider. The scope of such self-governance includes not only the development of the application, its processing, and the information it uses and generates, but also its technical artifacts such as tokens, the blockchain database, the network, nodes, node applications such as digital wallets, consensus algorithms, and the like.<sup>134 135</sup>

To better understand the impact that such a governance model may have on the overall financial system as well as on a particular service, it is helpful to review some aspects of generally-accepted governance practices, customs, and standards of care currently found in the incumbent financial services industry noting various strengths and weaknesses along the way.

**Traditional Corporate Governance.** Corporate governance is a mature, well-understood practice in the incumbent financial services industry, and there is little debate regarding its value or effectiveness.<sup>136</sup> For

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<sup>132</sup> They have also used open source software to reduce development costs and time, as well as crowdfunding, to attract outside investments.

<sup>133</sup> Cf. <https://www.investopedia.com/news/80-icos-are-scams-report/#:~:text=80%25%20of%20ICOs%20Are%20Scams%3A%20Report%20By%20Shobhit,the%20trading%20stage%20on%20the%20various%20cryptocurrency%20exchanges> (accessed May 24, 2022).

<sup>134</sup> Cf. <https://101blockchains.com/blockchain-ecosystem/> (accessed May 27, 2022).

<sup>135</sup> Together, along with the various classes of users, this is sometimes referred to as the blockchain ecosystem.

<sup>136</sup> There are well-established governance organizations and hierarchies as well as policies, processes, and procedures that are used throughout the industry such as those set forth in the Office of the Comptroller of the

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the purposes of these working papers, we define **governance** as the role that the board of directors and management play in establishing and supervising the way in which a particular organization operates. This is typically codified in a well-defined system of rules, practices, policies, and procedures directing and controlling that operation, which is typically audited by independent control organizations.<sup>137</sup> In other words, corporate governance is not simply an oversight function. Rather, it represents specifying the overall business architecture and rules supporting the delivery of particular service complete with embedded controls and independent oversight.

It is widely accepted that internal controls play a, if not *the*, central role in an effective governance program. To a great extent, these have been informed by lessons learned following past industry failures and crisis such as those discussed in Section 2.1.2 above, which, in many cases, resulted in regulations promulgated by government and industry regulators. Importantly (and often overlooked), these controls must be carefully designed to maintain the correct balance between safety and efficiency. Consequently, they must be continuously monitored and evaluated to ensure that they are still effective and modified or replaced if they are found wanting.

A core tenet of governance in the incumbent financial services industry is commonly referred to as the **segregation of duties**. Under this doctrine, supervising organizations act independently from business units, especially those involved in revenue generation. Such organizations found in the typical financial institution include:

1. **Compliance** – this group is responsible for ensuring that the financial institution is knowledgeable of and in compliance with all applicable rules, regulations, and guidelines. This group typically reads all pertinent information regarding existing and proposed rules and regulations, drafts internal policies and procedures related to applicable rules, regulations, and guidelines, staff education and training, and working with internal organizations and regulators as needed;
2. **Internal Audit** – this group is responsible for assessing all aspects of the business to ensure it is compliance with the internal policies and procedures;
3. **Financial Control** – this groups is responsible for ensuring that the organization’s book-and-records and financial reporting are correct;
4. **Risk Management** – this group is responsible for identifying sources of risk, independently measure and report the firm’s exposure to each risk factor, and work with the various business units to reduce any unwanted risk exposure where risk is usually classified as:<sup>138</sup>
  - a. **Market risk** – the risk of a financial loss due to adverse market or price movements;
  - b. **Credit risk** – the risk of a financial loss due to a borrowers’ inability or unwillingness to meet their obligations; and
  - c. **Operational risk** – the risk of a financial loss due to operational or technical failures.<sup>139</sup>

If the enterprise is large, it is common to find such supervising organizations within each of the key business divisions and departments, especially information technology (“IT”) as well as enterprise-wide.

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Currency (“OCC”) pamphlet, “Corporate and Risk Governance” (Office of the Comptroller of the Currency, 2019).

<sup>137</sup> Cf. <https://www.investopedia.com/terms/c/corporategovernance.asp> (accessed June 6, 2022).

<sup>138</sup> This classification is consistent with the standards set forth in what is known as the “Basel II Accords” as defined by the BIS’s, Basel Committee on Banking Supervision (Basel Committee on Banking Supervision, 2005).

<sup>139</sup> This often includes both legal risk (i.e., losses due to legal action) and regulatory risk (i.e., losses to regulatory actions).



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The other major supervising organizations are the various management committees as well as the board of directors.

Similarly, technology organizations also employ a similar independent governance structure under the moniker, “Quality Management,” which often consists of the following organizations:<sup>140</sup>

1. **Quality Assurance** – this group is typically tasked with putting in place policies and procedures preventing the existence of bugs and other defects in the technology;
2. **Quality Control** – this group is typically tasked with measuring the performance of the technology in production with an eye to improving it; and
3. **Project/Program Management** – this group is typically tasked with coordinating and overseeing the development of new technology as well as modifications to existing technology. Change management is critical component of this function.

Given the complexity of many fintech applications, a number of financial institutions and technology vendors have implemented enterprise-wide operational risk and compliance programs that put these control functions in more strategic context.

We now turn to some of the governance challenges facing DeFi applications.

**Democracy is Not Always the Best Governance Model.** While the democratization of the financial system is very laudable goal, it is pretty clear from past performance that democratic self-governance may not be the most effective form. For instance, in the typical DeFi operating model, users determine most, if not all changes to a DeFi application including state changes, data modification, when to introduce changes to the code, etc. However, this requires that all users take the time to study each of the proposed changes, have the ability to understand their ramifications, act rationally, and work in the best interests of the community and not simply for themselves. This is simply unrealistic, as many philosophers from the classical Greek era understood.<sup>141 142</sup> But even if this is achievable, it does not ensure that the majority’s opinion is correct.

Looking to classical Greece once more, Socrates was charged with the crime of corrupting the youth of Athens. However, his true “crime” was criticizing the Athenian democratic form of government and upsetting those in power because of it. Although the charges were false, he was convicted by a democratic jury of five hundred Athenians and subsequently executed.<sup>143</sup>

We could also look at more modern failed political systems such as the Soviet Union. In fact, there are many similarities between Marxist theory and the ideals of DeFi. Unfortunately, as the Soviet Union showed, it only takes a few bad actors to destroy those ideals and make the government serve their interests rather than those of population as a whole. The fact that estimates as high eighty percent of DeFi startups to be scams seems to confirm this.<sup>144</sup>

Putting lofty philosophic and political arguments aside, we need only look at few technology-based applications which rely extensively on user consensus. Take Wikipedia for instance. The online

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<sup>140</sup> The principles guiding quality management are set forth in the International Organization for Standards standard, ISO 9000 (ISO, 2015).

<sup>141</sup> For instance, *see* [https://www.bbc.co.uk/history/ancient/greeks/greekcritics\\_01.shtml](https://www.bbc.co.uk/history/ancient/greeks/greekcritics_01.shtml) (accessed May 25, 2022).

<sup>142</sup> In fact, the founding fathers of the U.S. understood many of the weaknesses of pure democracy and advocated for a constitutional democracy which limited the power of the government and offered protections for the minority (Adagbabiri, 2015).

<sup>143</sup> *Cf.* <https://historyofyesterday.com/how-democracy-killed-socrates-1062fb4a626d> (accessed May 25, 2022).

<sup>144</sup> *See* fn. 115 herein.

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encyclopedia relies on users to provide content as well as edit content provided by others, in what is essentially a purely democratic process on its face. However, the authors' have seen numerous biographical entries which they know contain incorrect factual information or are misleading at best. Additionally, the authors corrected a factual error on a page discussing a company they founded and ran. A few days later, that correction was removed. After a number of back-and-forths, they discovered that this was being done by a high school student with no direct knowledge of their business. Eventually, the authors simply gave up and let the factual error stand.

The development of DeFi applications face additional challenges given the extensive use of open source software, especially software that is maintained by the public at large.<sup>145</sup> The authors have no bias for or against open source.<sup>146</sup> It depends greatly on the particular application and development methodology in question. Financial regulators have also accepted the use of open source and have published various papers concerning its use and risk management.<sup>147</sup> However, the use of open source in DeFi applications is not limited to a few system primitives, but it constitutes the entire application. This, in turn, leads to number of critical issues. This is especially true given that the code is developed by a loosely managed open source community without a central authority and operates under a self-governance model.<sup>148</sup>

Proponents of DeFi point to the transparency of the open source as a means to ensure its safety and integrity. This is seemingly not practical. Anyone who has tried to read another's person code knows it is difficult at best, even it is well documented. It is virtually impossible given a complex application consisting of dozens or hundreds of routines. Moreover, given the amount of cryptocurrency and other financial assets resident in the typical DeFi application, it is criminally naïve to believe that bad guys will not try to game the system by introducing problematic code. In order for the DeFi application model to be reasonable and feasible, the application developers will have to provide the user community with sophisticated tools and data to ensure the application's safety and integrity beyond simply code walk-throughs.

In conclusion, there are still many open questions regarding the practicality and utility of DeFi. While substantial changes to financial systems may be warranted, it is not clear that DeFi is best in some (and certainly not in all) cases. Further, much of the current excitement around DeFi appears to be virtually in lockstep with the political and social populism that questions everything from incumbent power structures to basic scientific facts. Coupled with the current fintech IPO fever, there is reason to doubt the true viability of DeFi in both the near and long term. Rather than merely reciting dogma, the positive and negative impacts of each DeFi application must be carefully considered before anything can be said regarding its safety and efficacy. Importantly, this must be done not only with regard to a specific service, both in the context of the overall financial system as well. In the next working paper in the series, the

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<sup>145</sup> One of the authors has a great deal of experience with this issue having built one of the first UNIX-based trading systems used on Wall Street. In the mid-1980's, the most accessible form of UNIX was licensed through the Santa Cruz Operation ("SCO") and based on code developed primarily at UC Berkeley (note that the author's office mate at Berkeley was Bill Joy, one of the founders of Sun Microsystems). It was quite common in those days to contact the developer of a specific UNIX routine and discuss problems and potential improvements. Finding and fixing bugs in the UNIX code was just part of the overall software development process.

<sup>146</sup> For a good discussion of the pros and cons of open source development, *see* <https://www.noupe.com/development/open-source-development.html> (accessed June 6, 2022).

<sup>147</sup> For instance, *see* <https://www.fdic.gov/news/financial-institution-letters/2004/FIL11404a.html> (accessed June 6, 2022).

<sup>148</sup> For an introduction to open source communities, *see* <https://www.agiledrop.com/blog/power-open-source-communities> (accessed June 6, 2022).

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authors present a formal metric system for just such an assessment which incorporates a number of key measures from a variety of perspectives.

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