Artificial Intelligence in Finance and Quantitative Analysis

AI in FinTech: Metaverse, Web3, DeFi, NFT, Financial Services Innovation and Applications

Min-Yuh Day, Ph.D, Associate Professor

Institute of Information Management, National Taipei University

https://web.ntpu.edu.tw/~myday

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Tue 2, 3, 4 (9:10-12:00) (B8F40)

https://meet.google.com/paj-zhhj-myA
<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Subject/Topics</th>
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<tbody>
<tr>
<td>1</td>
<td>2022/09/13</td>
<td>Introduction to Artificial Intelligence in Finance and Quantitative Analysis</td>
</tr>
<tr>
<td>2</td>
<td>2022/09/20</td>
<td>AI in FinTech: Metaverse, Web3, DeFi, NFT, Financial Services Innovation and Applications</td>
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<td>3</td>
<td>2022/09/27</td>
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<td>Event Studies in Finance</td>
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<td>2022/10/11</td>
<td>Case Study on AI in Finance and Quantitative Analysis I</td>
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<td>2022/10/18</td>
<td>Finance Theory</td>
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## Syllabus

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<th>Date</th>
<th>Subject/Topics</th>
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<td>Data-Driven Finance</td>
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<td>2022/11/01</td>
<td>Midterm Project Report</td>
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<td>2022/11/08</td>
<td>Financial Econometrics</td>
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<td>10</td>
<td>2022/11/15</td>
<td>AI-First Finance</td>
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<td>11</td>
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<td>Industry Practices of AI in Finance and Quantitative Analysis</td>
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<td>12</td>
<td>2022/11/29</td>
<td>Case Study on AI in Finance and Quantitative Analysis II</td>
</tr>
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## Syllabus

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<tr>
<th>Week</th>
<th>Date</th>
<th>Subject/Topics</th>
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<tbody>
<tr>
<td>13</td>
<td>2022/12/06</td>
<td>Deep Learning in Finance; Reinforcement Learning in Finance</td>
</tr>
<tr>
<td>14</td>
<td>2022/12/13</td>
<td>Algorithmic Trading; Risk Management; Trading Bot and Event-Based Backtesting</td>
</tr>
<tr>
<td>15</td>
<td>2022/12/20</td>
<td>Final Project Report I</td>
</tr>
<tr>
<td>16</td>
<td>2022/12/27</td>
<td>Final Project Report II</td>
</tr>
<tr>
<td>17</td>
<td>2023/01/03</td>
<td>Self-learning</td>
</tr>
<tr>
<td>18</td>
<td>2023/01/10</td>
<td>Self-learning</td>
</tr>
</tbody>
</table>
AI in FinTech:
Metaverse,
Web3, DeFi, NFT,
Financial Services
Innovation and Applications
FinTech ABCD

AI
Block Chain
Cloud Computing
Big Data
Decentralized Finance (DeFi)
Block Chain Financial Technology

Block Chain & Bitcoin (BTC)

Smart Contract & Ethereum (ETH)

Decentralized Application (DApp)
Metaverse Development from 1991 to 2021

Web3: Decentralized Web

Internet Evolution

**Web 1.0**
1900s–2000
Static read-only web pages

**Web 2.0**
2000s–2020s
Information-centric and interactive

**Web 3.0**
2020s–?
User-centric, decentralized, private, and secure

Source: https://www.businessinsider.com/personal-finance/what-is-web3
Metaverse Economy

Blockchain in the Metaverse

Blockchain for Key Enabling Technologies of the Metaverse

Seven Layers of a Metaverse Platform

Layered Architecture of Blockchain

**Data Layer**
- Data block
- Chain Structure
- Timestamp
- Hash function
- Merkle tree
- Asymmetric encryption

**Network Layer**
- P2P Network
- Transmission mechanism
- Verification mechanism

**Consensus Layer**
- PoW
- PoS
- Dpos

**Incentive Layer**
- Issuance mechanism
- Distribution mechanism

**Contract Layer**
- Javascript
- Algorithm Mechanism
- Smart Contract

**Application Layer**
- Programmable (Currency, Finance, Social)

**Distributed Ledger**
- Realize the value exchange
- Reward blockchain nodes
- To solve the transaction credit problems
- Communication
- Data transmission

Primary Technical Aspects in the Metaverse

AI with ML algorithms and DL architectures is advancing the user experience in the virtual world.

Fusion of AI and Blockchain in Metaverse

DeAI: Synthesizing On-device AI, Edge AI, and Cloud AI

Smart Virtuality-Reality Metaverse Ecosystem: Metasynthesizing DeAI, Metaverse, Blockchain, Web3

The difference between AR, MR, and VR under the umbrella of XR

Extended Reality
- Entire experience spectrum from fully virtual to fully real

Virtual Reality
- User is completely immersed into a virtual world

Mixed Reality
- Environment aware
- 2D/3D content is overlaid onto the physical space

Augmented Reality
- Non-environment aware
- 2D/3D content is overlaid onto the physical space

Computer vision in the metaverse
with scene understanding, object detection, and human action/activity recognition

A Blockchain-based IoT Framework with ML to enhance security and privacy

5G and beyond for Metaverse Services
AI with ML algorithms and DL models contribute in multi-level tasks

A Data-Driven Digital Twin Architecture
for intelligent healthcare systems using ML to process raw data of IoMedicalThings devices

Brain-Machine Interfaces (BMIs) for processing neural signals and responding neural stimulations

## AI for the Metaverse

<table>
<thead>
<tr>
<th>Technical Aspect</th>
<th>Ref</th>
<th>Task</th>
<th>AI Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>NLP</td>
<td>[20]</td>
<td>Word and linguistic prediction for language modeling.</td>
<td>RNNs and LSTM networks with the attention mechanisms.</td>
</tr>
<tr>
<td></td>
<td>[25]</td>
<td>Analyzing and understand the representation of words from characters</td>
<td>General deep networks with CNN and LSTM architectures.</td>
</tr>
<tr>
<td></td>
<td>[27]</td>
<td>Identifying prefixes and suffixes and detecting mis-spelled words</td>
<td>DL framework with CNN, Bi-LSTM, and conditional random field.</td>
</tr>
<tr>
<td></td>
<td>[29]</td>
<td>Sentiment prediction and question type classification.</td>
<td>Various CNNs and LSTM networks with simple structures and advanced-designed architectures.</td>
</tr>
<tr>
<td></td>
<td>[31]</td>
<td>Generate short text in image captioning and long text in virtual question answer.</td>
<td>DL framework with single RNN/LSTM and mixture LSTM-CNN models.</td>
</tr>
</tbody>
</table>

AI for the Metaverse in the Application Aspects

healthcare, manufacturing, smart cities, gaming
E-commerce, human resources, real estate, and DeFi

Conversational AI to deliver contextual and personal experience to users

Blockchain-Registered: Crypto, Collectables, and Art.

Fungible

- Crypto
  - Currencies
    - Funds

Non-Fungible

- Collectable
  - Non-Digital
  - Digital
    - Algorithmic
    - Artistic

- Fine Art

Full Versus Fractional [NFT] Property Ownership Rights for an Artwork

<table>
<thead>
<tr>
<th>RIGHTS</th>
<th>Full Ownership</th>
<th>NFT (Fractional Ownership)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sell or dispose of</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Manipulate or modify</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Exclude Others</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Copyright</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Intellectual property</td>
<td>No</td>
<td>Possibly with some NFTs</td>
</tr>
<tr>
<td>Income from</td>
<td>Yes</td>
<td>Mostly no</td>
</tr>
<tr>
<td>Artist Resale (% for artist)</td>
<td>No</td>
<td>Possibly yes</td>
</tr>
</tbody>
</table>

Combination of Web3 with other Technologies

FinTech
Financial Technology

FinTech

“providing financial services by making use of software and modern technology”

Source: https://www.fintechweekly.com/fintech-definition
Financial Technology
Financial Services
Artificial Intelligence (AI)
Evolution of Computerized Decision Support to Analytics/Data Science

The timeline in Figure 1.8 shows the terminology used to describe analytics since the 1970s. During the 1970s, the primary focus of information systems support for decision making focused on providing structured, periodic reports that a manager could use for decision making (or ignore them). Businesses began to create routine reports to inform decision makers (managers) about what had happened in the previous period (e.g., day, week, month, quarter). Although it was useful to know what had happened in the past, managers needed more than this: They needed a variety of reports at different levels of granularity to better understand and address changing needs and challenges of the business. These were usually called management information systems (MIS). In the early 1970s, Scott-Morton first articulated the major concepts of DSS. He defined DSSs as "interactive computer-based systems, which help decision makers utilize data and models to solve unstructured problems" (Gorry and Scott-Morton, 1971). The following is another classic DSS definition, provided by Keen and Scott-Morton (1978):

Decision support systems couple the intellectual resources of individuals with the capabilities of the computer to improve the quality of decisions. It is a computer-based support system for management decision makers who deal with semistructured problems.

Note that the term decision support system, like management information system and several other terms in the field of IT, is a content-free expression (i.e., it means different things to different people). Therefore, there is no universally accepted definition of DSS.

During the early days of analytics, data was often obtained from the domain experts using manual processes (i.e., interviews and surveys) to build mathematical or knowledge-based models to solve constrained optimization problems. The idea was to do the best with limited resources. Such decision support models were typically called operations research (OR). The problems that were too complex to solve optimally (using linear or nonlinear mathematical programming techniques) were tackled using heuristic methods such as simulation models. (We will introduce these as prescriptive analytics later in this chapter and in a bit more detail in Chapter 6.)

In the late 1970s and early 1980s, in addition to the mature OR models that were being used in many industries and government systems, a new and exciting line of models had emerged: rule-based expert systems. These systems promised to capture experts’ knowledge in a format that computers could process (via a collection of if–then–else rules or heuristics) so that these could be used for consultation much the same way that one...
Value Creation by Big Data Analytics
(Grover et al., 2018)

Value Manifestation

- Strategy
- Leadership
- Technology
- Industry
- Trust
- Governance Support
- Competitive Dynamics
- Data-Driven Culture

Moderating Factors

- BDA Infrastructure
  - Big Data Asset
  - Analytics Portfolio
  - Human Talent
- BDA Capabilities
  - Ability to integrate, disseminate, explore, and analyze big data

Direct value from BDA

Value Creation Mechanisms
- Transparency and access
- Discovery and experimentation
- Prediction and optimization
- Customization and targeting
- Learning and crowdsourcing
- Continuous monitoring and proactive adaptation

Value Targets
- Organization Performance
- Business Processes Improvement
- Products & Services Innovation
- Consumer Experience & Market Enhancement

Impact
- Functional Value
- Symbolic Value

Learning by Doing (Coevolutionary Adaptation)

Investments → Assets → Capabilities → Applications → Targets → Impacts → Value

Architecture of Big Data Analytics

Big Data Sources
- * Internal
- * External
- * Multiple formats
- * Multiple locations
- * Multiple applications

Big Data Transformation
- Middleware
- Extract Transform Load
- Data Warehouse
- Traditional Format CSV, Tables

Big Data Platforms & Tools
- Hadoop
- MapReduce
- Pig
- Hive
- Jaql
- Zookeeper
- Hbase
- Cassandra
- Oozie
- Avro
- Mahout
- Others

Big Data Analytics Applications
- Queries
- Reports
- OLAP
- Data Mining

Source: Stephan Kudyba (2014), Big Data, Mining, and Analytics: Components of Strategic Decision Making, Auerbach Publications
Data Science and Business Intelligence

Predictive Analytics and Data Mining (Data Science)
- Typical Techniques and Data Types:
  - Optimization, predictive modeling, forecasting, statistical analysis
  - Structured/unstructured data, many types of sources, very large datasets
- Common Questions:
  - What if...?
  - What’s the optimal scenario for our business?
  - What will happen next? What if these trends continue? Why is this happening?

Business Intelligence
- Typical Techniques and Data Types:
  - Standard and ad hoc reporting, dashboards, alerts, queries, details on demand
  - Structured data, traditional sources, manageable datasets
- Common Questions:
  - What happened last quarter?
  - How many units sold?
  - Where is the problem? In which situations?

Source: EMC Education Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, Wiley, 2015
Data Science and Business Intelligence

Predictive Analytics and Data Mining (Data Science)

Source: EMC Education Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, Wiley, 2015
Predictive Analytics and Data Mining
(Data Science)

Structured/unstructured data, many types of sources, very large datasets

Optimization, predictive modeling, forecasting statistical analysis

What if...?
What’s the optimal scenario for our business?
What will happen next?
What if these trends continue?
Why is this happening?

Source: EMC Education Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, Wiley, 2015
Profile of a Data Scientist

• Quantitative
  • mathematics or statistics

• Technical
  • software engineering, machine learning, and programming skills

• Skeptical mind-set and critical thinking

• Curious and creative

• Communicative and collaborative

Source: EMC Education Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, Wiley, 2015
Data Scientist Profile

- Technical
- Quantitative
- Curious and Creative
- Skeptical
- Communicative and Collaborative

Source: EMC Education Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, Wiley, 2015
Framework for BD and BI Research

Definition of Artificial Intelligence (A.I.)
Artificial Intelligence

“... the science and engineering of making intelligent machines”

(John McCarthy, 1955)
Artificial Intelligence

“... technology that thinks and acts like humans”

Artificial Intelligence

“... intelligence exhibited by machines or software”

### 4 Approaches of AI

<table>
<thead>
<tr>
<th>Thinking Humanly</th>
<th>Thinking Rationally</th>
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<tbody>
<tr>
<td>Acting Humanly</td>
<td>Acting Rationally</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Thinking Rationally: The “Laws of Thought” Approach</td>
<td></td>
</tr>
<tr>
<td>4. Acting Rationally: The Rational Agent Approach</td>
<td></td>
</tr>
</tbody>
</table>

AI Acting Humanly: The Turing Test Approach
(Alan Turing, 1950)

• Knowledge Representation
• Automated Reasoning
• Machine Learning (ML)
  • Deep Learning (DL)
• Computer Vision (Image, Video)
• Natural Language Processing (NLP)
• Robotics

FinTech:
Financial Services Innovation

1. Payments
2. Insurance
3. Deposits & Lending
4. Capital Raising
5. Investment Management
6. Market Provisioning

Source: http://www3.weforum.org/docs/WEF_The_future_of_financial_services.pdf
FinTech: Payment

Source: http://www3.weforum.org/docs/WEF_The_future__of_financial_services.pdf
FinTech: Insurance

Source: http://www3.weforum.org/docs/WEF_The_future__of_financial_services.pdf
FinTech: Deposits & Lending

Source: http://www3.weforum.org/docs/WEF_The_future__of_financial_services.pdf
FinTech: Capital Raising

Source: http://www3.weforum.org/docs/WEF_The_future__of_financial_services.pdf
5 FinTech: Investment Management

Source: http://www3.weforum.org/docs/WEF_The_future__of_financial_services.pdf
FinTech: Market Provisioning

Source: http://www3.weforum.org/docs/WEF_The_future__of_financial_services.pdf
AI in FinTech
FinBrain: when Finance meets AI 2.0 (Zheng et al., 2019)

AI 2.0

a new generation of AI
based on the
novel information environment of
major changes and
the development of
new goals.

Yunhe Pan (2016), "Heading toward artificial intelligence 2.0." Engineering 2, no. 4, 409-413.
## Technology-driven Financial Industry Development

<table>
<thead>
<tr>
<th>Development stage</th>
<th>Driving technology</th>
<th>Main landscape</th>
<th>Inclusive finance</th>
<th>Relationship between technology and finance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fintech 1.0 (financial IT)</td>
<td>Computer</td>
<td>Credit card, ATM, and CRMS</td>
<td>Low</td>
<td>Technology as a tool</td>
</tr>
<tr>
<td>Fintech 2.0 (Internet finance)</td>
<td>Mobile Internet</td>
<td>Marketplace lending, third-party payment, crowdfunding, and Internet insurance</td>
<td>Medium</td>
<td>Technology-driven change</td>
</tr>
<tr>
<td>Fintech 3.0 (financial intelligence)</td>
<td>AI, Big Data, Cloud Computing, Blockchain</td>
<td>Intelligent finance</td>
<td>High</td>
<td>Deep fusion</td>
</tr>
</tbody>
</table>

Deep learning for financial applications: Topic-Model Heatmap

Fig. 9.
The histogram of publication count in model types.

the model-topic heatmap, in this case, we saw a distinction between the associations. Even though price data and technical indicators have been very popular for most of the research areas that are involved with time series forecasting, like algorithmic trading, portfolio management, financial sentiment analysis and financial text mining, the studies that had more significant spatial characteristics like risk assessment and fraud detection did not depend much on these temporal features. One other noteworthy difference came up with the adaptation of text related features. Highly text-based applications like financial sentiment analysis, financial text mining, risk assessment and fraud detection preferred to use features like text (extracted from tweets, news or financial data) and sentiments during their model development and implementation. However, the temporal characteristics of the financial time series data were also important for financial sentiment analysis and financial text mining, since a significant portion of these models were integrated into algorithmic trading systems.

Fig. 12 elaborates on the distribution of the dataset types for the research areas through a dataset-topic heatmap. If we analyze the heatmap, we see similarities with the feature-topic associations. However, this time, we had three main clusters of dataset types, the first one being the temporal datasets like Stock, Index, ETF, Cryptocurrency, Forex and Commodity price datasets, and the second one being the text-based datasets like News, Tweets, Microblogs and Financial Reports, and the last one being the datasets that had both numeric and textual components like Consumer Data, Credit Data and Financial Reports from companies or analysts. As far as the dataset vs. application area associations are concerned, these three main clusters were distributed as follows: Stock, Index, Cryptocurrency, ETF datasets were used almost in every application area except Risk Assessment and Fraud Detection which had less of temporal properties. Meanwhile, Credit Data, Financial Reports and Consumer Data were particularly used by these two application areas, namely Risk Assessment and Fraud Detection. Lastly, pure text based datasets like news, tweets, microblogs were preferred by Financial Sentiment Analysis and Financial Text Mining studies. However, as was the case in the feature-topic associations, temporal datasets like stock, ETF, Index price datasets were also used with these studies since some of them were tied with algorithmic trading models.

6. Discussion and open issues

After reviewing all the publications based on the selected criteria explained in the previous section, we wanted to provide our findings of the current state-of-the-art situation. Our discussions are categorized by the DL models and implementation topics.

6.1. Discussions on DL models

It is possible to claim that LSTM is the dominant DL model that is preferred by most researchers, due to its well-established structure for financial time series data forecasting. Most of the financial implementations have time-varying data representations requiring regression-type approaches which fits very well for LSTM and its derivatives due to their easy adaptations to the problems. As long as the temporal nature of the financial data remains, LSTM and its related family models will maintain their popularities.

Meanwhile, CNN based models started getting more traction among researchers in the last two years. Unlike LSTM, CNN works better for classification problems and is more suitable for either non-time varying or static data representations. However, since most financial data is time-varying, under normal circumstances,
Deep learning for financial applications: Topic-Feature Heatmap

- **Price data**: 35
- **Technical indicator**: 15
- **Index data**: 5
- **Market characteristics**: 6
- **Fundamental**: 2
- **Market microstructure data**: 8
- **Sentiment**: 1
- **Text**: 2
- **News**: 0
- **Company/personal financial data**: 0
- **Macroeconomic data**: 1
- **Risk measuring features**: 0
- **Blockchain/cryptocurrency specific features**: 0
- **Human inputs**: 0

**Figure 11.** Topic-feature heatmap.

**Figure 12.** Topic-dataset heatmap.

CNN is not the natural choice for financial applications. However, in some independent studies, the researchers performed an innovative transformation of 1-D time-varying financial data into 2-D mostly stationary image-like data to be able to utilize the power of CNN through adaptive filtering and implicit dimensionality reduction. This novel approach seems working remarkably well in complex financial patterns regardless of the application area. In the future, more examples of such implementations might be more common; only time will tell.

Another model that has a rising interest is DRL based implementations; in particular, the ones coupled with agent-based modeling. Even though algorithmic trading is the most preferred implementation area for such models, it is possible to develop the working structures for any problem type.

Careful analyses of the reviews indicate in most of the papers hybrid models are preferred over native models for better accomplishments. A lot of researchers configure the topologies and network parameters for achieving higher performance. However, there is also the danger of creating more complex hybrid models that are not easy to build, and their interpretation also might be difficult.

Through the performance evaluation results, it is possible to claim that in general terms, DL models outperform ML counterparts when working on the same problems. DL models also have the advantage of being able to work on larger amount of data. With the growing expansion of open-source DL libraries and frameworks, DL model building and development process is easier than ever.
Deep learning for financial applications: Topic-Dataset Heatmap

Fig. 11. Topic-feature heatmap.

Fig. 12. Topic-dataset heatmap.

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Stock Market Movement Forecast: Phases of the stock market modeling

Decentralized Finance (DeFi)
Block Chain FinTech
Decentralized Finance (DeFi)

• A global, open alternative to the current financial system.
• Products that let you borrow, save, invest, trade, and more.
• Based on open-source technology that anyone can program with.
Traditional Finance
Centralized Finance (CeFi)

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

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

Source: https://ethereum.org/en/defi/
Decentralized Applications (Dapps)

- Ethereum-powered tools and services
- Dapps are a growing movement of applications that use Ethereum to disrupt business models or invent new ones

Source: https://ethereum.org/en/defi/
The Internet of Assets

• **Ethereum** isn't just for digital money.

• Anything you can own can be represented, traded and put to use as non-fungible tokens (NFTs).

Source: https://ethereum.org/en/defi/
Non-Fungible Tokens (NFT)

CryptoKitties

Collect and breed furrever friends!

https://www.cryptokitties.co/

Source: Matt Fortnow and QuHarrison Terry (2021), The NFT Handbook - How to Create, Sell and Buy Non-Fungible Tokens, Wiley
### Top 10 Cryptocurrency Prices by Market Cap

The global cryptocurrency market cap today is $949 Billion (2022/09/19)

<table>
<thead>
<tr>
<th>#</th>
<th>Coin</th>
<th>Price</th>
<th>1h</th>
<th>24h</th>
<th>7d</th>
<th>24h Volume</th>
<th>Mkt Cap</th>
<th>Last 7 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bitcoin BTC</td>
<td>$18,661.01</td>
<td>1.1%</td>
<td>-6.4%</td>
<td>-14.0%</td>
<td>$36,957,734,563</td>
<td>$357,450,768,001</td>
<td><img src="https://www.coingecko.com/en" alt="Graph" /></td>
</tr>
<tr>
<td>2</td>
<td>Ethereum ETH</td>
<td>$1,313.63</td>
<td>1.3%</td>
<td>-8.5%</td>
<td>-25.4%</td>
<td>$18,988,880,341</td>
<td>$156,564,862,486</td>
<td><img src="https://www.coingecko.com/en" alt="Graph" /></td>
</tr>
<tr>
<td>3</td>
<td>Tether USDT</td>
<td>$0.997150</td>
<td>-0.2%</td>
<td>-0.5%</td>
<td>-0.0%</td>
<td>$46,657,045,064</td>
<td>$68,000,277,868</td>
<td><img src="https://www.coingecko.com/en" alt="Graph" /></td>
</tr>
<tr>
<td>4</td>
<td>USD Coin USDC</td>
<td>$0.996395</td>
<td>-0.2%</td>
<td>-0.5%</td>
<td>-0.1%</td>
<td>$5,228,754,733</td>
<td>$60,102,628,549</td>
<td><img src="https://www.coingecko.com/en" alt="Graph" /></td>
</tr>
<tr>
<td>5</td>
<td>BNB BNB</td>
<td>$260.50</td>
<td>0.6%</td>
<td>-5.9%</td>
<td>-11.6%</td>
<td>$689,626,161</td>
<td>$42,564,018,996</td>
<td><img src="https://www.coingecko.com/en" alt="Graph" /></td>
</tr>
<tr>
<td>6</td>
<td>Binance USD BUSD</td>
<td>$1.00</td>
<td>0.1%</td>
<td>0.4%</td>
<td>0.2%</td>
<td>$9,983,426,894</td>
<td>$20,819,973,178</td>
<td><img src="https://www.coingecko.com/en" alt="Graph" /></td>
</tr>
<tr>
<td>7</td>
<td>XRP XRP</td>
<td>$0.353198</td>
<td>1.3%</td>
<td>-7.0%</td>
<td>-0.4%</td>
<td>$2,380,959,267</td>
<td>$17,549,730,741</td>
<td><img src="https://www.coingecko.com/en" alt="Graph" /></td>
</tr>
<tr>
<td>8</td>
<td>Cardano ADA</td>
<td>$0.442609</td>
<td>1.4%</td>
<td>-7.6%</td>
<td>-13.0%</td>
<td>$713,335,000</td>
<td>$14,972,334,641</td>
<td><img src="https://www.coingecko.com/en" alt="Graph" /></td>
</tr>
<tr>
<td>9</td>
<td>Solana SOL</td>
<td>$31.30</td>
<td>1.2%</td>
<td>-6.1%</td>
<td>-10.3%</td>
<td>$859,963,985</td>
<td>$11,095,015,943</td>
<td><img src="https://www.coingecko.com/en" alt="Graph" /></td>
</tr>
<tr>
<td>10</td>
<td>Dogecoin DOGE</td>
<td>$0.056770</td>
<td>0.6%</td>
<td>-6.7%</td>
<td>-10.7%</td>
<td>$320,451,732</td>
<td>$7,535,360,925</td>
<td><img src="https://www.coingecko.com/en" alt="Graph" /></td>
</tr>
</tbody>
</table>

Source: https://www.coingecko.com/en
Top Stablecoins

(Tether USDT, USD Coin USDC, Dai)

Digital money for everyday use
Stablecoins are Ethereum tokens designed to stay at a fixed value, even when the price of ETH changes.

<table>
<thead>
<tr>
<th>CURRENCY</th>
<th>MARKET CAPITALIZATION</th>
<th>COLLATERAL TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>🌟 Tether</td>
<td>$67,921,899,068</td>
<td>Fiat</td>
</tr>
<tr>
<td>💲 USD Coin</td>
<td>$50,081,277,279</td>
<td>Fiat</td>
</tr>
<tr>
<td>🟠 Binance USD</td>
<td>$20,811,100,732</td>
<td>Fiat</td>
</tr>
<tr>
<td>💼 Dai</td>
<td>$6,411,784,420</td>
<td>Crypto</td>
</tr>
<tr>
<td>🟦 Frax</td>
<td>$1,358,584,284</td>
<td>Algorithmic</td>
</tr>
<tr>
<td>🌟 TrueUSD</td>
<td>$1,074,503,081</td>
<td>Fiat</td>
</tr>
<tr>
<td>💲 Pax Dollar</td>
<td>$963,944,923</td>
<td>Fiat</td>
</tr>
</tbody>
</table>

Source: https://ethereum.org/en/stablecoins/
DeFi Total Value Locked (USD)
(DeFi Pulse)

TOTAL VALUE LOCKED (USD)
$26.26B

MAKERDAO DOMINANCE
28.40%

DEFI PULSE INDEX
74.23  -7.66 (-9.36%)

Source: https://defipulse.com/
# Top 10 DeFi Applications (DApps)

(DeFi Pulse)

<table>
<thead>
<tr>
<th>#</th>
<th>NAME</th>
<th>CHAIN</th>
<th>SECTOR</th>
<th>TVL (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>🏆 MakerDAO</td>
<td>Ethereum</td>
<td>Lending</td>
<td>$7.25B</td>
</tr>
<tr>
<td>2</td>
<td>🎖 Curve</td>
<td>Ethereum</td>
<td>DEXes</td>
<td>$4.22B</td>
</tr>
<tr>
<td>3</td>
<td>🥦 Aave</td>
<td>Ethereum</td>
<td>Lending</td>
<td>$3.98B</td>
</tr>
<tr>
<td>4</td>
<td>🏆 Uniswap</td>
<td>Ethereum</td>
<td>DEXes</td>
<td>$3.60B</td>
</tr>
<tr>
<td>5</td>
<td>🎖 Compound</td>
<td>Ethereum</td>
<td>Lending</td>
<td>$2.10B</td>
</tr>
<tr>
<td>6</td>
<td>🦅 InstaDAp</td>
<td>Ethereum</td>
<td>Lending</td>
<td>$1.19B</td>
</tr>
<tr>
<td>7</td>
<td>🤑 Liquity</td>
<td>Ethereum</td>
<td>Lending</td>
<td>$643.3M</td>
</tr>
<tr>
<td>8</td>
<td>🤑 Balancer</td>
<td>Ethereum</td>
<td>DEXes</td>
<td>$488.8M</td>
</tr>
<tr>
<td>9</td>
<td>🎖 dYdX</td>
<td>Ethereum</td>
<td>Derivatives</td>
<td>$471.3M</td>
</tr>
<tr>
<td>10</td>
<td>🏆 SushiSwap</td>
<td>Ethereum</td>
<td>DEXes</td>
<td>$305.1M</td>
</tr>
</tbody>
</table>

Source: [https://defipulse.com/](https://defipulse.com/)
Financial Stability Challenges

Crypto Ecosystem

• Operational, cyber, and governance risks
• Integrity (market and AML/CFT) (Anti–Money Laundering / Combating the Financing of Terrorism)
• Data availability / reliability
• Challenges from cross-border activities

Stablecoins

• How stable are stablecoins?
• Domestic and global regulatory and supervisory approaches

Macro-Financial

• Cryptoization, capital flows, and restrictions
• Monetary policy transmission
• Bank disintermediation

Source: Parma Bains, Mohamed Diaby, Dimitris Drakopoulos, Julia Faltermeier, Federico Grinberg, Evan Papageorgiou, Dmitri Petrov, Patrick Schneider, and Nobu Sugimoto (2021), The Crypto Ecosystem and Financial Stability Challenges, International Monetary Fund, October 2021
Decentralized Finance Applications (DApps): Flash Loan Transaction

1. Transfer loan
2. Invoke
3. Run operations
4. Payback loan
5. Check state

The Economics of Money, Banking and Financial Markets

Economics of Money, Banking and Financial Markets

1. Money, Banking, and Financial System
2. Financial Markets
3. Financial Institutions
4. Central Banking and the Conduct of Monetary Policy
5. International Finance and Monetary Policy
6. Monetary Theory
7. Financial Services Industry

INTRODUCTION

1. Why Study Money, Banking, and Financial Markets?
2. An Overview of the Financial System
3. What Is Money?
4. Understanding Interest Rates

5. The Behavior of Interest Rates

6. The Risk and Term Structure of Interest Rates

7. The Stock Market, the Theory of Rational Expectations, and the Efficient Market Hypothesis

FINANCIAL INSTITUTIONS

8. An Economic Analysis of Financial Structure
10. Economic Analysis of Financial Regulation
11. Banking Industry: Structure and Competition
12. Financial Crises

CENTRAL BANKING AND THE CONDUCT OF MONETARY POLICY

13. Central Banks and the Federal Reserve System
14. The Money Supply Process
15. The Tools of Monetary Policy
16. The Conduct of Monetary Policy: Strategy and Tactics

MONETARY THEORY

19. Quantity Theory, Inflation, and the Demand for Money
20. The IS Curve
21. The Monetary Policy and Aggregate Demand Curves
22. Aggregate Demand and Supply Analysis
23. Monetary Policy Theory
24. The Role of Expectations in Monetary Policy
25. Transmission Mechanisms of Monetary Policy

Financial Services Industry

26. Financial Crises in Emerging Market Economies
27. The ISLM Model
28. Nonbank Finance
29. Financial Derivatives
30. Conflicts of Interest in the Financial Services Industry

Why Study Money, Banking, and Financial Markets?

Why Study Money, Banking, and Financial Markets?

• To examine how financial markets such as bond, stock and foreign exchange markets work
• To examine how financial institutions such as banks and insurance companies work
• To examine the role of money in the economy

Financial Markets

- Markets in which funds are transferred from people who have an excess of available funds to people who have a shortage of funds
  - Bond market
  - Stock market
  - Foreign exchange market

Financial Institutions

- Financial Intermediaries: institutions that borrow funds from people who have saved and make loans to other people:
  - **Banks**: accept deposits and make loans
  - **Other Financial Institutions**: insurance companies, finance companies, pension funds, mutual funds and investment banks

- **Financial Innovation**: the advent of the information age and e-finance

Money and Business Cycles

- Money plays an important role in generating business cycles
- Recessions (unemployment) and expansions affect all of us
- Monetary Theory ties changes in the money supply to changes in aggregate economic activity and the price level

Overview of the Financial System

Indirect Finance

Financial Intermediaries

Funds

Indirect Finance

Lender-Savers
1. Households
2. Business firms
3. Government
4. Foreigners

Borrower-Senders
1. Business firms
2. Government
3. Households
4. Foreigners

Direct Finance

Financial Markets

Funds

Funds

Funds
What is Money?

Money

Meaning of Money

• **Money** (=money supply) any vehicle used as a means of **exchange** to pay for goods, services or debts.

• In today’s society, any **asset** that can quickly be transferred into cash is considered money.

• The more **liquid** an asset is, the closer it is to money.

• In economics, **money** does not mean **wealth** nor does it mean **income**.

Functions of Money

• Medium of Exchange
• Unit of Account
• Store of Value

Medium of Exchange

• By eliminating barter, this function of money increases efficiency in a society.

• As human societies started to engage in exchange money had to be invented.

• Any technological change that reduces transaction costs increases the wealth of the society.

• Any technological change that allows people to specialize also increases wealth.

Unit of Account

• We use money to measure the value of goods and services.

• Suppose we had 4 goods and no money. How do we measure the price of each good?
  - A in terms of B
  - B in terms of C
  - C in terms of D
  - A in terms of C
  - A in terms of D
  - B in terms of D

• Money allows to quote prices in terms of currency only.

Store of Value

• All assets are stored value.

• Money, although without any return, is still desirable to hold because it allows purchases immediately.

• Other assets take time (transaction costs) to use as a payment for purchases.

• The more liquid an asset is, the less transaction cost it carries.

• Inflation erodes the value of money.

Evolution of the Payments System

• Commodity Money:
  • valuable, easily standardized and divisible commodities (e.g. precious metals, cigarettes).

• Fiat Money:
  • paper money decreed by governments as legal tender.

Electronic Money

• Debit Cards
  • Instant transfer from your checking account to merchant’s checking account.

• Stored Value Card
  • Gift cards.

• Electronic Cash
  • Account set up on a person’s PC from her bank whereby she can buy products over the Internet.

• Electronic Checks
  • Checks written on PC and sent through the Internet.

Benefits of Paper Checks

• Cheaper than telecommunications network.
• Provide receipts.
• Allow float.
• May be more secure; avoid hacker problems.
• Do not leave a wealth of information trail.

Measuring Money

• **M1:**
  • Currency, demand deposits, travelers checks.

• **M2:**
  • M1, saving deposits, small time deposits, retail MMMF.

• **M3:**
  • M2, large time deposits, repos, Eurodollar deposits, institutional MMMF.

• **MZM:**
  • M2, institutional MMMF minus small time deposits.

• Growth rates of these aggregates do not always go hand in hand, making monetary policy difficult since signals are conflicting.

The IS Curve
The IS (Investment/Saving) Curve

The IS (Investment/Saving) Curve

Demand

Price ($p$)

Quantity ($q$)

$P^*$

$Q^*$

Demand

The ISLM Model
Goods and Financial Markets:
The ISLM Model
(Investment Saving – Liquidity Preference Money Supply) model

The ISLM Model
(Investment Saving – Liquidity Preference Money Supply) model

Supply and Demand

Quantity ($q$) vs. Price ($p$)

Demand (D) and Supply (S) curves intersect at the Equilibrium point ($Q^*$, $P^*$).

Financial Services
Technology
Innovation
Innovation

Source: https://www.merriam-webster.com/dictionary/innovation
Innovation: a new idea, method, or device

Source: https://www.merriam-webster.com/dictionary/innovation
Innovation: something new

Source: https://www.merriam-webster.com/dictionary/innovation
Novelty:

something new or unusual

the novelty of a self-driving car

Source: https://www.merriam-webster.com/dictionary/novelty
Creativity is not a new Idea. Creativity is an old belief you leave behind.
FinTechs as Service Innovators: Analysing Components of Innovation

Innovation

“a process of searching and recombining existing knowledge elements”

Search and recombination process to innovate: A review of the empirical evidence and a research agenda

Innovation Research in Economics, Sociology and Technology Management

Innovation Research in Economics, Sociology and Technology Management

<table>
<thead>
<tr>
<th>Stage of process</th>
<th>Level of study</th>
<th>Type of innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economists</strong></td>
<td>Industry</td>
<td>Product and process</td>
</tr>
<tr>
<td>Generation</td>
<td></td>
<td>Only technical</td>
</tr>
<tr>
<td>Idea generation</td>
<td></td>
<td>Only radical</td>
</tr>
<tr>
<td>Project definition</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Technologists</strong></td>
<td>Innovation (in the industry context)</td>
<td>Product and process</td>
</tr>
<tr>
<td>Contextual technologists</td>
<td></td>
<td>Only technical</td>
</tr>
<tr>
<td>Generation</td>
<td></td>
<td>Radical and incremental</td>
</tr>
<tr>
<td>Commercialization and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>marketing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diffusion</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Organizational</strong></td>
<td>Organizational sub-system</td>
<td>Product and process</td>
</tr>
<tr>
<td>technologists</td>
<td></td>
<td>Only technical</td>
</tr>
<tr>
<td>Generation</td>
<td></td>
<td>Radical and incremental</td>
</tr>
<tr>
<td>Idea generation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem solving adoption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adoption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiation</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sociologists</strong></td>
<td>Organization</td>
<td>Product and process</td>
</tr>
<tr>
<td>Variance sociologists</td>
<td></td>
<td>Technical and administrative</td>
</tr>
<tr>
<td>Adoption</td>
<td></td>
<td>Radical and incremental</td>
</tr>
<tr>
<td>Initiation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implementation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process sociologists</td>
<td>Innovation (at the organizational level)</td>
<td>Product and process</td>
</tr>
<tr>
<td>Adoption</td>
<td></td>
<td>Technical and administrative</td>
</tr>
<tr>
<td>Initiation</td>
<td></td>
<td>Radical and incremental</td>
</tr>
<tr>
<td>Implementation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Gopalakrishnan, Shanti, and Fariborz Damanpour.  
Business, Innovation, and Knowledge Ecosystems

Business, Innovation, and Knowledge Ecosystems

Innovation Ecosystems
- integrate exploration (knowledge)
- and exploitation (business)
- ecosystems

Business Ecosystems
- focus on creating customer value

Knowledge Ecosystems
- focus on generating new knowledge and technologies

Focal Company or Platform

# Innovation Ecosystems

## Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Business Ecosystems</th>
<th>Innovation Ecosystems</th>
<th>Knowledge Ecosystems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline of Ecosystem</strong></td>
<td>Resource exploitation for customer value</td>
<td>Co-creation of innovation</td>
<td>Knowledge exploration</td>
</tr>
<tr>
<td><strong>Relationships and Connectivity</strong></td>
<td>Global business relationships both competitive and co-operative</td>
<td>Geographically clustered actors, different levels of collaboration and openness</td>
<td>Decentralized and disturbed knowledge nodes, synergies through knowledge exchange</td>
</tr>
<tr>
<td><strong>Actors and Roles</strong></td>
<td>Suppliers, customers, and focal companies as a core, other actors more loosely involved</td>
<td>Innovation policymakers, local intermediators, innovation brokers, and funding organizations</td>
<td>Research institutes, innovators, and technology entrepreneurs serve as knowledge nodes</td>
</tr>
<tr>
<td><strong>Logic of Action</strong></td>
<td>A main actor that operates as a platform sharing resources, assets, and benefits or aggregates other actors together in the networked business operations</td>
<td>Geographically proximate actors interacting around hubs facilitated by intermediating actors</td>
<td>A large number of actors that are grouped around knowledge exchange or a central non-proprietary resource for the benefit of all actors</td>
</tr>
</tbody>
</table>

Diffusion of Innovation Theory

(DOI)

Innovation
(Diffusion of Innovation)

1. Relative advantage
2. Compatibility
3. Complexity
4. Trialability
5. Observability

Diffusion of Innovation

Innovation Adoption Process

Initiation → Adoption Decision → Implementation

Innovation Adoption Process

Initiation → Adoption Decision → Implementation

Environmental Characteristics
Organizational Characteristics
Top Managers Characteristics
Innovation Characteristics
User Acceptance Attributes

RBV = Resource-Based View
DOI = Diffusion of Innovation Theory
TAM = Technology Acceptance Model

Source: Pichlak, Magdalena.
Innovation Adoption Process

Innovation Adoption Process

<table>
<thead>
<tr>
<th>Factors</th>
<th>Initiation</th>
<th>Adoption decision</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Me</td>
<td>Q3</td>
</tr>
<tr>
<td>Environmental characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dynamism</td>
<td>3.4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Hostility</td>
<td>3.3</td>
<td>3</td>
<td>4.25</td>
</tr>
<tr>
<td>Complexity</td>
<td>4.5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Organizational characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialization</td>
<td>3.8</td>
<td>4</td>
<td>4.25</td>
</tr>
<tr>
<td>Horizontal differentiation</td>
<td>2.8</td>
<td>3</td>
<td>3.75</td>
</tr>
<tr>
<td>Vertical differentiation</td>
<td>2.1</td>
<td>2</td>
<td>3.25</td>
</tr>
<tr>
<td>Centralization</td>
<td>2.1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Formalization</td>
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<td>Human resources</td>
<td>3.2</td>
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<td>4</td>
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<td>Financial resources</td>
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<tr>
<td>Top managers characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top managers attitude towards innovation</td>
<td>4.1</td>
<td>4</td>
<td>4.5</td>
</tr>
<tr>
<td>Top managers demographic characteristics</td>
<td>2.3</td>
<td>2</td>
<td>3.25</td>
</tr>
<tr>
<td>Innovation characteristics</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Relative advantage</td>
<td>3</td>
<td>3</td>
<td>4</td>
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<tr>
<td>Compatibility</td>
<td>2.8</td>
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<td>3.5</td>
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<td>Complexity</td>
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<td>4.25</td>
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<tr>
<td>Trialability</td>
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<tr>
<td>Observability</td>
<td>3.4</td>
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<td>4.25</td>
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<tr>
<td>User acceptance attributes</td>
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<tr>
<td>Usefulness</td>
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<td>4</td>
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<td>4</td>
</tr>
</tbody>
</table>

Note.  
Me = median; Q = quartile; QD = quartile deviation.

Source: Pichlak, Magdalena.  
## Innovation Adoption Process

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Round 1</th>
<th>Round 2</th>
<th>Adoption Decision</th>
<th>Round 1</th>
<th>Round 2</th>
<th>Implementation</th>
<th>Round 1</th>
<th>Round 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complexity in the environment</td>
<td>4.5</td>
<td>4.2</td>
<td>Dynamism in the environment</td>
<td>3.6</td>
<td>3.4</td>
<td>Dynamism in the environment</td>
<td>4.0</td>
<td>3.8</td>
</tr>
<tr>
<td>Specialization</td>
<td>3.8</td>
<td>3.4</td>
<td>Hostility in the environment</td>
<td>3.9</td>
<td>4.0</td>
<td>Hostility in the environment</td>
<td>3.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Horizontal differentiation</td>
<td>2.8</td>
<td>3.1</td>
<td>Centralization</td>
<td>3.8</td>
<td>3.8</td>
<td>Centralization</td>
<td>3.9</td>
<td>3.8</td>
</tr>
<tr>
<td>Human resources</td>
<td>4.9</td>
<td>5.0</td>
<td>Human resources</td>
<td>4.0</td>
<td>4.2</td>
<td>Formalization</td>
<td>3.3</td>
<td>3.2</td>
</tr>
<tr>
<td>Top managers attitude towards innovation</td>
<td>4.1</td>
<td>4.3</td>
<td>Financial resources</td>
<td>4.1</td>
<td>4.4</td>
<td>Human resources</td>
<td>4.1</td>
<td>4.4</td>
</tr>
<tr>
<td>Innovation complexity</td>
<td>3.6</td>
<td>3.3</td>
<td>Top managers attitude towards innovation</td>
<td>3.9</td>
<td>4.0</td>
<td>Financial resources</td>
<td>4.8</td>
<td>5.0</td>
</tr>
<tr>
<td>Relative advantage</td>
<td>4.4</td>
<td>4.1</td>
<td>Innovation compatibility</td>
<td>3.9</td>
<td>3.6</td>
<td>Top managers attitude towards innovation</td>
<td>4.0</td>
<td>4.4</td>
</tr>
<tr>
<td>Innovation compatibility</td>
<td>3.8</td>
<td>3.8</td>
<td>Innovation complexity</td>
<td>3.9</td>
<td>3.8</td>
<td>Innovation compatibility</td>
<td>3.9</td>
<td>3.9</td>
</tr>
<tr>
<td>Innovation trialability</td>
<td>4.1</td>
<td>3.9</td>
<td>Innovation complexity</td>
<td>3.8</td>
<td>3.8</td>
<td>Innovation trialability</td>
<td>4.1</td>
<td>3.9</td>
</tr>
<tr>
<td>Ease of use</td>
<td>4.0</td>
<td>4.2</td>
<td>Innovation trialability</td>
<td>4.1</td>
<td>3.9</td>
<td>Ease of use</td>
<td>4.0</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Source: Pichlak, Magdalena.

FinTech Innovation

FinTech high-level classification

Lending  Payments  Robo Advisors  Analytics  Others

Profile  Advice  Re-Balance  Indexing

1. Banking Infrastructure
2. Business Lending
3. Consumer and Commercial Banking
4. Consumer Lending
5. Consumer Payments
6. Crowdfunding
7. Equity Financing
8. Financial Research and Data
9. Financial Transaction Security
10. Institutional Investing
11. International Money Transfer
12. Payments Backend and Infrastructure
13. Personal Finance
14. Point of Sale Payments
15. Retail Investing
16. Small and Medium Business Tools

Source: http://www.venturescanner.com/financial-technology
Ethereum DeFi Ecosystem

**Assets Management Tools**
- coinbase
- Wallet
- METAMASK
- Huobi Wallet
- FRONTIER
- MyEtherWallet
- argent
- COBO
- Bitpax
- AlphaWallet
- FETCH
- BUTTON Wallet
- ENJIN
- BETOKEN
- ABRA
- MyCrypto
- imToken
- GNOSIS
- ZERION

**Analytics**
- Bloxy
- Alethio
- Dune Analytics
- DEFI PULSE
- defi portfolio
- Whos5x
- sentiment
- kyber tracker
- STABLECOIN INDEX
- HydroScan
- MakerScan
- MKR TOOLS
- LoanScan
- Poolz
- DexIndex
- chainbeat
- DEFI WATCH

**Decentralized Exchanges**
- IDEX
- dDEX
- ForkDelta
- AIRSWAP
- Bancor
- DeversiFi
- DutchX
- Dolomite
- 1inch
- liqit
- kyber
- paraswap
- UniSwap
- TOKENLON
- Shifly
- atomex
- SwitcheoNetwork

**DeFi Infrastructure & Dev Tooling**
- DutchX
- Chainlink
- 0x
- MoonPay
- Blocknative
- Oxcent
- Centrifuge
- CARBON
- Fortmatic
- hydro
- PayTri
- ports
- TORSUS
- MelonPort
- Set Protocol
- New Alchemy

**Decentralized Lending**
- Compound
- BlockFi
- Fulcrum
- nOx
- SALT
- ETHLend
- Constant
- DAO

**KYC & Identity**
- civic
- BOX
- Bloom
- COLENDI
- identity
- JOLOMOM
- SELFKEY
- sovrin

**Marketplaces**
- ORIGIN
- OpenBazaar
- Bounties Network
- district0x
- ecomi
- market
- OpenSea
- GITCHAIN
- Rare Bits

**Stablecoins**
- DAI
- PAXOS
- GEMINI dollar
- NEUTRAL
- USD Coin
- WBTC
- AUGMINT
- TrueUSD
- rDAI
- DDEX

**Ethereum-based DAO Platforms**
- ARAGON
- DAOstack
- COLONY

**Dec. Insurance Platforms**
- Nexus Mutual
- ETHERISC
- Mutual

**Payments**
- Celer
- Matic
- xDai
- Groundhog
- omise
- WBSP
- Request
- Congress
- StablePay
- Lightning Network

**Asset Tokenization**
- HARBOR
- NEUFUND
- OPENLAW
- TEMPLUM
- quidli
- MERIDIO
- SECURITIZE
- TOKENSOFT

**Margin Trading & Derivatives**
- TokenSets
- SYNTHETIX

**Prediction Markets**
- Helena
- CNOSIS
- augur

Decentralized Finance (DeFi) Ecosystem

Source: https://tokeny.com/defi-ecosystem/
Python in Google Colab (Python101)

Backtesting Cryptocurrency Bitcoin

- Financial Functions (ffn): [https://pmorissette.github.io/ffn/](https://pmorissette.github.io/ffn/)
- backtesting.py: [https://kernc.github.io/backtesting.py/](https://kernc.github.io/backtesting.py/)

```python
1!pip install ffn
2!import ffn
3!import plotly.express as px
4!%pylab inline
5!#BTC-USD Bitcoin USD
6!df = ffn.get('btc-usd', start='2016-01-01', end='2021-12-31')
7!print('df')
8!print(df.head())
9!print(df.tail())
10!print(df.describe())
11!df.plot(figsize=(14,10))
12
13!returns = df.to_returns().dropna()
14!print('returns')
15!print(returns.head())
16!print(returns.tail())
17!print(returns.describe())
18!ax = df.plot(figsize=(12,9))
19
20!perf = df.calc_stats()
21!perf.plot(figsize=(14, 10))
```

[https://tinyurl.com/aintpuppython101](https://tinyurl.com/aintpuppython101)
References

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- Matt Fortnow and QuHarrison Terry (2021), The NFT Handbook - How to Create, Sell and Buy Non-Fungible Tokens, Wiley
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