

Complementary and Synergistic Properties of Blockchain and Artificial Intelligence

By: [Nir Kshetri](#)

Kshetri, Nir (2019). "Complementary and Synergistic Properties of Blockchain and Artificial Intelligence" IEEE IT Professional, 21(6) 60-65. <https://doi.org/10.1109/MITP.2019.2940364>

© 20xx IEEE. Personal use of this material is permitted. Permission from IEEE must be obtained for all other uses, in any current or future media, including reprinting/republishing this material for advertising or promotional purposes, creating new collective works, for resale or redistribution to servers or lists, or reuse of any copyrighted component of this work in other works.

Abstract:

Artificial intelligence (AI) and blockchain are likely to bring powerful economic and social effects. Blockchain's ability to cryptographically validate identities and transactions and create immutable records can enhance trust, transparency, and accountability. Part of the fascinating character of the AI stems from the fact that computers perform better than humans in repetitive tasks. Their judgment and intelligence are not affected by emotions, feelings, and needs. They have better memories and can process large amounts of information.¹ AI, thus, enhances efficiency and provides new opportunities for cost savings and revenue generation. What is even more important is that AI and blockchain have strong complementary capabilities that can have dramatic effects on the performance of industries and markets. Each also has a potential to improve the performance and functioning of the other (see Figure 1).

Keywords: cryptocurrencies | artificial intelligence | complementary capabilities | transactions | blockchain

Article:

EFFECTS OF BLOCKCHAIN ON AI

Figure 1 reveals different mechanisms by which blockchain can influence AI. First, blockchain's ability to cryptographically validate and record each transaction and its clear audit trails can help bring together many smaller AI providers by giving ownership of their contributions via smart contracts. Each may provide different AI services. With a network effect, AI developers are encouraged to contribute, which can lead to the development of a rich AI ecosystem. Each of them will have their own community of equity holders.²

Currently, small companies lack the capabilities and resources for utilizing AI in order to solve extremely difficult problems. Big companies have unfair advantages and privileges. Blockchain's ability to create trustless relationships means that a small company does not need to have full ownership and full control over huge AI teams or huge amounts of data. It is possible to rely on *ad hoc* communities to solve specific problems that are controlled by smart contracts. If the communities provide more valuable services, more entities can join.²

Blockchain's clear audit trails can help the development of the AI marketplace. Blockchain can facilitate buying and selling of data, models, and AI applications in online marketplaces. Blockchain-verified data and model sharing could help lower the barrier to entry for smaller players and stimulate their participation in the AI world.³

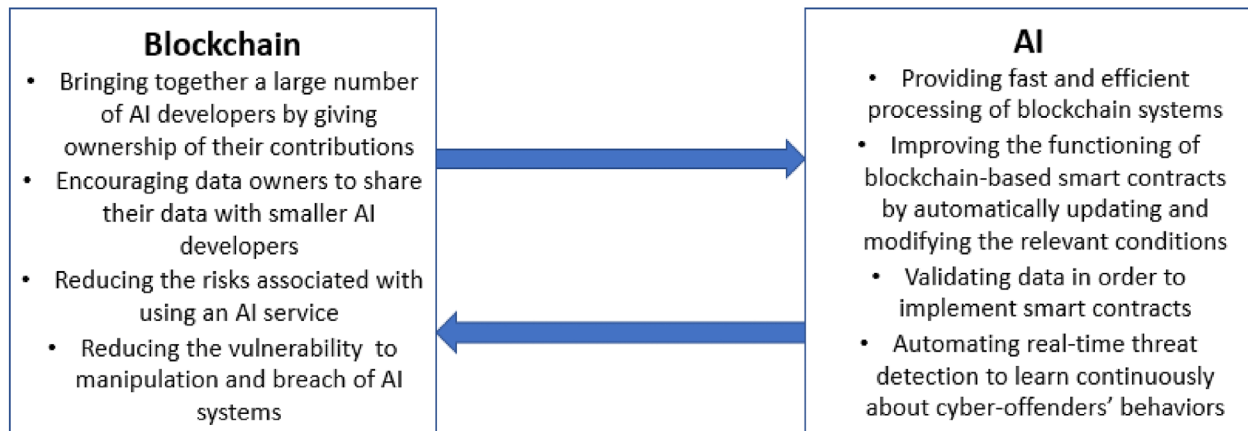


Figure 1. Synergistic effects of AI and blockchain.

Second, blockchain's data encryption feature can encourage data owners to share their data with smaller AI developers. A problem in nonblockchain systems is that someone buying data on a marketplace could distribute it. It creates a free-rider problem. With blockchain, consumers feel more confident that their data are not abused.⁴ Blockchain makes it possible to identify each block of data and anonymize it.

To take an example, Google's AI lab Google DeepMind is reported to be working on an “auditing system for healthcare data.” Blockchain makes it possible to share data and ensure that the data remain private, secure, accurate, and tamper-free (<https://www.wired.com/2017/03/google-deepminds-untrendy-blockchain-play-make-actually-useful/>). AI will allow healthcare professionals to obtain analytics on medical predictions that are drawn from patient profiles (<https://www.topbots.com/combination-ai-blockchain-revolutionize-10-industries/>).

Researchers in New Zealand are reported to be working on a project to develop a New Zealand-focused model of risk stratification. The goal is to identify patients who are most at risk and in need of services. Patients have access to their data via an application. They can input their data and choose how they can share with researchers (<https://www.healthcareitnews.com/news/reducing-health-inequities-and-increasing-access-care-using-ai-and-blockchain>). In this way, blockchain facilitates access to relevant data for small AI developers.

Data owners often tend to share data with big companies compared to smaller ones. Blockchain, thus, offers special benefits to small players that often lack the ability to demonstrate attributes that prove their trustworthiness. Especially, they are not in a position to produce characteristic-based trust,⁵ which is generated by identifiable attributes linked with trustworthy behavior. Entities that are known to possess certain well-defined attributes (e.g., large companies) are

viewed as trustworthy. Big companies may lose a size-dependent trust advantage with the availability of new encryption methods.² Thus, a level playing field is achieved for small AI startups. Many startups are promoting the development of data marketplace for AI:

- a) Enigma's data marketplace catalyst developed by an MIT-based team allows organizations to contribute data. Users can subscribe to and consume data via smart contracts. Computations can be performed over encrypted data. This means that nodes do not need to see the raw data in order to perform computing (<https://blokt.com/interview/enigmas-privacy-protocol-solves-key-blockchain-issues-preventing-global-adoption>).
- b) The Blockchain startup Datum's marketplace allows users to make money from their data. The company had over 90 000 people using its app to monetize their data with prescreened partners (<https://www.cbinsights.com/research/blockchain-ai-startups/>).
- c) Computable Labs uses blockchain to build a decentralized data marketplace for AI. The goal is to democratize access to data and algorithms needed for AI. It aims to provide a token curated registry (TCR) that serves as a hub for the buying and selling of data (<https://www.cbinsights.com/research/blockchain-ai-startups/>). A TCR is an incentivized voting game designed to create trusted lists, which are maintained by the users of data, algorithms, and applications. The idea is to use the “Wisdom of the Crowds” principle. Users vote to decide submissions that are valid and should be included in the list. Tokens are needed to vote (<https://education.district0x.io/general-topics/understanding-ethereum/token-curated-registry/>).

Third, blockchain can reduce the risks associated with using AI services. This is important because most organizations lack in-house AI capabilities. AI services often lack tools to estimate the quality of providers.

Diffusion of technologies such as AI depend on trialability.⁶ That is, organizations are more likely to adopt AI if providers offer risk-free trials. Blockchain increases AI's trialability by making it possible to offer AI deals in which payments are conditional. An AI consumer pays for services only if the provider is right. The provider may actually pay the consumer for wrong predictions.²

Most AI models function as “black boxes.” A few big companies dominate the AI field because they are viewed as reputable and providers of better AI services. When AI models are put on blockchain, predictions are immutable. Reputation of AI providers would depend less on their size and more on their capability to provide high quality AI services.² Blockchain increases the trustworthiness of AI. Blockchain can display a clear and impenetrable chain of information for AI to explain its processes (<https://www.techradar.com/news/understanding-the-power-of-blockchain-infused-with-ai>).

AI algorithms and data are vulnerable and susceptible to misuse, threat, and manipulation. Data manipulation may also go undetected for a long time. In such cases, organization may face difficulty to recover the correct data feeding its AI system. Such a scenario could lead to disastrous consequences in systems relying on AI in healthcare, finance, and other sectors

(<https://www.cfr.org/blog/cybersecurity-vulnerabilities-artificial-intelligence>). Blockchain can reduce such vulnerabilities.

Blockchain can ensure that the data and algorithms used in AI are secure. Perpetrators need to penetrate several entrance gates to attack a system. Since the database is encrypted, users that have not been granted access cannot view anything (<https://www.digitaldoughnut.com/articles/2018/march/blockchain-potential-to-transform-ai>).

AI makes it possible to understand and analyze huge amounts of data. While blockchain cannot perform well in terms of analysis, its decentralized feature can help protect data on which AI-related systems depend.⁷ Compared to a closed AI system, a blockchain-based system is more transparent. Records that are on a blockchain-based ledger can be reviewed and audited by any authorized party.

EFFECTS OF AI ON BLOCKCHAIN

Figure 1 portrays how AI can improve the functioning of blockchain-based systems. First, AI can provide fast and efficient processing of blockchain systems. Traditional computers without AI programs require huge amounts of processing power to manage blockchains in order to complete tasks. This is due to the encrypted nature of data and the lack of explicit instruction on how to process it. With AI, higher performance can be achieved in blockchain management. More intelligent machines improve the process (<https://www.techradar.com/news/understanding-the-power-of-blockchain-infused-with-ai>).

Second, AI improves the functioning of smart contracts by automatically updating and modifying the relevant conditions in such contracts. Smart contracts are created for transactions that may occur in future points of time. However, changes in the business world, political and legal institutions, and other factors may make the contracts outdated. AI and blockchain may work together to provide real time updated contracts. AI is useful if parts of those contracts dictate the fixed terms, and some aspects might change with changes in conditions in the business environment.⁸

Third, AI can effectively validate data to implement smart contracts. In a smart contract executed “above” the blockchain, the software program runs outside and feeds information to the blockchain (<http://www.kwm.com/en/knowledge/insights/10-things-you-need-to-know-smart-contracts-20160630>). In most cases, the IoT provides the data. The AI's analysis and intelligence conditions represented by the data meet the standards stipulated in the contract. For instance, IBM worked with the UAE's Dubai Customs and Dubai Trade, the telecommunications company Du, a letter of credit (LoC) issuing bank Emirates NBD Bank, the responding bank Santander, freight company Aramex, and an airline to use its blockchain platform Hyperledger in international trades. The plan was to integrate it with IBM Watson's AI after completing the proof-of-concept (PoC). The PoC was designed to track the shipment of fruit from India to Dubai via a cargo ship. In Dubai, the fruit would be processed to produce juice and then exported to Spain by an airplane. To move the transactions to blockchain, Du tracked data via IoT-enabled devices. Aramex would ship the fruit, and an airline company would transport the juice.

Finally, AI can be used to automate real-time threat detection to learn continuously about cyber-offenders' behaviors. The importance of this aspect stems from the fact that a number of crypto exchange platforms have faced cyberattacks. Some solutions have already been proposed for addressing such challenges. A virtual AI security analyst developed at MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) accurately identified 85% of attacks when it was trained by human experts. By doing so, it exceeded previous benchmarks and reduced false positives by factors of three and five.⁹

COMPLEMENTARY AND SYNERGISTIC INTERACTIONS BETWEEN AI AND BLOCKCHAIN

AI provides the analysis and intelligence. Blockchain builds trust and brings automation through smart contracts (<https://advancedmanufacturing.org/narayanaswami-combined-with-ai-and-iot-tech-blockchain-can-meet-many-supply-chain-challenges/>). The two technologies can be combined to achieve better and more desirable outcomes. Several examples can be given to illustrate synergistic effects of AI and blockchain.

Guaranteeing Traceability and Transparency of Supply Chains

Using AI and blockchain, it is possible to greatly improve supply chain traceability and transparency. The pharmaceutical company Merck has been granted a patent that combines AI with blockchain to enhance supply chain integrity and eliminate counterfeit products. The process links physical objects to blockchains to create "crypto-objects." Machine learning is used to create fingerprints using unique features, such as physical patterns, chemical signature, and DNA. Once the object becomes a crypto-object with a unique fingerprint, another layer of security can be provided with data, such as time or location. The receivers of a crypto-object can compare the discriminating data with corresponding reference data. The later sets of data are stored in repositories with restricted access.¹⁰

The blockchain startup Bext360 uses AI, blockchain, and other technologies to increase supply chain transparency and efficiency. Its solutions have been used in the supply chains of coffee, timber, seafood, mineral industries, and commodities, such as cocoa and cotton (<https://techcrunch.com/2017/04/11/bext360-is-using-robots-and-the-blockchain-to-pay-coffee-farmers-fairly/>). A solution developed by Bext360 consists of Stellar blockchain, cloud-based software, and smart contracts to track coffee from African farms to coffee shops in Europe and the U.S. (<https://sprudge.com/132380-132380.html>). In 2018, Denver, CO, based Coda Coffee sold what it claimed to be the world's first blockchain-traced coffee (<https://www.foodlogistics.com/technology/news/21016029/nestle-tests-blockchain-tracing-with-baby-food>). Its coinstar-like Bextmachines grade coffee beans using AI with smart image recognition technology machine vision, and IoT. It takes a 3-D scan of each bean's outer fruit (<https://sprudge.com/132380-132380.html>). At collection stations, when farmers pour their coffee, Bextmachines analyze the cherries and parchment and sort them to assess the quality. The machines grade them for color, size, and other characteristics and compare the images against a library with different images. Farmers that supply bigger and riper cherries are paid more.

The Bextmachines link the output to cryptotokens representing the coffee's value. New tokens are automatically created when the product passes through the supply chain. The values of tokens increase at successive stages

(<https://www.forbes.com/sites/alexknapp/2018/06/01/agtech-blockchain-startup-bext360-raises-3-35-million-to-provide-traceability-to-commodities/#7ee591276d25>).

Likewise, using blockchain, IBM's Everledger gives unique cryptographic ID to diamonds. The cognitive analytics systems cross-checks data related to regulations, relevant records, supply-chain, and IoT to ensure that the gems from conflict regions do not enter the global supply chain.⁷

Bringing Together and Facilitating Transactions Between Buyers and Sellers

AI and blockchain can help bring together and facilitate transactions between buyers and sellers. For instance, AI is used to identify products that have the best quality/price ratio. It is also possible to recommend the best times for sellers to put their products on the market. Customers can use a single platform for many e-commerce needs, which can increase the efficiency with which they can buy and sell products. It is not possible to change information about a product after it is entered on the blockchain. It is, thus, easier for stores to verify purchases and process returns.⁸

Improving Efficiency and Quality of Services

The combination of blockchain and AI can improve the efficiency and quality of web services applications. For instance, with blockchain, additional desirable features can be implemented in AI based chatbots. Blockchain makes it possible to track the ownership of various assets and manage them automatically in a trusted and secure manner. It might also be possible to have a cryptocurrency wallet with a built in chatbot. Such a system can execute commands over the blockchain. Payments can be made in cryptocurrencies. With advancement in technologies, AI chatbots can execute more complex transactions over blockchain.

Deloitte is reported to be building a chatbot that allows storage of product warranties on the blockchain. Consumers can send a barcode containing product warranty information to the chatbot. The chatbot saves the warranty on blockchain. This means that the content cannot be tampered with. Without the private key, the contents cannot be deleted or altered. If products, such as a refrigerator, break, the owner can describe the problem to the chatbot, which can recall the warranty. It then advises the options that customers with a valid warranty have (e.g., going to the a store to replace) (<https://blog.indorse.io/what-are-ai-chatbots-how-will-they-be-used-with-blockchain-fa6ad9c39d3b>)

Increasing the Fairness With Which Creators of Creative Works Are Treated

The music industry lacks fairness and transparency. Intermediaries capture most of the value, and artists get paid last. Intermediaries take over 80% of royalty fees
(www.nasdaq.com/article/how-the-blockchain-lets-musicians-connect-with-fans-and-get-paid-

[cm755712](#)). The current model is that streaming services first pay off the record labels, publishers, and Public Rights Organizations (PROs) before paying artists.

MusicLife combines AI and blockchain to ensure that artists are paid fairly. New artists' ventures can also be crowdfunded. AI is used to calculate a song's fair value based on popularity. A piece of music's popularity depends on daily revenue, play time, the number of listeners, and the locations where the music is played (<https://venturebeat.com/2018/08/27/musiclife-uses-ai-and-the-blockchain-to-solve-song-distribution/>). Using the "hardware-embedded system," it calculates the amount of music streamed on a hardware that tapping into its API. Doing this prevents fraudulent or falsified data. People can directly invest in their favorite artists. They can buy a cryptocurrency that supports an incubation program for new artists. Artists can license their music's copyright to MusicLife for distribution. They retain 95% of their songs' ownership rights.⁸

As a similar example, the smart speaker brand Volareo uses AI to respond to voice commands and play the songs people ask. People can support artists through cryptocurrency payments. They can also establish stronger bonds with artists.⁸ Blockchain's roles are to allow for direct cryptocurrency payments and secure data (<https://www.electronicdesign.com/embedded-revolution/blockchain-and-future-music-distribution>).

SUMMARY

There are various complementary and synergistic mechanisms by which blockchain and AI are likely to have powerful impacts on structures, conduct, and performance of industries and markets. AI can provide fast and efficient processing of blockchain systems to enable transactions. AI is likely to emerge as the driving force behind smart contracts by automatically updating and modifying the relevant conditions in and validating data to implement such contracts. Blockchain, on the other hand, can enhance access to data, algorithms, and applications to enhance the AI ecosystem. Blockchain can also help provide a level playing field in the AI world in many different ways. Combined together, AI and blockchain can drastically strengthen the cybersecurity landscape. Overall, their synergistic actions can enhance trust, transparency, efficiency, and accountability.

REFERENCES

1. L. Whitney, "Are computers already smarter than humans?" 2017, <http://time.com/4960778/computers-smarter-than-humans/>
2. Hyperledger, "Blockchain as the next artificial intelligence enabler," 2018, <https://www.hyperledger.org/blog/2018/11/27/blockchain-as-the-next-artificial-intelligence-enabler-2>
3. A. Woodie, "Can blockchain Help ML and AI?" 2018, <https://www.datanami.com/2018/06/13/can-blockchain-help-ml-and-ai/>
4. N. Kshetri, "Blockchain and electronic healthcare records," *IEEE Comput.*, vol. 51, no. 12, pp. 59–63, Dec.2018.

5. L. G. Zucker, "Production of trust: Institutional sources of economic structure, 1840–1920," *Res. Org. Behav.*, vol. 8, pp. 53–111, 1986.
6. E. M. Rogers, *Diffusion of Innovation*, 4th ed., New York, NY, USA: Free, 1995.
7. W. Thibodeaux, "AI is awesome, blockchain is a powerhouse. But here's what combining them could do," 2018, <https://www.inc.com/wanda-thibodeaux/ai-is-awesome-blockchain-is-a-powerhouse-but-heres-what-combining-them-could-do.html>
8. K. Matthews, "6 digitization trends coming from AI and blockchain," 2019. <https://www.informationweek.com/strategic-cio/digital-business/6-digitization-trends-coming-from-ai-and-blockchain/a/d-id/1334369>
9. A. Conner-Simons, "System predicts 85 percent of cyber-attacks using input from human experts," Apr.2016, <http://news.mit.edu/2016/ai-system-predicts-85-percent-cyber-attacks-using-input-human-experts-0418>
10. N. Ruggieri, "Merck's AI and blockchain patent gives objects unique 'fingerprints'," 2019 <https://www.ethnews.com/mercks-ai-and-blockchain-patent-gives-objects-unique-fingerprints>

Nir Kshetri is a professor of management with the Bryan School of Business and Economics, University of North Carolina at Greensboro. Contact him at nbkshetr@uncg.edu.