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Bridging the Trust Gap: Blockchain's Potential to Restore Trust in Artificial Intelligence in Support of New Business Models

By Marina Niforos

Rapid increases in computing power and data generation have turned artificial intelligence, blockchain, and the Internet of Things into potent technologies that are rapidly gaining use in many areas of society and commerce, with significant potential benefits for economic growth and development. These innovative technologies face multiple obstacles to implementation and—particularly in the case of AI—a general wariness of their potential implications for human society. Fortunately, an integrated implementation of the three technologies may be a solution that can restore human trust in AI and blockchain applications, resulting in new business models that deliver data security and privacy, efficiency, and inclusion along with their many other benefits.

Artificial Intelligence, or AI, designates "the science and engineering of making machines intelligent, especially intelligent computer programs…enabling an entity to function appropriately and with foresight in its environment."[1] While the technology has existed in some form for almost 60 years, it is the recent combination of deep learning algorithms, greater amounts of data, and enhanced computing power that have transformed it into a disruptive technology with enormous economic and business potential across multiple sectors.[2] The imminent deployment of 5G networks, in combination with the widespread use of Internet of Things (IoT) devices, will provide the infrastructure for faster and more stable data generation, which in turn will enable the ever more rapid development of AI technologies and spawn new business models, and will radically alter the way entire industries operate.[3]

AI already plays a critical role in optimizing processes and influencing strategic decision-making, and is expected to have enormous economic and social implications in the years ahead. Global consulting firm PwC predicts that AI will increase global GDP by an additional $15.7 trillion by 2030.[4] PwC expects China to reap the greatest economic gains from AI (a 26 percent boost to GDP in 2030), followed by North America (14.5 percent). The two combined are expected to total about $10.7 trillion and account for almost 70 percent of the global economic impact of AI.[5] According to the PwC study, developing countries are projected to see more modest gains from AI due to slower rates of technology adoption,[6] despite the fact that these markets have significant opportunities to use AI technologies to leapfrog traditional development models.[7]

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AI thrives on data: the more data that is fed into its algorithms, the more intelligent they become. Yet this massive demand for and accumulation of data has made it necessary to find better systems for data storage and processing. Along with cloud computing, Distributed Ledger Technology (DLT)[8] has been put forth as a potential way to store, manage, and process data generated by AI.[9] Blockchain acts as a distributed database,[10] maintained by a peer-to-peer network of users, without a central authority or intermediary, to validate business processes and act on data.[11]

DLT is a fairly new technology that has not yet attained maturity, having come into existence with the birth of bitcoin in 2008. DLTs have been gaining momentum, collecting $5.5 billion in venture capital flow through 2018 and showing equal pace in 2019.[12] Gartner forecasts that blockchain will generate an annual business value of more than $3 trillion by 2030.[13] Blockchains are more than a technical solution to solve the problem of double-spend in digital cash, "they can change the balance of power in networks, markets and even the relationship between the individual and state."[14] The technology is being tested in cases across multiple sectors to provide secure, digital identification, to manage fraud and ensure transparency in global value chains, and to create greater transparency and efficiency in financial and government services. Yet the technology is also likely to take years and go through several transformations before it becomes mainstream.[15]

Nevertheless, this distributed form of data sharing provides some novel attributes over centralized databases, and these can be essential to addressing some of the challenges of AI, including: (i) enhanced security since there is no central point of attack; (ii) transparency and auditability, as the data is available to all participants in real time; and (iii) immutability and traceability, since its consensus-based verification makes it virtually impossible to tamper with data or obfuscate its origin. If blockchain is able to deliver these advantages at scale, with speed and cost-efficiency, it could provide an efficient and transparent infrastructure for AI data generation and processing.

The ability of blockchain to potentially provide a "trust mechanism" for AI data ecosystems is critical. There is growing mistrust among both businesses and citizens—as well as increasing perceptions of risks regarding governance—about AI data collection and usage. Awareness about the technology's strategic importance raises concerns about its ability to make important decisions in a fair and transparent way, respecting human values that are relevant to the problems being tackled.[16] Concerns about AI-powered automation and its potential threat to employment have only added to wariness about the technology.

As a result, there is a widely held desire for greater transparency and accountability with regard to AI technologies, including a call for agreed ethical guidelines over their implementation.[17] Along those lines, AI data storage systems need to be able to provide more safeguards in terms of reliability, accessibility, scalability, and affordability.[18]

The AI Trust Deficit

The AI trust deficit needs to be resolved if the technology's promises of economic growth and innovation of data marketplaces are to be realized. Fortunately, blockchain-enabled storage systems are a potential solution, one that may be able to build and maintain trust between human communities and artificial intelligence applications designed to benefit them.

AI and Data: Need for Adapting Governance Rules

Data has been called the "new oil," as its proliferation offers staggering potential to drive economic growth and innovation. Yet unlike oil, data is not an exhaustible resource,[19] and AI algorithms can continually adapt and evolve organically with its availability. Yet as the business community becomes increasingly aware of the massive economic value of AI applications, it is also becoming clear that adapting governance rules for these emerging marketplaces is quite complex. The concept of nonrivalry of data, and the fact that data can be used by many firms simultaneously, imply increasing returns and have important implications for market structure and property rights.[20] Consumers and individual citizens are increasingly aware of the value of their personal data and are demanding greater control over its use and monetization (the focus on privacy protection by policy-makers and the proliferation of privacy laws are evidence of this). In the United States, Facebook recently received a record $5 billion fine and agreed to new layers of oversight to settle privacy violations, in addition to acknowledging it was under investigation from the Federal Trade Commission for antitrust concerns.[21]

Personal Data Marketplace: Protection and Monetization

While the vast majority of data is generated by machines, more than 10 percent of total data is created by people, which represents nearly a quarter of a trillion dollars in

economic value each year for the companies able to use it.[22] It has been posited that the recognition of data property rights in favor of the consumers who generate it can be an optimal market allocation mechanism, since consumers are likely to establish a balance between the value from the sale of their data and their privacy.[23]

If data are needed to help AI make better decisions, it is important that the humans providing that data are aware of how it is handled, where it is stored, and what uses it is put to. This is particularly important in industries like healthcare or financial services, where a high percentage of personal data generated is private and/or sensitive. In fact, customer data and profiling algorithms are already considered a business asset and protected through trade secrets provisions. Yet individuals do not seem to be fully aware of the present and future value of their data and so may be allowing the "appropriation" of their digital identity.[24] Regulations such as the General Data Protection Regulation (GDPR) in Europe provide some fundamental rights over personal data. A similar discourse is taking place in the United States at present with Senators Mark Warner and Josh Hawley sponsoring a bill that would require the big Internet companies to regularly inform users of the personal data they collect and disclose the value of that data.[25]

IoT Data Marketplace

By 2030, the IoT data marketplace is expected to generate $3.6 trillion and 4.8 zettabytes of yearly traded data.[26] While established "data-as-a-service" (DaaS) channels exist for companies to buy and sell data, IoT data streams are much more difficult to handle, as they are less structured and come directly from devices that control critical processes and produce sensitive information, which in turn makes them vulnerable to hackers. This is particularly relevant in an IoT environment with exponential growth of devices.[27] The potential of these machine-to-machine (M2M) data marketplaces will not be fully leveraged without addressing the issues of trust and security, the two obstacles that impact organizations' willingness to sell and buy IoT data.

Blockchain: Addressing AI's Trust Problem?

At present, the majority of machine learning and deep learning methods used by AI rely on a centralized model for training in which a group of servers run a specific model against training and validating datasets. This centralized nature of AI holds some important risks, as it renders it more vulnerable to data tampering and manipulation by hackers, and the data origin and authenticity are not guaranteed.[28] Given this context, it is critical to establish the traceability of data, and where and how data originated and was processed by AI systems. The perceived lack of transparency and accountability is holding back faster adoption despite recognition of its ability to drive business value creation. A recent report by the IBM Institute of Business Value underlines this ambivalence of the business community: 82 percent of enterprises surveyed are considering AI adoption, attracted by the technology's value creation potential, yet 60 percent of those same companies fear liability issues, and 63 percent say they lack the skills to harness AI's potential.[29]

What Can Blockchain do for AI?

Multiple AI and blockchain shortcomings could be addressed by integrating the two technologies. Blockchain has intrinsic capabilities to address concerns about AI and can unlock the potential of data marketplaces, namely by providing control over access to stakeholders, through cryptographic encryption to secure data, and with real-time auditability of the ledger visible by all participants. Enabled by blockchain, these marketplaces can restore trust and facilitate the exchange of data between buyers and sellers, potentially unlocking more than $3.6 trillion in value by 2030.[30] Conversely, AI can boost blockchain efficiency and computational power. The convergence in the implementation of AI and blockchain systems can work for their mutual reinforcement and further their respective adoption.

How Can AI Improve Blockchain Ecosystems?

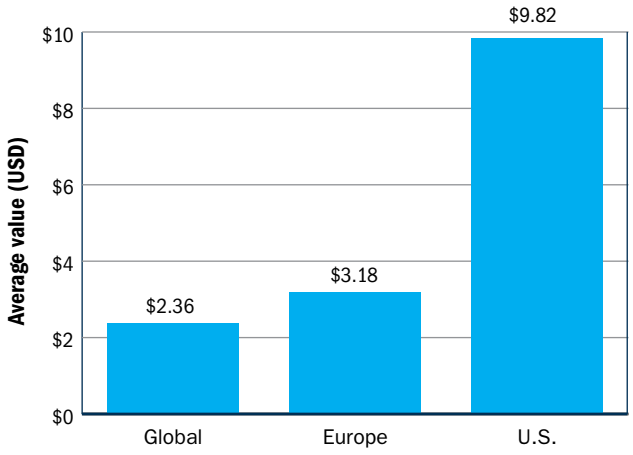

FIGURE 1 The Future Value of Data—Estimated Value of Data per Internet User in 2025 per month

Source: IDC's Global Data Sphere, November 2018; Facebook Annual Report 2017; Strategy & Analysis. "Tomorrow's Data Heroes", Strategy + Business. PwC. 2019. "Monetizing and Trusting Data: 2019 is the Year to Seize the Prize."

Smart Contracts and Distributed Governance

As discussed in EM Compass Note 41, blockchain's ability to truly transform economic and business ecosystems will require the continuous improvement and evolution of smart contracts, which are still limited in their capability and sophistication.[31] Smart contracts are embedded in code and can receive information and take actions based on predefined rules. They can be used in numerous scenarios, from the transfer of property titles to settlement of financial derivatives, and even to empower the governance of Decentralized Autonomous organizations (DAOs). The use of deep machine learning techniques and AI agents can accelerate the evolutionary process of the algorithmic blockchain-hosted entity. By utilizing the big data acquired by everyday transactions, IoT devices, or stored information on a blockchain, and then feeding them back into the process, it can render smart contracts, encoded statutes, and the overall decision-making process more autonomous, resilient, and "intelligent." AI's massive computational power may also be able to assist with some of the persistent challenges for blockchain, namely providing more energy efficient, scalable platforms, and can even address issues of security breaches that have occurred due to faults in the code.

Key Benefits of Blockchain Integration with AI

Enhanced Data Security

Cyberthreats are continuously evolving and AI can be a powerful tool in the hands of malicious attackers. A recent report found that adversaries will dwell in a network for an average of 86 days before they are discovered.[32] And a 2019 study by IBM Security and the Ponemon Institute found that a single data breach in the United States cost a corporate victim an average of $3.9 million.[33] The quality of data generated through AI is therefore critical. In a blockchain decentralized storage system there is no central repository of data, "no single point of failure" and once data is "on chain"—data codified on a blockchain—it cannot be altered. Still, blockchain has its technical hurdles: It remains slow and somewhat unwieldy, forcing a trade-off between security and efficiency.

Ensure Data Integrity and Privacy

One of the biggest challenges in data science today is the collection of a proper dataset that can be utilized for training a neural network.[34] The pluralism of data over the Internet is enormous, and even Internet giants such as Facebook and Google often fail to separate "signal from noise"[35]—the proliferation of fake news is evidence of this. Machine learning algorithms cannot reach their full potential using inaccessible, non-secure, and unreliable data.

The de facto standard in use is a centralized client-server architecture, in which data is collected from the client (the user) and owned by the server (the company). In an IoT environment with exponential growth in the number of devices, greater throughput for machine-to-machine communication and payment channels, and the need to protect increasingly personal data, this model is inefficient, as it increases data duplication and data transfers that congest network traffic. A blockchain data management system that avoids duplication and provides transparency and traceability can permit the structuring and qualification of data that in turn makes it actionable. In addition, blockchain allows participants to have direct control over access of their data through their ID authentication and a public/private key infrastructure, thereby addressing concerns regarding potential abuse of personal data.

Blockchain	Artificial Intelligence (AI)	Integration Benefits
Decentralized	Centralized	Enhanced data security
Deterministic	Changing	Improved trust on robotic decision
Immutable	Probabilistic	Collective decision-making
Data integrity	Volatile	Decentralized intelligence
Attacks resilient	Data-, knowledge-, and decision-centric	High efficiency

FIGURE 1 Key Benefits of Blockchain Integration with AI

Source: Salah, Khaled et al. 2019. "Blockchain for AI: Review and Open Research Challenges."

A recent paper from the EU Blockchain Observatory suggests that an intelligent application of criteria regarding which information to store on and off the blockchain, coupled with data obfuscation, encryption, and aggregation techniques in order to anonymize data, may help navigate some of these issues. The paper also stresses that "many of the GDPR's requirements are easier and simpler to interpret and implement in private, permissioned blockchain networks than in public, permissionless networks, where privacy can be 'designed'. Yet public networks are here to stay and represent a vital space of innovation that has the potential to create jobs and thriving companies." [36]

Higher Efficiency and Distributed Governance

AI can provide real-time analysis of data and decision-making on a large scale through a blockchain-enabled data registry. In a multi-stakeholder environment involving individual users, business firms, and governmental organizations, blockchain can provide a more efficient and transparent governance model for automatic and fast validation of data/value/asset transfers among different stakeholders, through the deployment of Distributed Autonomous Organizations (DAOs)[37] and smart contracts that govern the interactions of participants.

Inclusive Data-driven Business Models

Currently, the development and deployment of AI is mainly in the hands of large corporations with massive amounts of data, such as Google, Facebook, Baidu, or Tencent. These firms can amass user data to create and continuously improve AI algorithms. Users are not sufficiently aware of how the data they generate is deployed and do not share financially in the value they create (although strong arguments exist about the positive collateral benefits of platforms). This creates important asymmetries and market distortions in equitably leveraging the future development of AI. Insufficient transparency also feeds into the growing unease and lack of trust that consumers harbor about the new technology.

Blockchain could help buttress AI's trustworthiness by providing a system of decentralized ownership of data, thus breaking the oligopoly of large platforms while benefiting individual ownership and control of data. It can act as a platform to support individual rights while benefiting from the aggregation of vast amounts of data from the Internet of Things. Restoring trust in the system of data sharing can open access to vast numbers of data sources that can be used by AI developers that were previously inaccessible,[38] and can lower market barriers to new economic participants to reap the benefits of extensive predictive analysis.

Business models where both AI and blockchain converge can leverage huge computational power available through a blockchain network as a cloud-based service to analyze outcomes at a scale otherwise not possible, rendering the market more competitive and efficient. A decentralized data marketplace creates an economic mechanism for individuals and organizations to buy and sell data, reducing the incentive to hoard valuable unused data and remunerating the creators of data, not just the processors of it.

Cases that combine the power of both technologies are rapidly emerging—though they are still at early stages of development—in a wide variety of industries, from financial services, healthcare, and cybersecurity, to the creative industries, public services, and education. For example, Deep Brain, a Singapore-based foundation, is using AI and blockchain technologies to develop a distributed AI computing platform that is low-cost and privacy-protecting to train AI. Chinese company Cortex provides a low-cost, off-chain solution for companies to do AI research.

In Hong Kong, Datum is creating a blockchain-based marketplace where users can share or sell data on their own terms. It allows people to store duplicate copies of their data from social networks, wearables, smart homes, and other IoT devices securely, privately, and anonymously. California-based NetObjex is a smart city infrastructure platform that uses AI, blockchain, and IoT to power connected devices to cloud-based products. Cyware Labs, a U.S.-based startup, incorporates AI and blockchain-based tools into its cybersecurity and threat intelligence solutions. London-based Verisart combines AI and DLT to certify and verify works of art in real time by allowing artists to create tamper-proof certificates of work that prevent fraudulent copies from being sold as originals. U.S.-based Vytalyx and BotChain are using AI to give healthcare professionals blockchain-based access to medical intelligence and insights and to provide enhanced security of data.[39]

Global Supply Chains are Poised to Benefit

Global supply chains may have the most potential to leverage the advantages of artificial intelligence, blockchain, and IoT—and the convergence of the three. Supply chains have a high degree of organizational alignment and distinct business processes associated with supply chains, but they are encumbered by increasing complexity that puts a strain on technologies now in use.[40] Within supply chains, IoT interconnectivity has been difficult due to lack of common standards and interoperability. Each player promotes its

own proprietary standards and protocols, with siloed systems the result.[41]

Trust is one of the most important features in supply chain management. IoT serves as the essential foundation for linking the physical world with the digital world through the collection and transmission of data. With the increased complexity and volume of information, decision-making requires real-time and autonomous action, which AI can provide based on learned knowledge. Blockchain can provide the trusted registry needed to ensure AI learning is based on trustworthy and "clean" data.

Each transfer point in the supply chain tracks the status of the IoT devices and stores the data onto the blockchain. AI provides analytics and Smart Contracts with the flexibility to make decisions and trigger actions on the basis of this structured data.[42] Blockchain technology promises to accelerate the maturity of IoT and AI data exchanges by reducing the barriers to accessing data and providing a more efficient, secure, and transparent data storage and management option, creating a platform for value and asset exchange. Enterprise blockchains can develop across industry supply chains with a multitude of stakeholders breaking down silos and easing administrative procedures, both for the financial as well as the physical layer of the value chain, releasing significant amounts of untapped value.

Most of the blockchain-enabled supply chain platforms in operation today are permissioned. This fact raises concerns about potentially oligopolistic behavior—with the market dominated by a few big players—in the development of enterprise or consortia DLT solutions.[43] Additionally, on private blockchains there is a trade-off between: (i) the ability to decide access and therefore have "privacy by design" and better compliance with existing regulatory requirements; and, (ii) the reduced security robustness they afford, since by definition they are not fully distributed and have specific "gatekeepers" that can be targeted for attacks.

An important additional risk specific to AI is that a permissioned/private data management system requires the filtering of information by pre-certified parties that control access to the chain and make conscious decisions about which data goes on and off of it. The alleged implication is that these decisions may be more susceptible to explicit or implicit biases regarding information fed into the algorithms. For example, in establishing certification of persons for access to financial instruments (Anti-Money Laundering, Know-Your-Customer or others), a bias may be introduced around the characteristics of incumbent users, excluding new entrants, which could undermine the primary goal of financial inclusion. Sufficient safeguards and vigilance should be exercised in the design of sourcing and processing information that goes into AI decision making to avoid bias.

The need for greater trust throughout global value chains has been extensively documented.[44] Blockchain, working in conjunction with IoT and AI systems, can provide a system of automated trust[45] to establish the identity of users and the origin of goods, thus ensuring the transparency of data and their use. Businesses, from food to automotive to logistics and trade finance, are developing initiatives that combine these technologies to test new business models or improve existing ones.

Stowk's and Hannah Systems are developing AI-powered blockchain-based platforms to streamline business processes in the automotive industry, improving logistics and management of autonomous vehicle fleets.

Microsoft and Adents, a supply tracking solutions provider, teamed up to develop a blockchain and AI-based product tracking platform for product distribution chains that addresses performance, security, and governance.[46] They claim an 80 percent reduction in the need for data entry related to transport documentation, streamlining required cargo checks and customs compliance.[47] Industry players are also forming consortia to test solutions and develop common standards in the food industry (FoodTrust), pharmaceuticals (MediLedger), logistics and freight management (TradeLens), and financial services (We.Trade, Marco Polo, Voltron), among others.

Looking Forward

Convergence among these new technologies is not a process that will happen immediately or in a linear progression. Adoption will take place at different paces depending on technical limitations, political and social conditions, as well as the existing business ecosystem and the pool of requisite digital skills. Blockchain, for example, is a fairly new technology, and one that is still struggling to gain acceptance.

As with any emerging technology, there are challenges and doubts about blockchain's reliability, speed, security, and scalability. Such doubts are compounded by concerns about a lack of standardization and interoperability across blockchain systems, as well as associated regulatory uncertainty. On the other hand, proponents of artificial intelligence must also tackle mounting anxiety over the technology's rapid growth, which is sometimes perceived to be unchecked and/or unaccountable.

While AI and blockchain will not solve all problems, and there is little consensus about the contribution they will make to enhanced security and data protection, they have greater potential when they work in a complementary fashion to restore trust, both in the technology itself and with its stakeholders. Yet, important challenges remain for both AI and blockchain before they can attain real convergence—technical, regulatory, or even socio-political. In an IoT environment, enhanced connectivity will be required, including fast 5G cellular connectivity. Agreement over common industry standards will be necessary for interoperability and full network effects.

At present, blockchain struggles with scalability and is not capable of handling the enormity of data potentially generated by billions of IoT devices. Regulatory concerns will mount to address pivotal privacy issues, as well ethical considerations over the use of AI. A host of legal and regulatory challenges are associated with blockchain (see EM Compass Notes 57 and 59), including compatibility with data-privacy legislation, enforceability and jurisdiction, and legal recourse, among others. The risk to fair competition is especially pertinent for AI, given the oligopolistic concentration of the data holders, but it could also become a concern in blockchain development, given the rise of consortia in the search for standards.

In the EU, the European Commission has championed a multi-pronged approach to fostering the responsible development and deployment of AI, blockchain and 5G. A new €2.6 billion fund (Venture EU) has been established to spur investment in the fields, coupled with public investment in research and the promotion of public-private partnerships.

The EU has brought together experts from various disciplines in a European AI High Level Expert Group and the EU Blockchain Observatory to provide insights for the development of the guidelines[48] to promote the development of a human-centric approach. China has made artificial intelligence and blockchain pivotal vectors of the nation's thirteenth Five-Year Plan, and Chinese President Xi Jinping has stated China's intention of leading in blockchain innovation worldwide,[49] citing blockchain, AI, the Internet of Things and other technologies as the driving forces.[50] The United States adopted a U.S. plan (the American AI Initiative) for the strategic development of artificial intelligence,[51] promoting coordination across government agencies and providing financial means for research.

In emerging markets as well, many countries are mobilizing to articulate strategic plans concerning the development of AI (these include India, Mexico, Kenya, Malaysia, UAE, and South Korea, among others[52]). Significantly less strategic focus has been dedicated to blockchain development. In view of the increasingly dominant position of China and the United States around disruptive technologies and in particular AI, it is important to encourage a multi-disciplinary, multi-stakeholder approach that can build such a global system of trust in an inclusive manner and to the benefit of all. That system must include AI makers, AI users, and policymakers on an international basis, in order to ensure the principles of inclusive growth, sustainable development, and human-centric values for both developed and developing economies.

Such an interdisciplinary and collaborative approach would produce optimal solutions in efforts to foster a comprehensive environment for trustworthy AI. In June 2019 the G20 adopted human-centric principles, drawing from recommendations put forward by the OECD, which are well aligned with the recommendations of the High-Level Expert Group on AI appointed by the European Union. The framework for their implementation and monitoring remain to be tested in real-world scenarios.

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Please see the following additional reports and EM Compass Notes about artificial intelligence and the role of technology in emerging markets:

Reinventing Business Through Disruptive Technologies - Sector Trends and Investment Opportunities for Firms in Emerging Markets (March 2019); *Blockchain: Opportunities for Private Enterprises in Emerging Markets* (January 2019); *How Technology Creates Markets—Trends and Examples for Investors in Emerging Markets* (March 2018); *Artificial Intelligence: Investment Trends and Selected Industry Uses* (Note 71, Sept 2019); *The Role of Artificial Intelligence in Supporting Development in Emerging Markets* (Note 69, July 2019).

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