



Team Medicine

How life sciences can win with blockchain

IBM Institute for Business Value
survey conducted by
The Economist Intelligence Unit

Executive Report

Life Sciences and Blockchain

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More efficient and secure

Life sciences organizations are eager to take the next steps toward better patient outcomes and service delivery. However, antiquated and inefficient processes, along with regulatory concerns and an inherent caution in applying new technologies, have combined to cause life sciences to trail other industries in exploring the potential of blockchain. By providing faster access to trusted information, better collaboration and increased transparency, blockchain could go a long way to help transform life sciences in such areas as personalized patient engagement, reduced counterfeit medicines and more effective research and development (R&D).

Executive summary

The IBM Institute for Business Value surveyed 205 life sciences executives in 18 countries. The study, conducted in collaboration with the Economist Intelligence Unit (EIU), included chief financial officers (CFOs), chief technology officers (CTOs) and chief information officers (CIOs). Those participating had to meet specific criteria: they were either working with — or planning to work with — blockchains in the next 12 months, and they needed to be familiar with the blockchain strategies of their organizations.

In our analysis of responses, we focused on First Movers:

- *“First Movers”* — These are the life sciences companies that are making the initial forays into blockchain. Twenty percent of life sciences executives surveyed said they are working with and investing in blockchain now. They expect blockchain to accelerate internal transformation, improve their ability to access secure, accurate information and enhance collaboration with other members of the healthcare and life sciences ecosystem.
- *New business models and benefits* — First Movers expect to see significant reductions in cost, time and risk, as well the opportunity for business model innovation across four areas: regulation and compliance, intercompany processes, patient empowerment and end-to-end serialization (E2E).



20 percent of life sciences industry executives surveyed, the First Movers, are working with and investing in blockchain today



Nearly 70 percent of all life sciences executives surveyed expect to have a blockchain network in production by 2020



7 in 10 of First Movers anticipate that blockchain will help introduce new business models and transform patient engagement

- *Disruption potential* — For life sciences First Movers, our survey reveals that disruption is possible across three completely different areas: revenue management, adverse event tracking, and outcome-based contracts. All of these are currently being transformed across the industry.

Life sciences organizations face different challenges than those in many other industries when implementing new processes and technologies. The industry is highly regulated, and significant geographical differences exist in the degree of regulation. Therefore, as life sciences companies proceed upon their pathways to blockchain, they must consider how fast should they move, whether network-wide standards are possible and how new delivery models can be initiated.

Life sciences First Movers – who they are and what they expect

While executives in life sciences profess a keen interest in developing blockchain solutions, the expected time frame for doing so trails the first wave of industries we surveyed: banking, financial markets, healthcare, government and electronics. As a collective, 15 percent of organizations in those industries — the Trailblazers — planned to have commercial blockchain solutions at scale by the end of 2017, and a significant majority said they expected to have such a solution in production by 2019 (see Figure 1).

Figure 1

Playing catch-up: Life sciences industry adoption rate compared to first wave of industries (banking, financial markets, healthcare, government, electronics)

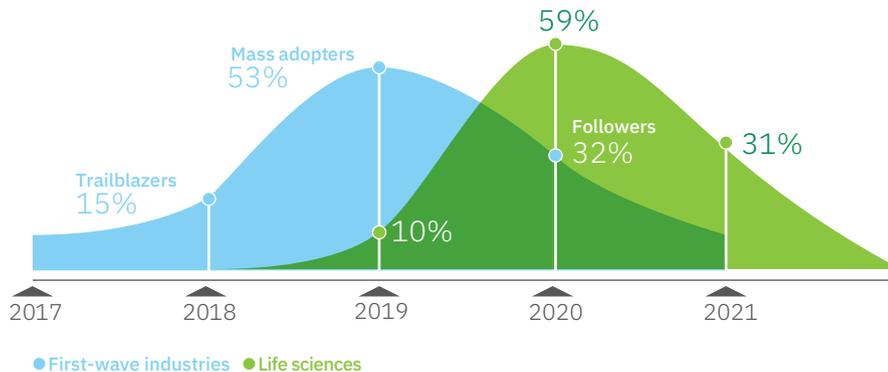
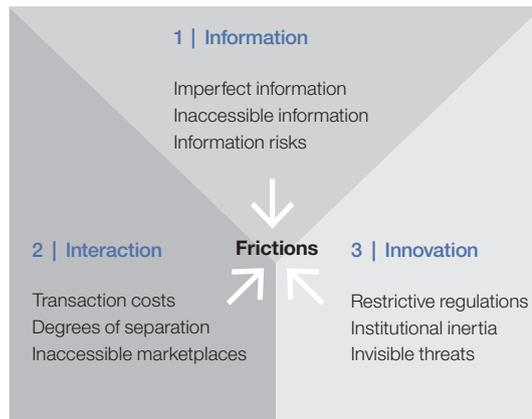


Figure 2

Frictions framework: Blockchains are expected to greatly reduce nine frictions.



Even though 20 percent of life sciences organizations surveyed indicated they are working with and investing in blockchain now, the path to commercialization is expected to be slower than the first wave of industries. As the green curve in Figure 1 shows, 10 percent of life sciences organizations plan to have fully functional blockchain solutions in place by 2019, and almost 70 percent expect to have programs in production by 2020.

Differences also exist in the adoption of blockchain solutions among the various subsectors of life sciences. Biotechnology companies, pharmaceuticals and generic manufacturers account for almost 80 percent of First Movers within life sciences. Medical technology, contract services (research, clinical, manufacturing) and academia make up most of the remaining First Movers.

For those companies ready to begin implementing solutions, blockchain has the potential to provide a more transparent and secure way to conduct business, resulting in consensus, provenance, immutability, finality and efficiency — all of which are areas in which life sciences organizations have room to improve.

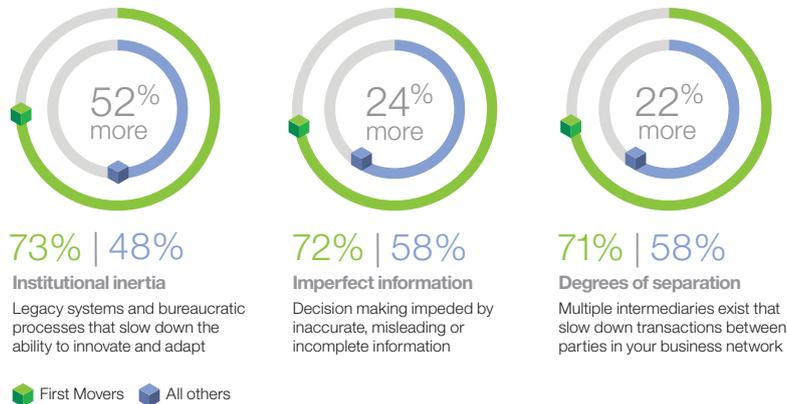
Reducing the frictions that impede progress

In our initial blockchain study, we defined three friction domains that blockchains can help overcome: information, interaction and innovation (see Figure 2).¹ Growth requires a steady march against friction. Today, friction adds costs and remains a drag on global business. It has the power to slow progress and sometimes stop it cold.

We asked life sciences First Movers to identify, from among these three domains, the top frictions they expect to have the greatest impact on their organizations. They selected institutional inertia, imperfect information and degrees of separation. (see Figure 3).

Figure 3

Freefall: Top three frictions life sciences First Movers expect to diminish using blockchain



Life sciences First Movers stand out in their expectation that blockchain will help overcome institutional inertia. Restrictive regulations, bureaucracy and legacy processes are primary reasons for inertia. Interestingly, institutional inertia ranks among the top three frictions in only one other industry we surveyed: government. Both life sciences and government march in lockstep with the regulations and processes that bind them, which makes transformation much more difficult than in many other industries.

It isn't surprising that First Movers see blockchain impacting imperfect information. In life sciences and healthcare, much patient and clinical data is digitized. But risk and regulations keep many organizations from sharing data. The lack of interoperability standards further shuts down the exchange and accessibility of information. Finally, even where data is shared, too often it isn't trusted — in part because it is incomplete or may include errors that result from the manual re-entry of data. Verifying data increases costs and delays.

Life sciences was the only industry surveyed in which degrees of separation was ranked among the top three frictions. Multiple intermediaries, such as medical distributors, slow down transactions among various entities within the large and complex life sciences/ healthcare network. But, perhaps, the biggest issue is that life sciences companies do not have direct access to the ultimate consumers of their products. They often have to buy the data they need.

Being distanced from the end-user also is a significant contributor to a general lack of trust in the industry. Pharmaceuticals, in particular, struggle with consumer trust. More than 80 percent of people surveyed in one report say pharmaceutical companies put profits over people, and a similar number prefer governments more tightly regulate the industry.²

Not every life sciences organization should respond to blockchain technology the same way. For some, blockchain technology can be transformational. Others, however, may see varied benefits. How individual organizations respond will depend on their individual circumstances and needs. As with any new, potentially transformational technology, there is no "one-fits-all" approach. However, the plans, priorities and investments of the First Movers now working and investing in blockchain can provide a high-level blueprint for others to follow.

New benefits and business models

Slow, antiquated processes that are inefficient and expensive, along with the industry's failure to fully embrace digital technology, make life sciences prime for disruption from outside influences. Such sources as new competition, customer expectations/engagement, shifting focus, changing regulations and innovation have the potential to significantly impact the industry. Blockchain can be a solution that helps life sciences organizations mitigate some of these disruptors.

Life sciences executives recognize that blockchain technology has the potential to provide benefits, such as the reduction of cost, time and risk, as well as open opportunities for new business models to emerge. Approximately seven in ten First Movers anticipate the highest blended benefits (cost, time, risk) to accrue in three areas: regulation and compliance, intercompany processes and patient empowerment. And they expect new business models to emerge in three areas: patient empowerment, E2E serialization, and regulation and compliance (see Figure 4).

Figure 4

Blockchain benefits and business models: First Movers see impact across six areas

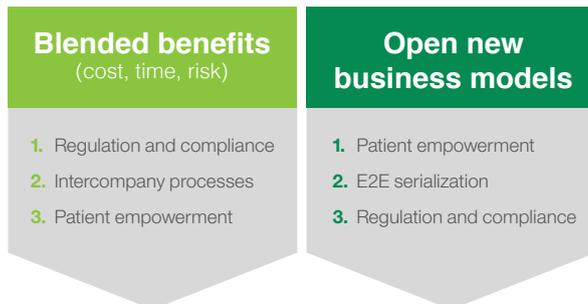
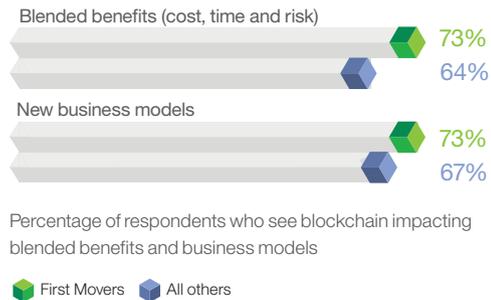


Figure 5*Regulation and compliance: Streamlining monitoring and enforcement***Regulation and compliance**

Regulation and compliance ranked first in blended benefits and third in new business models among First Movers in life sciences (see Figure 5).

Blockchain solutions not only track compliance, they also can enable smart contract-based checks as a deterrent to non-compliance. They establish a trusted audit trail verifiable in real time. This means they also streamline enforcement and deter bad actors from the outset. Instead of relying on periodic spot inspections, blockchain-enabled smart contracts can help make sure the appropriate parties are notified of non-compliant events as they happen.

Blockchains establish a platform to automatically enforce privacy regulations because rules embedded via smart contracts dictate what can be seen and when. Moreover, as data and transactions are shifted or linked to blockchains, organizations can track who has shared data and with whom, without revealing the data itself.

Intercompany processes

Our survey revealed that blockchain First Movers in life sciences rank intercompany processes, such as transfer of funds, services, raw materials and finished goods, as the area in which they expect blockchain will most reduce risk (see Figure 6).

Smart contracts can assure the reliable exchange of goods and information among companies in the complex life sciences ecosystem. Transactions over the intercompany supply chain are subject to compliance and audit in finance, accounting, transfer pricing, capital control and more. In each area, current processes are inefficient and cumbersome. Blockchain has the potential to bring all transactions into a single platform, making planning and compliance easier.

One example is a collaboration in which two organizations are exploring blockchain for the medical devices supply chain. In specialties such as cardiology, the process of getting devices to hospitals is unwieldy and involves multiple exchanges. Every time data is exchanged, a potential point of failure is created, such as loss of transparency of assets or the introduction of incorrect data. Blockchain, however, introduces a method of recording data to a single, immutable chain. As a result, full transparency of assets would be available across the supply chain all the way to the patient — ultimately increasing efficiency and reducing waste.³

Figure 6

Intercompany processes: Shortening the audit trail

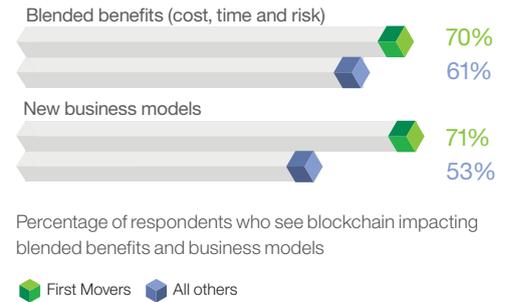
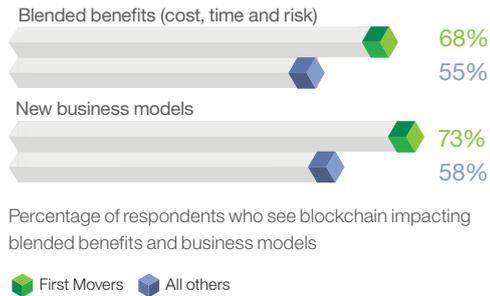


Figure 7*Patient empowerment: Putting patients in the center***Patient empowerment**

Increasingly the patient is being put at the center of healthcare to drive better health outcomes and take out cost. Not surprisingly, patient empowerment led the way among life sciences First Movers as a way to save cost and create new business models (see Figure 7). Blockchain provides the opportunity for life sciences companies to add patient data in a unified manner in such areas as consent, adherence and integrated device data — something never before possible.

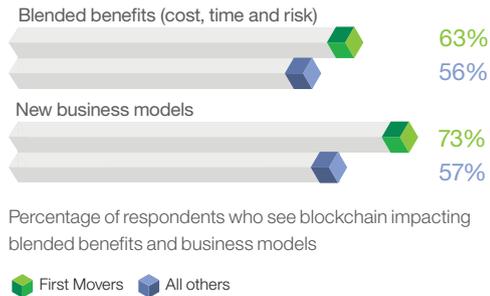
Examples of how blockchain can be used for patient empowerment are beginning to emerge across the industry. The U.S. Food and Drug Administration (FDA), for instance, recently began a blockchain initiative aimed at defining a secure, efficient and scalable exchange of health data.⁴ Transformative healthcare solutions are possible when healthcare researchers and providers have access to a 360-degree view of patient data. This blockchain technology is also designed to give patients the opportunity to share their data securely — for research purposes or across their healthcare providers — and creates opportunities for major advancements in patient care.

Case study: PokitDok – Blockchain for healthcare and life sciences API⁵

PokitDok, with offices in California and South Carolina, powers the DokChain blockchain for healthcare and life sciences. The company recently partnered with PillPack Pharmacy and Intel.

PillPack entered into a strategic alliance to leverage PokitDok's Pharmacy Plan API and Pharmacy Formulary API to get a consolidated view of patient prescription plans, qualified formularies, and related financial information.

DokChain provides identity management to validate that each party involved in the transaction is who they say they are, whether consumer or provider. Also, it can perform what it is known "autonomous auto-adjudication." The blockchain can also validate the supply chain so that, for example, when a doctor writes a prescription, it gets logged on the chain with transparent pricing for the consumer. This solution has broad implications for inventory and order management of medical supplies and pharmaceuticals. When combined, all three of these functions provide a level of proof that makes it much harder to introduce fraud into the system, while eliminating much of the friction in the current workflow and protecting the privacy of patient data.

Figure 8*E2E serialization: Improving provenance and traceability***E2E serialization**

More than 70 percent life sciences First Movers ranked E2E serialization — a non-disputable record of supply chain transactions — second among areas in which they anticipate blockchain to spur business model innovation. Additionally, more than 60 percent expect blockchain to help reduce cost, time and risk in E2E serialization (see Figure 8).

Counterfeit drugs create a worldwide problem in both patient health and lost revenue. It is estimated that illegal operators globally cause more than 100,000 deaths per year and cost pharmaceutical companies around 18 billion USD in lost revenue.⁶ Blockchain, however, makes trusted data available in real time and strips uncertainty out of each step of the process across the supply chain. For life sciences, this means improved provenance and traceability. Every transaction in the supply chain, from origin to distributor, can be accurately traced, assuring delivery of authentic products. Any sudden interruptions or bottlenecks — such as the shipment of a partial order or products delayed at customs — can be detected. The U.S. Drug Supply Chain Security Act (DSCSA) requires serialization in the United States for certain prescription pharmaceutical shipments, and similar legislation exists in Europe.⁷

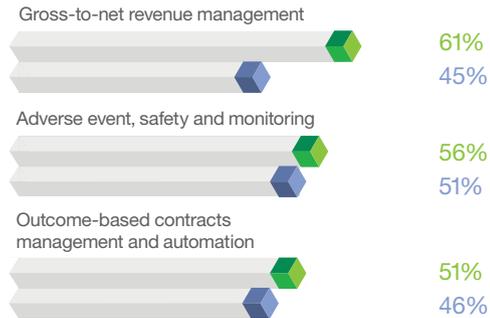
Chronicle, a company specializing in smart supply chain solutions, has partnered with The LinkLab, which focuses on serialization in life sciences, to create the MediLedger project, a serialized track-and-trace pilot for the pharmaceutical industry.⁸ The companies, both based in San Francisco, are aiming for a more secure approach to meet existing regulatory requirements that is less expensive and cumbersome. The project's goal is to develop blockchain solutions around GS1 (barcode) standards and to emphasize data privacy.⁹

Another example is how temperature-controlled supply chains or "cold chains," in conjunction with blockchain technology, can help preserve the intended attributes of temperature-sensitive pharmaceuticals.

Blockchain technology can enable a complete record of a product's temperature to be tracked from shipping to end user.¹⁰ Temperature deviations from prescribed levels — either too hot or too cold — can trigger early warning signals and prompt necessary adjustments. These include changing "use by" dates (based on previous pharmaceutical stability testing), rerouting goods for express delivery or pulling goods from distribution.

Case study: Verifying drug provenance¹¹

A cell phone artificial intelligence technology is being developed that can identify unique substances and liquids and thus prove the authenticity of pharmaceutical products. The application captures detailed information about a product, and places that record on the blockchain. The pharmaceutical product can then be scanned as it passes from one party to another in the supply chain, to verify that the data matches what was originally placed on the blockchain when the substance was created, thus helping prevent the transport and sale of counterfeit products. For instance, the application can scan two pills that look similar to the naked eye and tell them apart, or even detect if a drug label has been switched or counterfeited.

Figure 9*Business areas disrupted: Revenue management tops the list*

Top three internal processes respondents say blockchain will disrupt.

 First Movers  All others

Business areas ripe for disruption

Previously, we listed many external forces that could cause disruption to the industry, such as new competition and highly restrictive regulations. But what internal processes within life sciences companies are prone to disruption by blockchain?

First Movers selected gross-to-net revenue management as the area most likely to be disrupted by blockchain. More than 60 percent identified this as an area they expected blockchain to improve, compared to just 45 percent from all other organizations. Adverse event and safety monitoring, and outcome-based contract management were the other areas in which at least half of First Movers expected to see the most disruption from blockchain (see Figure 9).

Gross-to-net revenue management

The fact that First Movers identified gross-to-net revenue management as the area most likely to be disrupted indicates the premium they are placing on the areas where blockchain can bring the most financial value. For example, it is common for life sciences companies to lose a percentage of revenue through errors in chargebacks, rebates, returns and undocumented shortages.¹² In the United States alone, revenue loss from “leakage” accounts for tens of billions of dollars.¹³ Blockchain technology can help alleviate this issue by providing better efficiencies in tracking and tracing areas where leakage occurs. A single version of the truth provides transparency for every action and interaction.

Adverse event and safety monitoring

Fifty-six percent of First Movers cited blockchain as a potential disruptor for adverse event and safety monitoring. For example, the pharmaceutical industry has the prime responsibility for the safety of medicines, vaccines, blood products, biotechnology, herbal medicines and traditional medicines. Many companies have developed innovative and efficient monitoring systems that have contributed to the successful detection of new safety signals.¹⁴

Healthcare providers are the major contributors of case reports of suspected adverse drug reports (ADR). With reporting from all healthcare professionals involved in patient care, blockchain makes it possible to detect the full spectrum of complications related to pharmaceutical treatment. Patients also play an important role in pharmacovigilance activities, from reviewing the product information to the spontaneous reporting of adverse events from their medicines.

Blockchain to track dispensation of opioids¹⁵

Opioid abuse is becoming more common. In the United States, healthcare issues associated with opioid overdose have become epidemic.

Today when a dispenser orders a controlled substance, the seller, either a distributor or manufacturer that sells direct, checks the order against a suspicious order monitoring (SOM) system. Part of that check is the number of opioids the dispenser has ordered in the past. However, each seller only knows what it has sold the dispenser. No industry-wide consolidation of records exists.

Blockchain can create an industry-wide, single source of aggregate information about opioid orders for each dispenser. The total amount would then be available to sellers to use in SOM systems, while still maintaining the confidentiality of individual order information.

With such information, analytics could be used to determine how many opioids are too many for a dispenser to order, taking into consideration the nature of the dispenser. For example, the needs of a pain clinic would likely differ substantially from the needs of a neighborhood pharmacy.

Outcome-based contracts

The value of a new drug depends on several variables. For example, what is the disease progression in the patient and what outcome can be reasonably expected? Given the well-publicized rise in drug prices, increasing pressure is being applied to pharmaceutical companies to prove the effectiveness of their offerings. At the same time, the costs for life sciences to develop new drugs via traditional methods have risen to levels that stifle innovation.

Outcome-based contracts provide for payment once value is demonstrated. For example, one pharmaceutical company just entered a contract with the U.S. Centers for Medicare & Medicaid Services (CMS) that stipulates payment for a new leukemia drug will be made only if patients respond to treatment by the end of the first month of administration.¹⁶ The cost of the medication approaches a half million USD for a one-time application. Industry experts expect the same arrangements to be offered to private insurers. The net result is that pay-for-performance pricing may increase immediate drug costs, but, in the long term, reduce patient cost. Blockchain technology can help manage this process by providing trusted verification of outcomes at the individual level.

Recommendations

To best extract value from blockchains, we recommend life sciences organizations to ask themselves and consider their answers to three questions:

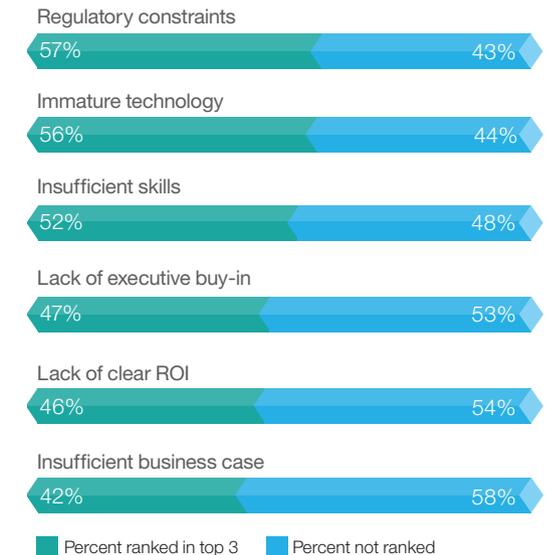
How fast should I move?

Twenty percent of life sciences organizations surveyed have already started. And 70 percent expect to have blockchain production in progress by 2020. Organizations not investing now in blockchain should prepare to join the industry in exploring blockchain use cases and potential network partnerships as soon as possible. However, for many life sciences companies, the path forward may be a bit bumpier than that for many other industries. The stringent regulatory environment, a perception of lack of mature technology and insufficient blockchain skills in the industry all serve as barriers to early blockchain adoption (see Figure 10).

Life sciences companies, in deciding how to move, should pick specific use cases relevant to their businesses and examine what challenges exist and what steps to take. For example, consortia should look at use cases, led by regulators, that require industry-wide standards. Smaller working groups might look for use cases focused on regional ecosystem differences.

Figure 10

Blockades: Barriers to rapid blockchain adoption



Can I achieve network-wide standards?

As Figure 10 illustrates, life sciences organizations are aligned on the barriers to blockchain adoption, with regulatory constraints topping the list. However, blockchain provides the technology to mitigate a number of regulatory challenges. Blockchain provides the visibility regulators, such as the FDA, need at every step of the process, from product creation and approval through delivery to the end user. Blockchains can provide up-to-the-minute, trusted audit trails, which create widespread accountability and, potentially, reducing the need for regulatory spot checks.

Consortia, such as non-profit PhUSE, have been laying the groundwork for a better understanding of blockchain benefits for the life sciences industry, with many organizations already recognizing that strategic partnerships are necessary to create new business models across the value chain¹⁷

How can I scale with new revenue models?

Our survey shows that nearly half of life sciences First Movers ranked the lack of a clear ROI strategy and executive buy-in as barriers to blockchain implementation. These are issues that should be organizational priorities. Also, dedicated efforts must be in place to attract the talent needed to address the lack of necessary skills.

Blockchain is an effective technology to solve industry challenges that transcend organizational boundaries. The business case is predicated on “collective benefits” and the industry needs to embrace collective solutions. Focus on shared industry problems that deliver value for all parties.

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Notes and sources

- 1 Cuomo, Jerry, Shanker Ramamurthy, James Wallis, et al. "Fast forward: Rethinking enterprises, ecosystems and economies with blockchains." IBM Institute for Business Value. September 28, 2016. <https://www-935.ibm.com/services/us/gbs/thoughtleadership/blockchain>
- 2 White, Kym. "Trust in healthcare: Making progress." Edelman Website. March 2017. <https://www.edelman.com/post/trust-healthcare-making-progress>
- 3 IBM Institute for Business Value analysis, based on internal case studies or interviews.
- 4 "IBM Watson Health Announces Collaboration to Study the Use of Blockchain Technology for Secure Exchange of Healthcare Data." IBM. January 2017. <http://www-03.ibm.com/press/us/en/pressrelease/51394.wss>
- 5 "PillPack Deploys PokitDok for Instant Pharmacy Eligibility Assessments." Business Wire. July 2016. <http://www.businesswire.com/news/home/20160721005100/en/PillPack-Deploys-PokitDok-Instant-Pharmacy-Eligibility-Assessments>; "PokitDok teams with Intel on healthcare blockchain solution." Tech Crunch. May 2017. <https://techcrunch.com/2017/05/10/pokitdok-teams-with-intel-on-healthcare-blockchain-solution/>
- 6 Gilbert, David. "Blockchain Technology Could Help Solve \$75 Billion Counterfeit Drug Problem." International Business Times. April 19, 2016. <http://www.ibtimes.com/blockchain-technology-could-help-solve-75-billion-counterfeit-drug-problem-2355984>
- 7 "Drug Supply Chain Security Act." U.S. Food and Drug Administration. <https://www.fda.gov/Drugs/DrugSafety/DrugIntegrityandSupplyChainSecurity/DrugSupplyChainSecurityAct/>

-
- 8 "Chronicle and The LinkLab Announce The MediLedger Project, a Revolutionary Blockchain-backed System to Safeguard the Pharmaceutical Industry." Cision PR Newswire. September 2017. <https://www.prnewswire.com/news-releases/chronicle-and-the-linklab-announce-the-mediledger-project-a-revolutionary-blockchain-backed-system-to-safeguard-the-pharmaceutical-industry-300522426.html>
- 9 "Pharma Companies Tap Startups to Develop Protocol for Tracking and Verifying Prescription Drugs using Blockchain." Cision PR Newswire. March 2017. <https://www.prnewswire.com/news-releases/pharma-companies-tap-startups-to-develop-protocol-for-tracking-and-verifying-prescription-drugs-using-blockchain-300428313.html>
- 10 "Where Blockchain Meets Cold Chain." The Wall Street Journal. November 22, 2017. <http://partners.wsj.com/ups/blockchain-meets-cold-chain/>
- 11 IBM Institute for Business Value analysis based on internal research.
- 12 IBM Institute for Business Value analysis, based on publicly available information.
- 13 Ibid.
- 14 Argentinis, Elenee, Louisa Roberts and Heather Fraser. "Scaling safety expertise in life sciences: With timeliness critical to safety operations, cognitive computing can add speed, scale and consistency to the pharmacovigilance process." IBM Institute for Business Value. April 2017. <https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=GBE03829USEN&>
- 15 IBM Institute for Business Value analysis, based on publicly available information.
- 16 IBM Institute for Business Value analysis, based on publicly available information.
- 17 "Blockchain Technology." PhUSE wiki. http://www.phusewiki.org/wiki/index.php?title=Blockchain_Technology

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March 2018

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