Blockchain in Manufacturing: Enhancing Trust, Cutting Costs and Lubricating Processes across the Value Chain

Manufacturers recognize the disruptive potential of blockchain to streamline complex supply chain operations, simplify trade finance and spur the transition to customized manufacturing made possible by 3-D printing. Yet, most manufacturers are not moving aggressively to prepare for the transformative changes that blockchain will bring.
EXECUTIVE SUMMARY

Blockchain technology is poised to disrupt manufacturing over the next few years by fundamentally redesigning inefficient processes in areas such as supply chain management and trade finance, as well as spawning entirely new business models. Although the technology is still in its early stages of development, manufacturers must begin assessing how they will harness blockchain networks to generate business value and prepare for the new competitive realities that the technology will bring.

Fully exploiting its potential will require manufacturers to more effectively collaborate with supply chain partners, financial institutions and other stakeholders on joint projects to test how blockchain’s distributed ledger technology, in combination with smart contracts, can be deployed to streamline and automate business operations. Manufacturers that move quickly will also be able to capture first-mover advantages in transitioning to the new competitive landscape created by blockchain innovations. This is particularly true for capabilities powered by 3-D printing and smart devices to create new and more trusted ways of interacting and transacting across manufacturing’s distinct disciplines – from product design and R&D, through manufacturing, logistics and fulfillment.

To understand how manufacturers view blockchain, we conducted a global survey of 281 manufacturing professionals on how they expect blockchain to impact their organizations and the steps they are taking to leverage the technology (see Methodology, page 28).

Major manufacturers incur enormous time and expense in managing their complex global supply chains - identifying and selecting trusted suppliers, negotiating and enforcing agreements, tracking products during production and delivery, and ensuring timely
payment. These cumbersome processes are largely manual, requiring numerous e-mails, phone calls and meetings. The $4 trillion market for trade finance suffers from similar process inefficiencies in negotiating contracts, adding amendments and resolving payment disputes.

Blockchain promises to dramatically streamline these and other operational areas through its ability to allow disparate organizations to share information securely without the need for a trusted intermediary. Blockchain’s ability to support smart contracts, which negotiate and execute agreements automatically, could eliminate many of the manual processes that currently slow processing, increase costs and often lead to ambiguities and disputes. Manufacturers could also improve planning by gaining real-time visibility into their supply chain.

Beyond increased efficiency, blockchain could also fuel the transition toward the democratization of manufacturing - small production runs of customized products - made possible by 3-D printing. Smart contracts on a blockchain network could automatically connect designers, manufacturers and buyers, and then execute the agreement. All participants would gain real-time visibility into the production process and delivery.

Manufacturers should move quickly to gain experience with these and many other potential applications of blockchain. They can begin by identifying the business processes where the need to interact with multiple external partners creates inefficiencies that drive up costs, such as in the supply chain. Once manufacturers gain experience in understanding how blockchain could be employed in these areas, they should expand their horizons to consider how to benefit from the new business models this technology will enable.
Key Findings

- **Blockchain’s potential is disruptive.** Three-quarters of respondents said they believe blockchain will be either very important or important to the future of their industry. With the technology’s ability to streamline operations, 84% of respondents expect annual cost savings of more than 2.5% by applying blockchain in their organization.

- **Blockchain strategies are not just a technology concern.** Manufacturers need to gain experience with blockchain technology, develop use cases, initiate pilot projects and acquire needed talent. As a result, blockchain initiatives should have a strategic focus, with manufacturers working to identify the concrete business problems and opportunities that the technology can address. Organizations are finding many ways to gain insight into potential blockchain applications. These include investments or partnerships with external organizations, such as acquiring start-ups focused on niche areas (21%), investing in a start-up/established company (20%), partnering with a start-up (19%) and collaborating with an established vendor (16%).

- **Platform selection is still ongoing.** Respondents were divided on which type of blockchain platform their organization plans to adopt, with the most common approaches being open (public) blockchains (37%) and permissioned (private) blockchains (33%). Manufacturers should choose the platform that is best suited to the requirements of each use case, considering the needs for functionality, privacy, security and speed.

- **A top adoption challenge is understanding blockchain’s business value.** Over half (56%) of respondents said that understanding blockchain use cases was a top internal barrier to adoption. Other frequently named barriers were related to the challenge of developing a business case for blockchain: evaluating cost-benefits of use cases (46%) and uncertainty around when benefits would accrue (42%). In their efforts to identify the specific business areas where blockchain can streamline operations or open new business opportunities, manufacturers should recognize that blockchain benefits are typically achieved over the long term and may not be easily quantified in a short timeframe.

- **The talent gap needs to be closed.** Many respondents said their organization will need additional blockchain expertise in cybersecurity (66%), risk management (61%) and compliance (61%). However, respondents appear to underestimate the talent challenge they will face in two areas: business strategy, where only 44% felt they need additional expertise, and in technical areas, where just 56% believe they need more skilled professionals. Most organizations will need more expertise in understanding how blockchain can support their business strategy, as well as more skills in technical areas such as public key infrastructure (PKI), information architecture, software engineering, network infrastructure and integration, and user interface/user experience.

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Manufacturers will need to gain experience with working more closely with external organizations for mutual benefit, and recognize that becoming comfortable with collaboration will take time and significant cultural change.

- **Security concerns are a top external roadblock.** The external adoption challenge cited most often by respondents was privacy and security (68%). Operators of permissioned blockchain networks are working to design ways for enterprise users to limit access to their data. Despite these concerns, blockchain networks provide much higher levels of security than are currently available via other approaches. The second most often-cited barrier was creating standards (64%). Creating a single set of standards for each application across an industry will yield the greatest efficiency gains, although that will take time given blockchain’s early stage of development. Finally, 63% of respondents cited scalability/latency. Manufacturers should consider the speed and scalability required for each use case, keeping in mind that performance claims made by platforms regarding speed should be independently verified.

- **The collaboration imperative requires a mindset shift.** The greatest benefits from blockchain will result from applications that streamline the interactions of manufacturers with external parties such as supply chain partners, financial institutions and customers. Yet, only 19% of respondents said their organization has started working with external supply chain partners on blockchain, while 18% said they are working with other industry partners/competitors. Respondents said a number of issues make collaboration difficult, including establishing connectivity with partner systems (91%), agreeing to a shared data model between parties for blockchain use (81%) and identifying and finalizing blockchain use cases (80%). Manufacturers will need to gain experience with working more closely with external organizations for mutual benefit, and recognize that becoming comfortable with collaboration will take time and significant cultural change.

Blockchain is poised to rewrite the rules of competition in manufacturing. Yet, many manufacturers are hanging back, waiting for the many blockchain platforms to consolidate into a small number of survivors and the optimal manufacturing applications to become apparent. Manufacturers that adopt a wait-and-see approach may find it difficult to catch up with more enterprising competitors.

To ensure they are not left behind, manufacturers should move quickly to gain experience with the operational efficiencies and new business models made possible by blockchain technology.

**THE DISRUPTIVE POTENTIAL OF BLOCKCHAIN**

First used in 2009 for the digital cryptocurrency Bitcoin, blockchain technology has moved far beyond financial services and is being applied in a variety of applications throughout nearly every major industry, including manufacturing. Blockchain provides a way to conduct and record transactions through a peer-to-peer network that replaces the traditional role of a central trusted authority. Blockchain networks create proof of ownership by using unique digital signatures that rely on both public
Blockchain's distributed ledger technology could allow manufacturers to slash the trust tax by reimagining global supply chains.

encryption keys known to everyone on the network and private keys known only to the owner. Complex algorithms drive consensus among users, ensuring that transaction data cannot be tampered with after it is verified, reducing the risk of fraud.

Blockchain platforms can be public (i.e., permissionless) like Bitcoin, with anyone allowed to submit a transaction and take part in validating other transactions. Or they can be private (i.e., permissioned), where only authorized participants can share and validate information. Private blockchains pivot around the reputational investment of the network participants, which boosts confidence in the transactions' validity.

Using blockchain, manufacturers can potentially boost operational efficiency, reduce production costs and create new business opportunities. The value chains that support global manufacturing depend on achieving trust among a complex web of suppliers, distribution partners and customers. Suppliers must be selected carefully and then monitored for quality and reliability. Manufacturers must confirm that distribution partners have delivered finished products on time. To meet regulatory requirements, manufacturers also engage with service providers to conduct inspections and issue certifications to ensure best practices are followed.

Coordinating among the thousands of organizations involved in a global supply chain for a major manufacturer, and gaining the required assurances, is a slow and often expensive process entailing paperwork, e-mails, phone calls and site visits. Despite these efforts, manufacturers and other users of raw materials confront $300 billion per year in supply chain fraud and leakage. In effect, today's cumbersome processes impose a “trust tax” on manufacturers around the world and on their supply chain partners.

Blockchain's distributed ledger technology could allow manufacturers to slash the trust tax by reimagining global supply chains. By automating today's manual processes and reducing the need for service providers to conduct inspections, a blockchain network could ensure product quality and authenticity, speed transactions and reduce processing fees. Manufacturers would gain a granular and real-time view of their global supply chain, documentation of the chain of custody for their products, and immutable records that cannot be altered inappropriately or tampered with.

Many of today's procurement processes could be streamlined through “smart contracts” placed on a blockchain. A smart contract is computer code that specifies the terms and conditions of the contract – such as the type of goods, quality requirements, needed delivery dates and price – and executes automatically, providing payment when its conditions have been met. For example, a supplier could issue a smart contract on a blockchain platform that specifies the product definition, quantity, price, availability date, and shipping and payment terms. A manufacturer could automatically search the blockchain for smart contracts that meet its requirements, verify the reputation of the seller for quality and timeliness based on data on the network, and then complete the transaction, without the need for a manually-generated purchase order. The supplier could then automatically locate and execute a smart contract with a carrier for delivery.

Once the carrier enters delivery confirmation into the network, both the contract for delivery and also the contract for purchase of the product would be paid automatically.
Beyond Efficiency: New Business Models
But blockchain will not only increase operational efficiency; it will also help create entirely new business models. Distributed ledger capabilities will enable the movement toward mass customization and made-to-order production made possible by 3-D printing, allow manufacturers to remotely upgrade and repair connected devices, and gather data from products after sale to allow the provision of value-added services.

Many of these new business models will pivot on sensors in the Internet of Things (IoT) and related device instrumentation to bump blockchain from its infrastructure roots into a catalyst for delivering what some pundits have dubbed the Internet of Value. Projects that marry blockchain’s shared infrastructure with 3-D printing illustrate how this emerging technology can elevate trust and open new market opportunities for manufacturers – both OEMs and component manufacturers – and logistics companies across the value chain.

For example, The Genesis of Things Project is a secure online platform for industrial 3-D printing that employs blockchain to identify the optimal 3-D printer, securely transfer production files, and establish smart contracts to automate access, use, logistics, rights and payments (learn more about this topic on page 11).

Respondents broadly concurred that blockchain will have far-reaching impacts on their organizations and their industry. Eighty-seven percent of respondents predicted that blockchain will be either critical or important to the future of their organization, with 41% believing it will be critical. Similarly, 75% of respondents predicted that blockchain will be either very important or important to the future of their industry, including 44% who predicted it will be very important, i.e., will fundamentally transform their industry.

Respondents expected blockchain to profoundly impact their organization, with 59% anticipating a high level of impact on operations, and 41% on supply chain management execution (see Figure 1).

Blockchain Impact on Business Functions

Respondents were asked to indicate the impact blockchain will have on the following functional areas. (Percent rating impact as “high”)
The functional areas where a high level of impact was expected include operations (59%) and supply chain management/execution (41%). These findings are consistent with the most often-cited benefits of blockchain: its ability to provide trusted data on raw materials, production and products (63%) and the elimination of non-value-adding intermediaries in the global supply chain (53%) (see Figure 2).

The increased efficiency in operations and supply chain is expected to result in significant cost savings. Eighty-four percent of respondents said blockchain will result in annual cost savings for their organization of more than 2.5%. Much of the savings could result from automation, with 76% of respondents predicting that blockchain will allow their organization to automate more than 2.5% of its jobs.

Given its benefits, respondents reported that their organizations are exploring a variety of use cases, many of which are focused on product design, including acquiring and securing IP (68%), and operations (65%) (see Figure 3, page 10). Two of the most promising blockchain applications illustrate this potential: enabling 3-D printing and streamlining the conventionally cumbersome trade finance marketplace.
A supplier could issue a smart contract on a blockchain platform that specifies the product definition, quantity, price, availability date, and shipping and payment terms. A manufacturer could automatically search the blockchain for smart contracts that meet its requirements, verify the reputation of the seller for quality and timeliness based on data on the network, and then complete the transaction, without the need for a manually-generated purchase order. The supplier could then automatically locate and execute a smart contract with a carrier for delivery.
Enabling the 3-D Printing Revolution

The era of mass production, made possible by the early 20th century introduction of standardized parts and the assembly line, will soon be replaced by the era of mass customization, in which products are designed and produced to meet each customer’s individual requirements. The new model will require distributed manufacturing models, such as 3-D printing, in which large-scale manufacturing is broken down into modular processes.

3-D printing allows designers and inventors to create new products anywhere and then produce them by sending the design files to a remote printing facility, effectively “borrowing” part of the factory on-demand when they need it. Major manufacturers can use 3-D printing to flexibly execute small runs of products that meet the needs of individual customers, while micro-factories and designers will gain the ability to produce innovative products targeted toward niche markets.

Blockchain could provide the infrastructure required for 3-D printing to truly take off. Blockchain can facilitate the 3-D printing process by providing inexpensive and assured integrity for design files and each step in the production process: that the correct design and raw materials were used, the production met product specifications, the product was shipped and received on-time, and payment was made according to the terms of the contract.

The use of smart contracts on a blockchain could automate many manual tasks, such as allowing manufacturers, designers and buyers to easily find each other and agree on contract terms for small production runs and then automatically execute the contract terms, such as price, quality level, delivery date and payment. Further, the assurance required can be provided without the need for expensive third parties, such as banks, escrow agents, service providers and lawyers.
To demonstrate how a low-cost, blockchain-based solution could facilitate the 3-D printing supply chain, we worked with Innogy (a European energy company) and EOS GmbH Electro Optical Systems (a leader in industrial 3-D printing) on a pilot to develop a blockchain-based shared 3-D printing factory. The prototype (created for the Genesis of Things initiative) provided end-to-end encryption to protect 3-D print files that describe high-margin, precision-manufactured parts, such as components in jet engines or power generation equipment, from their creation to their use at a 3-D printer.

Eliminating the middleman, smart contracts allowed these files to automatically execute pre-programmed pricing and other terms and conditions with local 3-D printers, logistics providers and customers. The blockchain, if commercialized, could provide a unique digital memory for each product, its parts and all the quality, design and printing process data. (For more information on this project, see our report “How Blockchain Can Slash the Manufacturing ‘Trust Tax.’”)

Reengineering Trade Finance

To export products to customers around the world, global manufacturers depend on more than $4 trillion in trade finance provided by financial institutions. Yet, the current system of trade finance suffers from process inefficiencies, changing trade regulations and requirements across geographies, and the operational and logistical complexities that arise when a large number of entities interact. The difficulties are evident in the increase in litigation and fraud related to trade financing over the last few years.

When using letters of credit, for example, payment disputes and delays often emerge due to ambiguities in the contract language, data mismatches or errors in documents. In fact, 70% of documents are rejected when first presented for evaluation in letters of credit. Contract amendments add additional time and expense. The cost and inefficiencies make letters of credit unprofitable for small transactions or for those involving time-sensitive or perishable goods. These inefficiencies may explain the steady decline in the last three years in the volume of MT700s, which account for approximately 90% of all letter-of-credit transactions.

Blockchain holds the potential to streamline the trade finance process. Trade transaction records stored on a blockchain would be tamper-proof, reliable and verifiable by all parties at any time, which would provide visibility into asset status for tracking merchandise. Contractual obligations could be executed automatically through smart contracts. A single source of truth for trade transactions would emerge, reducing the potential for double spend and fraud, and eliminating the need for continuous reconciliation between trading and financing parties in the transfer of these digital assets.
For letters of credit, these could be created as smart contracts on a blockchain network consisting of the manufacturer, the customer and the banks or other trade finance entities. The self-executing contract would codify the terms and conditions of trade regarding the time, place and manner of shipment and delivery; the description and quantity of the goods shipped; and the documentary evidence required for verification. The contract would execute automatically, and payment would be made when its conditions were met.

Automated verification of compliance with contract terms would ensure faster payment by preventing disputes due to ambiguities in the contract. Storing contracts on a blockchain would also allow discrepancies to be discovered quickly and speed the amendment process, which could shorten the time it takes to issue a letter of credit, which currently averages seven to 10 days. (For more on blockchain in trade finance, read our white papers “How Blockchain Can Revitalize Trade Finance” and “Blockchain for Trade Finance: Payment Method Automation.”)
**QUICK TAKE**

**Broad Spectrum of Use Cases**

The following are among the promising uses cases for blockchain in manufacturing.

- **Real-time procurement.** Smart contracts on a blockchain could continuously query all other nodes for the best pricing, delivery times and other terms and conditions for specialized parts. This would allow major manufacturers to ramp up more easily to meet demand, while helping component manufacturers meet customer demand.

- **Supply chain visibility and traceability.** A blockchain supply chain application could provide real-time visibility into each stage of the production and delivery of products and parts. When problems occur with raw material or components, manufacturers could reduce their liability by quickly identifying the individual products and customers affected.

- **The shared-vehicle economy.** Blockchain could support the creation of a shared economy of autonomous vehicles in which consumers own rights to a type of vehicle, rather than owning an individual vehicle. In such an economy, with so many possible peer-to-peer interactions, trust in the transactional data is paramount. Telematics data, including transactional data for vehicle usage and on-board services usage, would be recorded in a blockchain. The data stored on the blockchain would enable a litany of players to take decisive action. Insurance companies could execute smart contracts as needed, payment processors could charge customers according to their usage, and Tier 1 suppliers could gather data to predict failures and quickly trace recalls back to their source.

- **Tapping data from IoT.** Blockchain technology could unlock the power of data generated by smart devices at the edge of the network, allowing manufacturers to improve quality and features by providing better insight into how their products perform over time. Blockchain could provide the platform on which IoT data could be indelibly stored and used as the basis for decisions across the business spectrum. Access to this data would also help manufacturers move beyond production and track-and-trace to more lucrative sales and services, such as the proactive replacement of failing parts.

- **Marketplaces providing access to digital product memories.** These marketplaces could provide customers with reliable data about products and manufacturing processes, significantly reducing the cost of quality control, regulatory compliance, and warranty and recall actions.

- **“Asset-light” enterprises.** As manufacturing becomes smarter through real-time connectivity to connected devices and the use of deep data, new models are emerging in which businesses would add value to product design, marketing and supply chain management by supplying data to otherwise “dumb” factories. These business models would rely on access to the secure data-sharing infrastructure that blockchain provides.
Blockchain Initiatives

The potential of blockchain in manufacturing is drawing interest from a variety of companies, including the following.

- **The Trusted IoT Alliance** was launched in 2017 by major companies, including Bosch, Cisco and HCM International of Foxconn Group, to develop standards for an open source blockchain protocol to support IoT technology.\(^{11}\)

- **Toyota recently announced** several projects that will use blockchain technology, including sharing data from autonomous vehicles to improve safety and efficiency, developing tools for ride-sharing and creating new usage-based insurance products.\(^{12}\)

- **An economic development firm owned by the city of Kouvoia in Finland** – which is a key shipping location that hosts 200 logistics companies – has launched a project to employ blockchain to streamline the supply chain involving trucking, warehousing and freight carriers.\(^{13}\)

- **Bernstein Technologies in Munich, Germany**, has developed a blockchain application that allows companies to prove the ownership and integrity of any IP asset while creating a digital trail of records of processes, such as inventions, designs and proofs of use.\(^{14}\)

- **SolarChange is a German startup** that uses blockchain technology to improve the use of solar energy, allow energy and utility companies to manage their networks more efficiently, and enable owners of solar equipment to gain more value from their systems.\(^{15}\)

- **Provenance** is a start-up that’s using blockchain to record each step that a product takes in the global supply, which consumers can access scanning a QR code.\(^{16}\)

- **Everledger has established relationships with certificate houses** around the world and has now registered the unique identification codes for more than one million diamonds to reduce fraud.\(^{17}\)
DEVELOPING A BLOCKCHAIN STRATEGY

Although blockchain could be more disruptive than the advent of the commercial Internet, its adoption by manufacturers is still in its early stages. Manufacturers should move quickly to understand where they can leverage blockchain capabilities to address their operational challenges or take advantage of new business opportunities. Equally important, they need to gain experience with what will be required to implement blockchain solutions. Waiting until the direction becomes clear could leave manufacturers playing catchup.

Early adopters will be able to influence the development of networks and consortia, including the choice of participants and governance rules. By road-testing potential applications, early adopters can develop and test pilot applications, while assessing their internal readiness to support blockchain solutions. Manufacturers that move quickly to test blockchain will gain a better understanding of the costs and benefits of potential use cases, identify their internal strengths and weaknesses, and begin planning with their supply chain partners. Beyond increasing operational efficiency, early adopters could also gain competitive advantage by developing the capabilities required to compete successfully as new business models gain traction.

Given that nearly all respondents said blockchain will be important to their company’s success, it is notable that only 52% said their organization had identified the functional areas and business processes that could be impacted by blockchain, although an additional 42% said they are currently in the process of doing so.

Manufacturers need to take blockchain from theory and put it into practice, identifying concrete business problems and opportunities that the technology can help address. For each use case, a manufacturer should:

• Specify the actions needed for implementation.
• Assess the resources required, create a process map and develop an implementation guide.
• Determine key performance indicators (KPIs) that can be used to evaluate success. The KPIs will allow the organization to not only assess performance but also communicate value to senior management.

Developing a blockchain strategy should not be seen narrowly as a technology issue, but instead should involve stakeholders from across the business at the outset (see Quick Take, next page). A blockchain pilot project may demonstrate how the technology works, but it is even more important to learn whether the project is an optimal solution for the business problem being addressed and how a full-scale implementation would impact the organization’s business.

Not surprisingly, our study did not detect consensus among manufacturing respondents on how their organizations are pursuing blockchain. Most respondents cited approaches that rely on investments or partnerships with external organizations: 21% said they had acquired a small or medium-size start-up focusing on a specific niche area, 20% said they had invested in a start-up/established company, 19% said they were partnering with a start-up, and 16% said they were collaborating with an established vendor. Other respondents reported that their organization is pursuing an internal approach: 19% said they were pursuing blockchain internally, and 5% said they had joined a consortium of start-ups and competitors.
Developing an Effective Blockchain Strategy

Manufacturers need to develop a cohesive blockchain strategy rather than taking on projects in a piecemeal fashion. Other strategy considerations include:

- **Blockchain projects should be driven by cross-functional teams with a business sponsor.** Ensure the blockchain project addresses specific business problems or opportunities. Rather than emanating from IT, the initiative should involve business stakeholders from the outset.

- **Set clear goals.** Assess whether blockchain technology is well suited to the business issue being addressed, and clearly specify which objectives will be achieved.

- **Don’t wait until costs and benefits are clear.** Learning will be iterative, and costs and benefits may only become defined more clearly as the project progresses. In addition, many reasons to move forward are strategic in nature and cannot be quantified at the outset.

- **Stay flexible.** Recognize that blockchain is still in the early stages of development; innovation will continue, and the infrastructure will evolve.

- **Explore a variety of platforms, including both permissioned and permissionless.** For each use case, choose a platform based on how well it is tailored to the business need, and not the one with the most buzz.

- **Gain experience collaborating with other players across the value chain.** Don’t underestimate the importance - and challenge - of managing people to create an effective culture of collaboration. Work with industry partners on blockchain projects and assess the obstacles in working successfully with external organizations.

- **Focus on blockchain projects with real-world potential.** The risk of doing nothing is greater than the risk of doing the wrong thing.
We believe it is unlikely that one blockchain will dominate in manufacturing given the varying business requirements of different use cases. Instead, we expect to see consolidation around a small number of platforms that will meet the demand for different capabilities.

SELECTING A PLATFORM

It’s still unclear how the blockchain ecosystem will evolve, and respondents were divided on its future direction. The two most common views were that a sustainable private blockchain will emerge (30%), as will a sustainable open blockchain (29%). However, 24% of respondents predicted the emergence of a combination of private and consortia-driven blockchains that are in part connected to a public blockchain, while 14% expected consortia-based blockchain would dominate.

There was a similar range of expectations among respondents on which type of blockchain their organizations plan to adopt, with the most frequently cited types being an open (public) blockchain (37%) and a permissioned blockchain only for trusted participants (33%). Recognizing that the greatest benefits from blockchain will come from its ability to allow multiple stakeholders to collaborate, only 19% of respondents said their organization is planning to adopt a private blockchain for use within the organizational firewall, i.e., among various departments. In addition, 12% of respondents said they are not sure which type of blockchain their organization will adopt.

We believe it is unlikely that one blockchain will dominate in manufacturing given the varying business requirements of different use cases. Instead, we expect to see consolidation around a small number of platforms that will meet the demand for different capabilities.

Given the uncertainty of the nascent blockchain ecosystem, manufacturers should gain experience with a variety of platforms. The most frequently cited platforms being explored by respondents include Ethereum (62%), MultiChain (54%) and PeerNova (50%). Several other platforms were named by more than one-third of respondents, including both infrastructure and solution offerings from a variety of companies (see Figure 4, next page). Forty-eight percent of respondents said their organization is exploring Bitcoin, which is surprising since its use for vehicle purchases or B2B segments appears to be far in the distance.

Permissioned blockchains - which allow manufacturers to customize standards to their specific requirements - have different capabilities, such as optimization for smart contracts (i.e., Corda, Hyperledger and Monax). Businesses have recently sought our help in exploring permissioned platforms such as Corda, Hyperledger Fabric, MultiChain and Quorum.

Differentiation among public networks is also occurring, such as Bitcoin’s strength as a cryptocurrency and Ethereum’s in smart contracts. Hybrid models continue to emerge, such as the efforts to build a corporate version of Ethereum with increased privacy functionality.
Manufacturers should choose the platform that can best meet the business needs of each use case. This assessment should consider:

- **Applicability.** Does the platform possess features, such as smart contracts, that meet the needs of the business use case?

- **Capability.** Does the technology meet the business requirements for privacy, security, scalability and speed?

- **Business risk.** Does the platform create unacceptable levels of business risk? For example, companies should consider whether a platform has reasonable long-term prospects, such as having gained some traction and diverse developer support, or if there is vendor dependency from strict IP rights or platform lock-in.

Manufacturers should gain experience with open-source platforms to help prevent lock-in. However, it is important to recognize that some open-source networks attempt to lock in participants through other means, such as requiring the use of proprietary services or the need to make substantial infrastructure investments.
Differentiation among public networks is also occurring, such as Bitcoin’s strength as a cryptocurrency and Ethereum’s in smart contracts. Hybrid models continue to emerge, such as the efforts to build a corporate version of Ethereum with increased privacy functionality.
The difficulty of identifying where blockchain can best be applied and the challenges of assessing the associated costs and benefits may explain why 48% of respondents cited securing budgets as a top barrier to adoption, while 46% said other technology investments are taking priority.

UNDERSTANDING BLOCKCHAIN’S BUSINESS VALUE

Respondents agree that blockchain is more of a business challenge than a technical one. The top-cited internal barrier to adopting blockchain technology was understanding blockchain use cases (56%) (see Figure 5). The difficulty of understanding how blockchain technology can be leveraged to address business issues is also clear, with 46% of respondents saying that evaluating cost-benefits of use cases was a top internal barrier, and 42% citing uncertainty around the time needed to reap benefits.

Manufacturers need to involve business stakeholders in identifying how blockchain solutions can generate business value. Companies can benefit by creating a dedicated blockchain team with stakeholders assigned to spur innovation and adoption. A dedicated team can help drive the development of strategy

Internal Obstacles to Blockchain Adoption

Respondents were asked to name the top five internal barriers to adopting blockchain for their organization.

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<thead>
<tr>
<th>Obstacle</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Understanding blockchain and use cases</td>
<td>56%</td>
</tr>
<tr>
<td>Securing budgets</td>
<td>48%</td>
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<tr>
<td>Ensuring data security</td>
<td>47%</td>
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<tr>
<td>Other technology investments are taking priority</td>
<td>46%</td>
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<tr>
<td>Evaluating cost-benefits of use cases</td>
<td>46%</td>
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<tr>
<td>Communicating blockchain to key decision makers</td>
<td>43%</td>
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<tr>
<td>Uncertainty around time needed to start reaping benefits</td>
<td>42%</td>
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<tr>
<td>Gaining buy-in from organizational leaders and internal divisions</td>
<td>40%</td>
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<tr>
<td>Reengineering business processes</td>
<td>37%</td>
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<tr>
<td>Procuring talent and expertise</td>
<td>33%</td>
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<tr>
<td>Understanding legal and compliance issues</td>
<td>29%</td>
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<tr>
<td>Integrating legacy systems with existing enterprise architecture</td>
<td>23%</td>
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<tr>
<td>Culture and change management</td>
<td>10%</td>
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Figure 5
by identifying and developing use cases, exploring the potential of working with business partners and researching partnerships with vendors. (View our video to learn more on this topic.)

The difficulty of identifying where blockchain can best be applied and the challenges of assessing the associated costs and benefits may explain why 48% of respondents cited securing budgets as a top barrier to adoption, while 46% said other technology investments are taking priority.

Manufacturers should recognize that they may not be able to precisely determine the expected cost-benefits of a blockchain project at this point given that it is a nascent technology that is rapidly developing. The cost-benefits of a project are typically long-term in nature and will become more apparent over time. Yet, organizations should be able to specify the objectives that each project is designed to achieve to create a yardstick by which to judge success.

In contrast with these strategic considerations, the technical issue of how blockchain will be integrated with existing systems is less of a concern. Only 23% of respondents cited integrating existing enterprise systems with blockchain platforms as one of the top barriers to adoption. Manufacturers are well-advised to do this wherever possible, rather than making extensive changes to their technology infrastructure. Replacing an entire legacy system would delay implementation, require a massive investment and likely undermine the project’s value proposition. Over the longer term, however, there will be the potential for blockchain to replace legacy systems, especially in cases where business models shift.

**CLOSING THE TALENT GAP**

While business considerations should drive blockchain strategy, manufacturers will also need to attract or develop the expertise in how the technology can be applied. Yet, only 36% of respondents said their organization has assessed the internal skills that will be required to support blockchain adoption.

**Blockchain Expertise Needed**

Respondents were asked to indicate their organization's level of blockchain expertise in the following areas.

![Blockchain Expertise Needed](Figure 6)
Many respondents acknowledged that their organization will need additional blockchain expertise in a variety of areas, including cybersecurity, risk management, compliance and legal. However, we believe most manufacturers will, over time, find additional skills are needed to apply blockchain thinking and technology.
Many respondents acknowledged that their organization will need additional blockchain expertise in a variety of areas, including cybersecurity, risk management, compliance and legal (see Figure 6, previous page). However, we believe most manufacturers will, over time, find additional skills are needed to apply blockchain thinking and technology.

This is especially the case with business strategy, where only 44% of respondents felt their organization needed additional blockchain expertise. Yet, identifying use cases was the most-often cited internal barrier to adoption, and companies will need professionals with experience and insight into how blockchain can advance their organization’s business strategy.

In technical areas, 56% of respondents expected their organization will need additional blockchain expertise, but we believe the need will be even greater. In our experience, most manufacturing organizations will discover that they need experts in blockchain-specific technical areas such as cryptography, PKI, information architecture, software engineering, network infrastructure and integration, and user interface/user experience, among others.

Manufacturers are using a mix of internal and external strategies to close the talent gap. When respondents were asked which strategies their organization uses to address the skills gap, the most common strategy was training (such as attending technical workshops) (70%). Other internal strategies used by companies include innovation labs (56%) and hiring talent with blockchain skills (54%). But manufacturers are also using a variety of external strategies to acquire additional expertise, including partnerships with blockchain technology companies (52%), targeted acquisitions (43%) and investing in start-ups (37%).

**OVERCOMING EXTERNAL ROADBLOCKS**

In addition to understanding the optimal business uses of blockchain, there are also significant external obstacles that must be addressed. When asked about the top external roadblocks to blockchain adoption, the top-cited issues were privacy and security (68%), creating standards (64%) and scalability/latency (63%) (see Figure 7).

**External Roadblocks**

Respondents were asked to name the top five external roadblocks to blockchain adoption.

![Figure 7](image-url)
Much of the innovation underway in permissioned platforms is designed to provide additional ability for participants to limit access to their data.

**Privacy and Security**

Manufacturers are concerned that any data placed on a blockchain remain private and can only be accessed by supply chain partners or other stakeholders with appropriate credentials. However, the concern over privacy primarily relates to permissionless blockchains, which are less applicable to the needs of B2B manufacturers.

Much of the innovation underway in permissioned platforms is designed to provide additional ability for participants to limit access to their data. Some of the top innovations that permissioned blockchains have developed include:

- **Channels.** These allow peers to “subscribe” to what can be characterized as an independent chain of blocks where the information is available only to peers with access to the channel.

- **Specialization of nodes.** For example, R3, which was formed by the world’s largest banks, has the concept of notaries, which are specialized nodes that the parties can designate to validate the transaction and thus prevent double spend. The other nodes on the network are not able to see any details of the transaction, which helps maintain privacy.

While many respondents are concerned about security, blockchain networks actually provide much higher levels of security than are available currently, and they protect data from tampering due to consensus mechanisms and cryptographic algorithms employed when publishing and storing information on the network.

The concerns over blockchain privacy and security can be compared to the fear of self-driving cars. People expect self-driving cars to have a spotless safety record, and whenever one is involved in an accident, this is cited as evidence that the technology cannot be trusted. In reality, most vehicle accidents are the result of human error, and self-driving cars are expected to be much safer than traditional vehicles. It takes time for people to become comfortable with a new technology, which we believe will also occur with blockchain.

**Creating Standards**

Blockchain promises to drive much greater efficiency in such areas as global supply chains and trade finance by allowing stakeholders and partners to automatically negotiate agreements and coordinate activities through a peer-to-peer network. Since no one company has a dominant position in most industries, there is the potential for multiple blockchain networks to be created for a single application, such as supply chain management. Much of the potential gains in efficiency would be lost since manufacturers and suppliers would need to join multiple networks, each with different standards and protocols.
Instead, blockchain’s potential will be maximized if a single set of standards is adopted for each marketplace or application. Yet, rather than postponing their blockchain initiatives until industry-wide standards are established, manufacturers should gain experience with how to leverage the technology’s capabilities and also seek to influence the common standards that will be developed.

Some groups are already working to create common standards, such as the Blockchain in Trucking Alliance (BITA) for the freight industry. Adopting common standards will be important over the long run; however, it may be premature for an industry to commit to a set of standards today given the rapid pace of development.

**Scalability/Latency**

Blockchain platforms have been working to improve speed and transaction volumes. Ripple announced its Ripple Consensus Ledger, which can handle nearly 1,000 transactions per second, and the speeds of blockchain networks are expected to continually rise. When choosing a platform for each use case, manufacturers should consider the required transaction volumes and speeds. For example, a blockchain application employed for a supply chain may have much lower transaction volumes than a consumer-oriented application such as provisioning of replacement parts.

Although blockchain platforms often promote their speed, organizations should remember that these claims may not be achievable in practice. When testing speed, organizations need to make sure they are assessing the time required for the complete process, from transaction initiation to final confirmation. Some platforms quote fast times that could be misleading because they don’t incorporate the entire lifecycle of the transaction.

**The Challenges of Collaboration**

Although applying blockchain thinking to internal processes may yield limited benefits, the greatest opportunities to generate value will require manufacturers to work collaboratively with outside organizations, such as supply chain partners. Disseminating information quickly and efficiently among multiple organizations is one of the primary benefits of using blockchain.

Consider a simplified supply chain for a product, comprising a manufacturer, a subcontractor producing components and a distribution company. Today, these three entities would maintain separate sets of books, with transactions recorded separately by each organization. A blockchain solution would replace the three sets of books with a single ledger supported by smart contracts. The benefits for all three companies would include lower operating costs, no need for reconciliation, greater accuracy and faster payments.

However, many manufacturers are not accustomed to sharing data and working collaboratively with outside organizations. Roughly half of respondents (49%) said that working with partners/ecosystem members is one of the top obstacles to blockchain adoption.
Challenges in Collaborating with External Organizations

Respondents were asked to indicate the level of difficulty in the following areas while working with external partners/stakeholders.

<table>
<thead>
<tr>
<th>Challenge</th>
<th>High</th>
<th>Medium</th>
<th>0%</th>
<th>20%</th>
<th>40%</th>
<th>60%</th>
<th>80%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishing connectivity with partner systems</td>
<td>47%</td>
<td>44%</td>
<td>40%</td>
<td>38%</td>
<td>36%</td>
<td>34%</td>
<td>32%</td>
<td>30%</td>
</tr>
<tr>
<td>Agreeing to a shared data model between parties for use in the blockchain</td>
<td>41%</td>
<td>40%</td>
<td>39%</td>
<td>38%</td>
<td>37%</td>
<td>36%</td>
<td>35%</td>
<td>34%</td>
</tr>
<tr>
<td>Identifying and finalizing blockchain use cases</td>
<td>32%</td>
<td>48%</td>
<td>40%</td>
<td>38%</td>
<td>36%</td>
<td>34%</td>
<td>32%</td>
<td>30%</td>
</tr>
<tr>
<td>Convincing partners to share experiment data</td>
<td>37%</td>
<td>42%</td>
<td>40%</td>
<td>39%</td>
<td>38%</td>
<td>36%</td>
<td>35%</td>
<td>34%</td>
</tr>
<tr>
<td>Developing monetization approaches</td>
<td>36%</td>
<td>38%</td>
<td>40%</td>
<td>38%</td>
<td>36%</td>
<td>35%</td>
<td>33%</td>
<td>31%</td>
</tr>
<tr>
<td>Choosing which blockchain platform to work on</td>
<td>33%</td>
<td>40%</td>
<td>40%</td>
<td>38%</td>
<td>36%</td>
<td>34%</td>
<td>32%</td>
<td>30%</td>
</tr>
</tbody>
</table>

(Percentages may not total due to rounding)

Figure 8

Few respondents said their organization is currently working on blockchain with either its supply chain partners or with other groups across the industry. Only 19% of manufacturing respondents reported that their organization is working with external supply chain partners on blockchain, while 27% said this was in progress. Similarly, only 18% of respondents said their organization was working with other industry partners/competitors, while 26% said this was in progress.

Working with external partners/stakeholders presents significant challenges, with roughly three-quarters or more of respondents describing a series of issues as presenting either a high or medium level of difficulty (see Figure 8). The issue rated most often by respondents as presenting high or medium difficulty was establishing connectivity with partner systems (91%). In individual manufacturing sectors, no single company dominates and will be able to set standards unilaterally. Instead, active collaboration and coordination will be required to establish standards across companies and unlock blockchain’s value. Other issues included agreeing to a shared data model between parties for use in the blockchain (81%) and identifying and finalizing blockchain use cases (80%), which respondents also named as a major internal barrier to adoption.

Working collaboratively and sharing data with external stakeholders, partners and even competitors will require a significant culture change. Many manufacturers appear to underestimate the challenges in changing long-standing assumptions and business practices. Only 10% of respondents cited culture and change management as a top internal barrier to blockchain adoption. Manufacturers need to recognize that it will take a focused effort to help their employees become comfortable collaborating with external organizations.

They will face a similar challenge with their supply chain partners. The largest companies wield sufficient buying power to require their supply chain partners to share data in a blockchain application, but smaller manufacturers may face an uphill battle to secure buy-in. Manufacturers will need to educate their supply chain partners on the benefits to be gained by collaborating to implement a shared blockchain application.
LOOKING FORWARD

Blockchain’s distributed ledger technology could offer manufacturers the ability to streamline the current time-consuming and expensive processes involved in selecting, vetting and managing relationships with the numerous partners in their complex global supply chains.

At the same time, blockchain promises to spur trends already underway that will disrupt current business models. The introduction of 3-D printing has made possible small production runs of products customized to the needs of small customer segments, or even individual customers, and designers may soon rent production facilities on-demand for small runs. The proliferation of smart devices throughout business facilities and homes has raised the prospect of automating replacement parts and repairs, as well as the enticing potential for mining the data generated to improve product quality and provide additional value-added services.

Yet, despite blockchain’s potential to increase efficiency and drive down costs, many manufacturers are moving cautiously, seemingly reticent to commit to a new technology that is developing rapidly and which will require them to rethink their current ways of doing business and collaborate more closely with their supply chain partners.

Manufacturers need to move off the sidelines by forming blockchain task forces, identifying use cases, designing pilot projects with specific implementation plans and acquiring needed skills, either internally or through acquisitions and partnerships.

But it is important for manufacturers to avoid the pattern of many IT projects that are massive in scale, time-consuming to implement and slow to meet expectations. Instead, a more nimble, entrepreneurial approach is required to keep pace with fast-changing blockchain technology, which can be summarized as: start small, fail fast, identify what works, and scale quickly.

Manufacturers that act aggressively to learn how to leverage blockchain to drive business value will capture early-mover advantages on their faint-hearted rivals as blockchain disrupts the manufacturing landscape.
METHODOLOGY

We conducted an online survey among 281 respondents from manufacturing companies familiar with blockchain from January through early March 2017. When asked to describe their level of understanding of blockchain, 16% described themselves as expert, 48% as proficient, 27% as competent and 9% as beginner.

Seventy-two percent of respondents are from Europe, and 28% from the U.S. Multiple manufacturing segments were represented, including 22% in process manufacturing, 19% in light industry manufacturing, 18% in small-scale manufacturing, 17% in automotive manufacturing, 16% in heavy manufacturing and 8% in supply chain management.

Respondents have the following titles: 11% C-suite, 21% vice-president, 34% director, 20% senior manager and 14% manager.

Respondents work in the following functional areas: 18% in IT/support activities; 17% each in strategy, operations, R&D/innovation and compliance/security; 12% in procurement; and 2% in legal.

Respondents come from organizations with a variety of sizes as measured by annual revenue: 10% from companies with revenues of less than $250 million, 27% from companies with more than $250 million to $500 million, 35% from companies with more than $500 million to $1 billion, 19% from companies with more than $1 billion to $2 billion, and 9% from companies with more than $2 billion.
Blockchain in Manufacturing: Enhancing Trust, Cutting Costs and Lubricating Processes across the Value Chain

Digital Systems & Technology

FOOTNOTES


4 Smart contracts are not unique to blockchain, but they are greatly enhanced by blockchain networks.


9 Ibid.

10 Ibid.


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