How Blockchain Can Slash the Manufacturing "Trust Tax"

BY BURKHARD BLECHSCHMIDT AND DR. CARSTEN STÖCKER

Blockchain-enabled smart contracts, distributed ledgers and immutable cryptographic records are poised to reduce production costs, drive greater operational efficiencies, and unleash new business opportunities for manufacturers worldwide.

Executive Summary

Without trust, value chains – particularly those that support global manufacturing – would not exist. However, that trust has been historically difficult, and costly, to establish.

Trusted suppliers are thoughtfully selected and managed, as well as monitored and certified for quality, reliability and consistency. Regulators demand certifications and audits to ensure that best practices are followed, and companies such as Intertek conduct inspections and provide quality certifications. At the end of the value chain, customers purchase products because they trust the quality of the brand, which is the key differentiator for many companies.

The immense volumes of data generated by global supply chains – if properly mined – can help to verify the trustworthiness of the manufacturing processes and resulting products. However, the process requires numerous manual interventions and the involvement of many parties.

Providing such assurances in today's manufacturing world imposes a hidden (and growing) "trust tax" on worldwide supply chain participants (see Quicktake, next page). From the use of "conflict-free" raw materials, to Six Sigma manufacturing practices, to Independent Standards Organization (ISO) certifications, to the validity of purchase orders – the work of verifying all these characteristics requires reams of paperwork, endless e-mails and phone calls, and costly site visits and audits. These cumbersome activities reduce productivity and efficiency throughout the economy, making it more expensive, complex and time-consuming for customers and suppliers to find and do business with one another.

We believe there is a simpler, less costly and more efficient way to establish trust in manufacturing value chains, using blockchain, a software-based distributed ledger system maintained on multiple computing nodes (see glossary, page 10). This white paper demonstrates how blockchain technology and thinking can slash the "trust tax," starting with newly formed distributed manufacturing value chains, and reveals how businesses can use a blockchain-based approach to more effectively orchestrate global supply chains.

QuickTake

Creating Trust in the Diamond Trade

Jewels are high-value, portable items that can be easily stolen or sold with no trustworthy record of their actual source or owner. Every year, insurers pay more than £100 million in claims related to jewelry theft, according to UK-based startup Everledger.[1]

Everledger is attempting to solve this problem with a "permanent blockchain-based ledger for the certification of diamonds and related transaction histories." The business hopes to make money by providing blockchain-based verification of the value and history of individual diamonds for everyone from diamond owners to insurance companies and law enforcement, according to its website. As of early 2016, the company claims to have registered close to a million diamonds, with each stone's unique identity calculated from 40 data points about it.

The company also says it is working to use blockchain to reduce the fraud associated with current paper-based processes for keeping "blood diamonds" (those mined in conflict zones) out of the market. Everledger plans to develop a similar database to combat fraud in the fine arts market.

Seeing Blockchain through a Manufacturing Lens

The "trust tax" imposes particular costs on newly formed distributed manufacturing models, such as 3-D printing. 3-D printing allows designers and inventors to create new products anywhere and produce them by shipping the design files to a remote printing facility. This model allows businesses to effectively "borrow" part of a factory (in the form of a 3-D printing facility) on-demand, when and for how long they need it.

Blockchain can greatly ease the deployment of such distributed 3-D manufacturing value chains, as it offers low-cost, distributed and assured integrity for contracts, product histories, production processes and more. The technology also enables the use of smart contracts to automatically locate the most appropriate printer (based on attributes such as availability, price, quality and location) and automatically negotiate terms, such as price, quality level and delivery date. Finally, blockchain enables the creation of secure digital product memories – immutable records of everything from the source of the raw materials used, to where and how they were manufactured, to their maintenance and recall histories.

When 3-D printing and blockchain are combined, these capabilities could result in the following advancements in manufacturing:

- Boost innovation and economic development by enabling entrepreneurs in even remote areas to monetize their ideas.
- Slash inventory costs and service times by enabling companies to print parts on a just-in-time basis.
- Automate trade finance processes via smart contracts from inside the supply chain.
- Speed the flow (and reduce the cost) of new products.
- Create new market opportunities and increase market efficiencies by facilitating mass customization of products and smaller production runs.
- Monetize local overcapacities globally by trading manufacturing flexibilities.

To demonstrate how low-cost, blockchain-based distributed trust could facilitate the 3-D printing supply chain, Cognizant partnered with innogy (a subsidiary of RWE, a leading European energy and utility company) and EOS GmbH Electro Optical Systems (a leader in industrial 3-D printing) to develop a prototype of a blockchain-based shared 3-D printing factory (see Quicktake, page 4, and Figure 1, page 5).

The pilot uses blockchain technology to protect print files that describe high-value, high-margin, precision-manufactured parts, such as components in jet engines or power generation equipment. Such parts can command purchase prices that are hundreds or thousands of times higher than their printing cost due to the engineering and development effort required to create a 3-D design file. These design files are the crown jewels of 3-D manufacturing value chains, and must be extremely well-protected against theft or tampering when shared among a global network of printing facilities.

The solution will provide end-to-end encryption to protect 3-D print files, all the way from their creation by a designer to their transmission and use at a 3-D printer. Blockchain-enabled smart contracts will allow these files to automatically negotiate pricing and other terms and conditions with customers, as well as with local 3-D printers and logistics services providers without the need for a middleman. It will also ensure the execution of secure crypto-payments to the owners of the file, as well as royalty payments to designers and other intellectual property owners.

The blockchain will provide a unique digital product memory for not only the product itself but also each part of the product, including the materials used in production and all the quality, design and printing process data. Importantly, it will also hold information on the product's ownership, provenance, authenticity, purchase price and the currency used. All of this information can be protected with crypto-conditions that allow multiple supply chain partners to verify the authenticity and security of a message.

The digital product memory would serve as the digital representation of the physical world and would contain a full "story" describing every physical product manufactured and traded. This representation could be used to significantly increase manufacturing productivity and product quality. It would also dramatically reduce the cost of tracking for warranty, maintenance and recycling purposes.

The solution will ultimately result in the print file "becoming" the business. The print file would contain not only secure intellectual property but also the ability to negotiate terms and conditions, make payments and provide immutable do cumentation and authenticity for each part.

The solution will ultimately result in software-defined manufacturing, as the print file "becomes" the business. The print file would contain not only secure intellectual property but also the ability to negotiate terms and conditions, make payments and provide immutable documentation and authenticity for each part.

Blockchain: Busting the "Trust Tax"

The need for trust imposes uncertainty, cost and delay, even in "virtual" value chains such as those that enable 3-D printing. First, there is the need for inventors or designers to protect their designs during and after the journey to the remote printing location. Then, there is the need to protect the associated parameters required to calibrate and operate each 3-D printer to ensure it can print the actual product to the specifications and precision required.

Customers also require multiple assurances: that the correct original design has been referenced, the right raw materials were used in the creation of the part, the 3-D printer worked correctly, and the part was shipped and received on time. As in any supply chain, all partners must have assurance of payment and the ability to hold business partners accountable. Finally, manufacturing partners need immutable records that validate and verify the ownership of their intellectual property, such as their proprietary manufacturing methods, as it moves along the value chain.

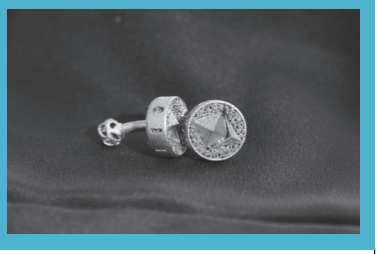
Blockchain technology can reduce the need for expensive third parties, such as banks, escrow agents, lawyers and even internal accounting functions to measure, minimize or manage risk. It can also reduce the need for, and cost of, the middle managers who now control such information. In their place, smart contracts will automatically manage trade finance payment terms (such as letters of credit) and negotiate price, terms and conditions. Digital product memories maintained on the blockchain and connected to validated IoT devices along the supply chain will provide secure proof of everything from

QuickTake

Making Cufflinks on the Blockchain

Using our proposed 3-D printing platform, we have designed and produced cufflinks in titanium with a unique ID and digital product memory. The process of printing a seemingly simple product using a 3-D printer shows how the combination of progressive thinking and new technologies can drive agile, lower cost manufacturing models. Here's how it works:

- To execute a print order, any 3-D printing service or 3-D printer can be borrowed, on-demand.
- Designers will need to register their designs on the blockchain; they will automatically receive royalties once an order is received for a product they have designed. Our proof of concept demonstrates how to secure IP and automate royalty accounting.
- The digital product memory provides information about the material used (titanium), as well as many other design elements and owners. We have demonstrated, in a powerful way, how supply chain transparency can be easily established on an immutable record and how product provenance becomes authentic and trusted if its metadata resides on the blockchain.
- Normally, buying a larger lot of cufflinks from another country could require significant time and effort to orchestrate trade finance processes and document processing (e.g , dealing with documents such as letters of credit, shipping documents, purchase orders, bills of lading). We demonstrated how this information, if stored on a secure, immutable record on a blockchain, can eliminate most of the checking and verification processes in trade finance.
- Mass customization is also enabled, as each cufflink includes a serial number in its design, printed on the side.
- Each cufflink box is tagged to a QR code, which connects the cufflink's identity to its digital product memory (in this case, the tagging solution is not fully secure because a secure tag is not physically connected with the cufflink).



manufacturing processes to quality controls. Further, blockchain-based Public Key Infrastructure (PKI) encryption can protect sensitive intellectual property. These technologies will allow the creation of "trust factories" – decentralized institutions and organizations that provide trust at a far lower cost than traditional providers.

These technologies will allow the creation of "trust factories" – decentralized institutions and organizations that provide trust at a far lower cost than traditional providers.

Blockchain can also provide the scalability required for "mass customization," which drives sales by better meeting consumers' needs for specific functions or styles. Mass customization also creates more efficient markets by making it easier to produce small production runs of unique products. Smart contracts make it easier and quicker for buyers and sellers to find and trust each other and agree on terms. New manufacturing models such as 3-D printing eliminate the delays and costs of the tooling and production setup that once had to be spread across massive production runs. The combination of blockchain technology and 3-D printing allows organizations to quickly and easily reconfigure virtual supply chains and enable and scale a model of global micro-manufacturing. Manufacturing flexibilities in production schedules can be tokenized and traded to ensure better resource utilization.

New Business Models Take Root

Even greater than the near-term advantages of lower transaction costs and increased agility, blockchain will transform manufacturing by creating entirely new business models. Traditional value chains will be deconstructed as more players will be able to flexibly plug in and out of the manufacturing process, such as "borrowing" parts of a factory on short notice for only as much production capacity as they need at a given time. Further, niche players such as micro-factories or small

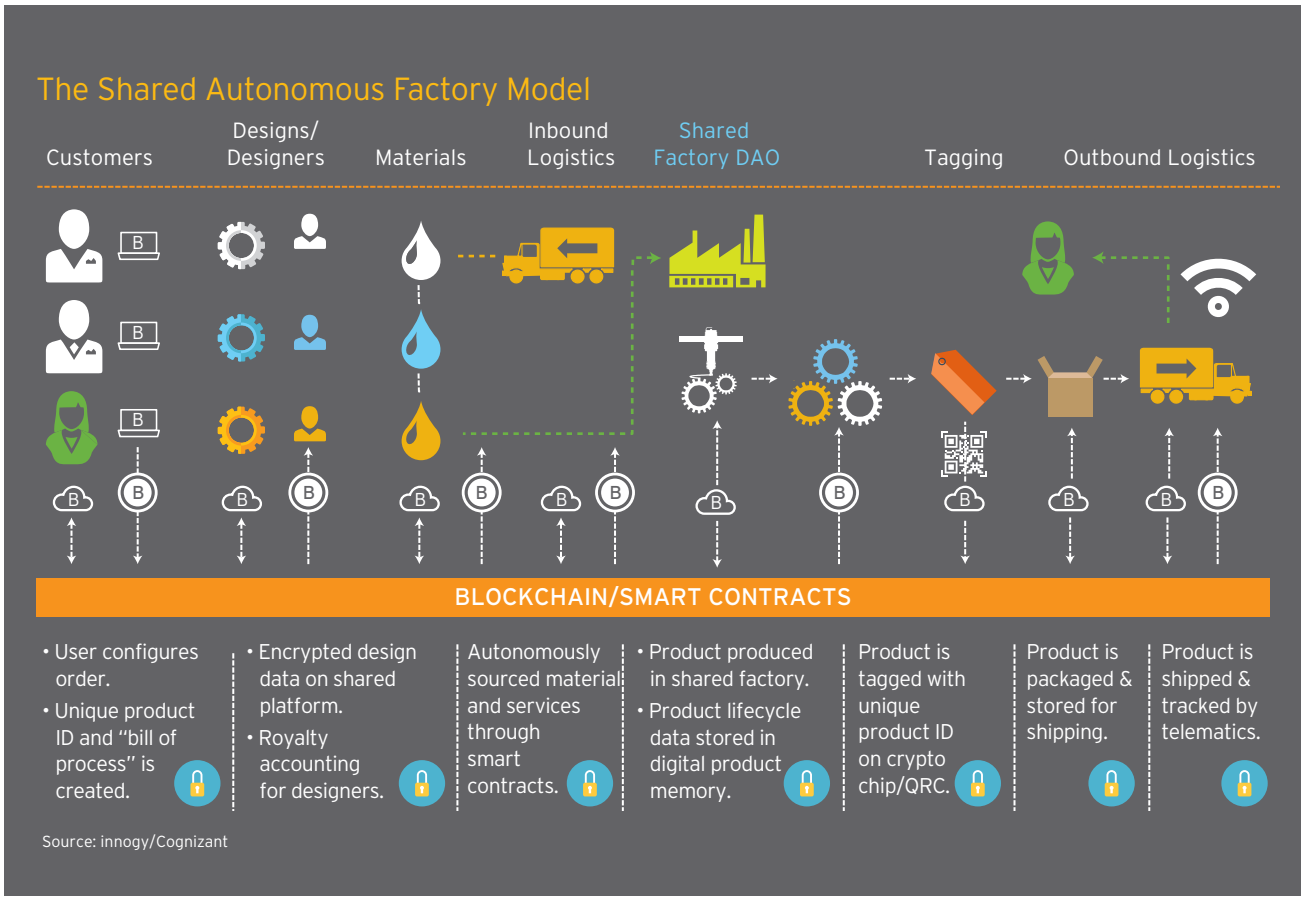


Figure 1

3-D print service providers will be able to expand their markets and serve more customers.

Examples of these new models include:

- **Marketplaces for designers to publish their work in the form of 3-D files.** Designers will also be able to receive micro-royalties (much like composers in the music world) whenever their designs are used.
- **Marketplaces enabling access to, and analysis of, digital product memories.** These marketplaces will provide customers with reliable data about the materials and processes used in their products' manufacturing plants, as well as manufacturing location and dates. Insights from such data can dramatically reduce the cost of activities such as quality control, regulatory compliance and warranty or recall actions. While any supply chain partner can access some of this data, skilled partners may be able to analyze it and provide business-boosting insights more quickly and cost-effectively.

  Such insights could include the optimum combination of raw materials for 3-D printing, the speed or sequence with which the materials are printed in layers, or which components, printed with materials or methods, worked best in various applications.
- **"Asset-less" or "asset-light" enterprises that provide value-add in areas such as product design and marketing, supply chain orchestration or smart, data-driven manufacturing rather than physical product manufacturing.** As manufacturing becomes "smarter" through more sensors, real-time connectivity in the plant and the use of deep data, new business models are emerging that deal only with manufacturing data and selling it to "dumb factories." For these business models, access to a secure data-sharing infrastructure will be key.

> The combination of blockchain technology and 3-D printing allows organizations to quickly and easily reconfigure virtual supply chains and enable and scale a model of global micro-manufacturing.

QuickTake

Pioneering Asset-Light Manufacturing

One example of asset-light manufacturing in the pre-blockchain world is Li & Fung, an $18.8 billion global supply chain manager. The business does no manufacturing itself but instead manages a network of more than 15,000 suppliers in more than 40 markets. Through this network, Li & Fung provides services such as product development and costing, factory compliance, order processing, manufacturing control and logistics. Its core asset is its continuously updated knowledge of market conditions, its process architecture and the performance of its suppliers. In this way, Li & Fung monetizes its intelligence and its process infrastructure or "protocol."

Consider, however, if the company applied blockchain thinking and technology to its asset-light approach. By putting its source data from a multitude of suppliers onto an open, decentralized and encrypted platform (e.g., a blockchain) and encoding its commercial agreements and supplier deals into smart contracts, the company could supercharge its business model by embracing new types of manufacturing initiatives that connect various players throughout the global supply chain. Li & Fung's cost base could be reduced substantially in this scenario, which could increase profitability in the short term. In the longer term, supply chain transparency would create informed, autonomous customers and end consumers who would ask for lower prices.

The knowledge of everything from where to source raw materials, to the best manufacturers, to the location of goods in transit and payment will be stored in reliable, trusted blockchains and continuously updated by business rules contained in smart contracts.

- **Hyper-specialized players that invest only the time and capital required to be the best at what they do.** Such businesses will hand off other tasks to entities further up or down the value chain through blockchain-enabled smart contracts. They might, for example, specialize only in manufacturing or in one step of the manufacturing process (such as chip packaging vs. chip fabrication). Other specialties might include extraction of raw materials or quality control of work in progress (see Quicktake, above).
- **Cloud-based, "software-defined" manufacturing in which customers don't need to know where products are made.** Software (in the form of smart contracts) would find and finalize agreements with whichever partner offers the best combination of cost, terms and conditions, delivery dates and quality. The knowledge of everything from where to source raw materials, to the best manufacturers, to the location of goods in transit and payment will be stored in reliable, trusted blockchains and continuously updated by business rules contained in smart contracts. The resulting transactions will be analyzed for efficiency and legitimacy through fit-for-purpose algorithms.
- **Brokers of data generated along the value chain.** Such data could range from production yields for various production processes or combinations of raw materials, to best practices for maintenance or customer support.
- **Marketplaces for crowd-sourced product optimization services.** Crowd-based data will become trusted data on a blockchain; further, the emergence of reputation engines built on blockchain technology will drive qualified, crowd-based product and service optimization. These engines could also be combined with prediction markets (e.g., a market based on predicting the first-year sales numbers for a new product).

QuickTake

The Projected Impact of the Software-defined Manufacturing Era

It's difficult to predict winners and losers in the early days of blockchain-enabled manufacturing value chains. But it is not too soon to project how existing geographies, industry players and groups of workers might be affected.

Potential Winners

In the blockchain economy, companies with demonstrably better products and business and manufacturing processes will be best positioned to win. That is because the improved access to information will help customers and business partners identify and choose the real champions. Other potential winners include:

- **Product and service providers in geographies with weak rule of law and intellectual** property. Blockchains will allow these businesses to participate in manufacturing value chains by providing cost-effective trust even in the absence of strong governmental institutions.
- **Smaller product designers, raw material suppliers and service providers** that otherwise find it too expensive or time-consuming to ensure trust with worldwide customers.
- **Aggregators and sellers of blockchain-protected data on manufacturing or operations** that can help manufacturers and customers maximize the value of products produced within blockchain value chains.
- **Service providers for decentralized autonomous manufacturing organizations** enabled by blockchain. Such services could include shipping, financing and 3-D printing.

Potential Losers

The losers in the blockchain economy will be any supply chain member with higher hidden costs and inefficiencies or lower quality related to traditional, cumbersome, opaque trust mechanisms. Other potential losers include:

- **All intermediary business services,** including e-commerce aggregators that match buyers and sellers.
- **Lower-skilled workers,** both on the assembly line and in supporting clerical jobs, as blockchain and new technologies such as 3-D printing automate routine assembly and tracking of products and contracts.
- **Higher-skilled workers,** such as buyers, accountants, vendor managers, auditors and lawyers, as blockchain technology automates complex negotiations, tracking and verification processes.
- **The authority of financial, auditing and related institutions** as payment assurance moves to the blockchain.

A Work in Progress

Blockchain technology, thinking and skill sets are still in development. Early adopters will face the following issues and implications:

- **Security:** A public blockchain for smart contracts would represent the fundamental standard infrastructure for the "Internet of value." It would need to be completely safe and unhackable for the next 30 years at least. However, highly publicized incidents, such as the hack of the blockchain-based Ethereum digital currency platform,[2] raise important concerns about blockchain security. Established vendors and small startups are investing significant time and effort in resolving such concerns. Until these security issues are fully addressed, the majority of blockchains will likely be private, invitation-only ecosystems governed by a discrete set of stakeholders, such as a company, organization, country or consortium of companies or even an entire industry.

- **Maturity:** Two key issues of blockchain include the cost and effort required by the consensus mechanisms (the so-called "proof of work/stake" that assures the integrity of data and transactions), and the ability to handle very large transaction volumes. We are confident the open-source blockchain community will develop the required solutions for many of these issues, such as scalable blockchain-based databases. Another outstanding issue is the fact that cryptocurrencies and smart contracts can, unlike physical currency, potentially disappear without a central trusted party that can be held accountable. Startups are said to be addressing this issue with blockchains that also have a physical representation.
- **Links to legacy systems:** Significant effort may be required to build the interfaces needed between new cryptocurrencies and legacy systems. As organizations wait for de facto standards to emerge, they may want to begin with small initiatives focused on niche products and markets to better understand the technologies, opportunities and challenges.
- **The need to use blockchain in conjunction with other decentralized solutions** (e.g., IPFS, or the InterPlanetary File System, and the BigchainDB scalable blockchain database). Doing so can provide a protocol-like layer that processes transactions with other work being done off the chain.
- **The skills gap:** Startups and established players alike will find they lack the necessary skilled personnel to execute blockchain efforts at scale. High-demand skills will include cryptographers to develop secure smart contracts, consultants who understand the business implications of blockchain, and technology architects who can use and integrate blockchain technologies and tools.
- **Corporate culture obstacles:** Internal blockchain evangelists will be challenged to convince large, conservative and slow-moving enterprises to move at the speed of digital. Their small and medium-size competitors will be the first to implement new systems and business models.
- **The need to prove trust:** Even as blockchain eliminates the need for some traditional "trust" providers, it poses a challenge as organizations move their trust from individuals, organizations or the legal system to mathematical algorithms they don't understand. This lack of understanding could slow implementation until such solutions prove themselves in practice. The providers of blockchain technology may need to offer some type of "bonding" or insurance against loss, much like what banks provide to deposit-holders if their accounts are hacked.

As organizations wait for de facto standards to emerge, they may want to begin with small initiatives focused on niche products and markets to better understand the technologies, opportunities and challenges.

- **User interface design:** Gateways will be needed to onboard ordinary companies and individuals into the machine-to-machine (M2M) or blockchain economy and provide a high-quality end-user experience built around a human-centered design philosophy. (Learn more about UX design in our white paper "How Design Thinking Can Power Creative Problem-Solving, Drive Change and Deliver Value.")

Blockchain's Next Steps

While no one would recommend moving to blockchain overnight, it's essential to begin experimenting now by funding targeted proofs of concept to explore where and how blockchain thinking and technology could deliver transformative benefits.

Key questions to help focus preliminary efforts include:

- Where in the value chain – both internally and externally – is my organization paying the highest "trust tax" in terms of excess cost, effort or lack of agility?
- Which types of partners, in what geographies and expertise areas, could my company benefit from working with, if only the transactional costs and efforts were lower?
- Which information assets (such as manufacturing, maintenance, operational data, usage information, warranty, etc.) about my organization's products could we monetize if there were a secure way to do so?
- How could access to blockchain-enabled markets, such as trading of surplus energy or other products, help my business?

- How would the availability of a digital product memory drive value for us, our customers and our business partners?
- What are some comparatively low-volume, high-value products for which the secure capture and transmission of digital product memory would deliver significant benefit to the manufacturer or customer? Examples might include parts (such as a fuel injector in an aircraft engine) whose secure digital product memory about its efficiency over the life of the engine could lead to improved manufacturing or maintenance procedures that far outweigh the cost of the part.
- How can my organization optimize internal processes (e.g., order to cash) by replacing manual processes with blockchain-enabled smart contracts?

Looking Forward

All the elements required to deliver blockchain-enabled "distributed trust" supply chains are not yet in place. But given the significant investment made by leading players – and the scope of potential benefits of initial implementations that are expected to reach the market by early 2017 – we are confident that blockchain will soon demonstrate its ability to eliminate the trust tax.

Manufacturing enterprises that wait for blockchain to become mainstream will potentially lose the first-mover advantage. We recommend that manufacturers aggressively proceed with proofs of concept in selected areas such as 3-D printing, where the benefits of low-cost distributed trust are a particularly good match for the benefits of blockchain.

In this spirit, we suggest that manufacturers focus on proofs of concept or prototypes where the key feature of the blockchain (the immutability of the data, for example) can be implemented immediately to add value at little to no risk, such as on a private blockchain within a single enterprise. As we know, employees within a single company don't necessarily trust each other or information from their peers.

Our experience reveals that such information-sharing has a direct implication on overall bottom-line success. Using blockchain as a trusted database, or "single version of the truth," to enable such sharing can deliver significant benefits with minimal cost and delay.

We recommend that manufacturers aggressively proceed with proofs of concept in selected areas such as 3-D printing, where the benefits of low-cost distributed trust are a particularly good match for the benefits of blockchain.

Note: *The proof of concept detailed in this whitepaper is called "Genesis of Things." It is a trusted, encrypted and open platform for the entire 3-D printing supply chain. Its intellectual property scales globally and stays protected. Each printed product has its own ID and digital product memory. Supply chain processes including trade finance are automated. Every product has a story: hhere it came from; how it was made; and how it is used. With Genesis of Things, the story is now revealed for all to know.*

Footnotes

[1] Everledger website: http://www.everledger.io/.

[2] Justin O'Connell, "Ethereum Insiders Believe the DAO Hack Was an Inside Job, Claims Source," *Cryptocoin News*, July 27, 2016, https://www.cryptocoinsnews.com/source-ethereum-insiders-believe-dao-hack-inside-job/.

References

- Klaus Schwab, "Four Leadership Principles for the Fourth Industrial Revolution," World Economic Forum, Oct. 11, 2016, https://www.weforum.org/agenda/2016/10/four-leadership-principles-for-the-fourth-industrial-revolution/.
- "Deep Shift: Technology Tipping Points," World Economic Forum, September 2015, http://www3.weforum.org/docs/WEF_GAC15_Technological_Tipping_Points_report_2015.pdf.
- Eva Geisberger and Manfred Broy (editors), "Living in a Networked World: Integrated Research Agenda Cyber-Physical Systems," Acatech, March 2015, http://www.acatech.de/de/publikationen/empfehlungen/acatech/detail/artikel/living-in-a-networked-world-integrated-research-agenda-cyber-physical-systems-agendacps.html.
- Prof. Wolfgang Wahlster, "From Smart Product to Smart Service," presentation at Empolis Executive Forum, Berlin, April 2014, https://www.youtube.com/watch?v=igBDttFup5c.
- Ian Allison, "Blockchain Plus 3-D Printing Equals 'Smart Manufacturing' and Ethereum You Can Touch," International Business Times, Oct. 11, 2016, http://www.ibtimes.co.uk/blockchain-plus-3d-printing-equals-smart-manufacturing-ethereum-you-can-touch-1585747.
- Carsten Stöcker and Burkhard Blechschmidt, "Genesis of Things: 3-D Printers on Blockchain," Meetup.com, http://www.meetup.com/de-DE/ethereum/events/234464403/?eventId=234464403&chapter_analytics_code=UA-46327287-2.

Appendix: Glossary

- **Blockchain:** A series of encrypted databases connected by the Internet that ensure the integrity and security of data, such as financial transactions.
- **Digital product memory:** A secure, immutable, software-based record of important facts that customers want to know about a product, from raw materials, to manufacturing location, to service history.
- **Decentralized autonomous organization (DAO):** An organization that uses smart contracts and whose financial records and business rules are maintained on a blockchain.
- **Smart contract:** Blockchain-based software that can automatically find business partners, negotiate terms and finalize transactions.
- **Software-defined manufacturing:** A form of manufacturing in which not only product designs and specifications but also manufacturing processes and financial transactions are stored and executed as code.
- **Trust tax:** The price all players in the manufacturing process pay to ensure the quality, integrity and authenticity of products, or the protection of their financial or intellectual property rights.
- **Value chain:** The steps a product undergoes in its transformation from raw materials to finished goods.

About the Authors

Burkhard Blechschmidt is a leader in Digital Strategy & Transformation and CIO Advisory at Cognizant Business Consulting. He has over 25 years of experience in consulting mainly Fortune 500 companies across industries. He is currently focused on exploring blockchain and IoT-based business innovations in manufacturing, logistics, mobility and communications. Working with a group of innovation partners, he is co-founder of "Genesis of Things," a blockchain-based platform initiative for 3-D printing, including a digital product memory. He can be reached at Burkhard.Blechschmidt@cognizant.com | Linkedin: https://www.linkedin.com/in/bblechschmidt.

Dr. Carsten Stöcker is the Machine Economy Innovation Lighthouse Lead at innogy SE, and a co-founder of "Genesis of Things." He is a physicist by training with a Ph.D. from University of Aachen. He also serves as a Council Member of Global Future Network for the World Economic Forum. Prior to joining innogy SE, Dr. Stöcker worked for the German Aerospace Center (DLR) and Accenture GmbH. He can be reached at Carsten.Stoecker@innogy.com | Linkedin: https://www.linkedin.com/in/carsten-stoecker-1145871.

About Cognizant

Cognizant (NASDAQ: CTSH) is a leading provider of information technology, consulting, and business process services, dedicated to helping the world's leading companies build stronger businesses. Headquartered in Teaneck, New Jersey (U.S.), Cognizant combines a passion for client satisfaction, technology innovation, deep industry and business process expertise, and a global, collaborative workforce that embodies the future of work. With over 100 development and delivery centers worldwide and approximately 244,300 employees as of June 30, 2016, Cognizant is a member of the NASDAQ-100, the S&P 500, the Forbes Global 2000, and the Fortune 500 and is ranked among the top performing and fastest growing companies in the world. Visit us online at www.cognizant.com or follow us on Twitter: Cognizant.

About innogy

innogy SE is an European energy company. With its three business areas of Renewables, Grid & Infrastructure as well as Retail, it addresses the requirements of a modern, decarbonised, decentralised and digital world. The focus of innogy SE's activities is on offering existing and potential customers innovative and sustainable products and services which enable them to use energy more efficiently and improve their quality of life. Visit us online at www.innogy.com.