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Blockchain Technology in Supply Chains – What are the Opportunities for Sustainable Development?

Summary

While blockchain technology (BT) has gained a great deal of publicity for its use in cryptocurrencies, another area of BT application has emerged away from the public eye, namely supply chains. Due to the increasing fragmentation and globalisation of supply chains in recent years, many products have to pass through countless production steps worldwide (from raw material extraction to the point of sale). Ensuring the quality and sustainability of production in preceding steps is a major challenge for many firms and thus, ultimately, also for the consumer. BT offers potential for achieving significant progress on this front. Put simply, the blockchain makes it possible to verify data decentralised within a network, store it in a tamper-proof and traceable format and make it accessible to all members of a network.

The potential benefits of BT lie firstly with the consumer, who is able to trace the origin of products, which makes sustainable purchases easier. Secondly, BT enables producers to automate parts of their supply chains and to verify cost effectively the quality and origin of their products. Thirdly, there are hopes that BT could make supply chains more inclusive for small and medium-sized suppliers, especially in developing countries. BT also offers a means of more easily creating confidence in intermediate goods supplied, thereby dismantling barriers to entry. Taken together, BT could thus help to make consumption and production more environmentally friendly, socially equitable and inclusive, and thereby foster sustainable development.

So far, pilot projects have received investment primarily from very large companies. Both the firms and their consumers can now audit a number of products in real time for manufacturing method and origin. While BT can securely store and chain together the inputted data, it cannot yet guarantee the accuracy of that data. This remaining challenge regarding the digital-analogue link could be addressed through links with other technologies, such as the Internet of Things (IoT). However, independent analogue audits are still the only means in most cases of checking compliance with labour, environmental, animal-welfare and other relevant standards. Consequently, the use of BT offers substantial potential benefits for sectors in which the digital-analogue link can be effectively bridged, such as the food and high-quality commodities sectors.

Small-scale suppliers in developing countries also frequently lack the digital education, equipment and infrastructure needed in order to deploy BT. This is where national and international development policy is needed to leverage the benefits of BT solutions for inclusive production. General technological standards can also help to counteract the monopolisation of technological developments by multinational concerns. In this way, policy-makers could help to harmonise the interests of consumers and producers with those of small and medium-sized enterprises (SMEs) in the supply chain.

Blockchain technology in the supply chain

Blockchain technology can be used where stakeholders share data with one another, for example, when transferring goods and information between producers and consumers along supply chains. Here, it makes it possible to track products across the supply chain, find out about the type of manufacturing employed, make steps between supplier and recipient more agile and verify product origin. Multinational corporations have so far used random sampling or relied on certification organisations to check this information. The cost- and labour-intensive nature of both processes makes them prohibitive for SMEs in many cases. BT facilitates greater transparency even in the absence of a central authority, which is more cost-intensive and vulnerable to subsequent falsification. Instead, data blocks of information are managed decentrally, based on a common consensus mechanism for all stakeholders. This Briefing Paper sheds light on the potential offered by BT for gearing supply chains to the common good.

The use of BT can contribute in many different ways to sustainability as defined by the Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda. The ability to reliably check the origin of goods is essential to sustainable consumption and production (SDG 12). The resulting cost savings could make it easier for producers to engage in international trade in particular and thereby contribute to economic growth (SDG 8). The use of BT could also enable SMEs in developing countries especially to document their production methods cost effectively and thus to be integrated as suppliers in global value chains (SDG 9). It could thus help to make global supply chains more sustainable, efficient and inclusive.

When it comes to sensitive commodities such as diamonds, production processes under what are often socially critical conditions (such as textile manufacturing), and perishable products in particular, controls and transparency in the supply chain are important aspects of sustainable and efficient enterprise. However, not all supply chains are equally suited to the efficient use of BT. We will present a number of examples below to illustrate the options for employing BT and the limits to its use.

How does BT work in practice?

Back in late 2008, the textile company KiK began to use independent audits of production facilities to digitalise the certificates of the individual suppliers, mark them with a unique digital identity, and store them in tamper-proof form on the relevant blockchain. Forged certificates are identified and immediately blocked. The production route can be accessed anonymously in real time by scanning the QR code on a t-shirt. This allows consumers to see for themselves the countries in which the product has been manufactured and the corresponding manufacturing conditions; all they need to do so is a QR scanner on a mobile device. Nonetheless, independent auditing of production methods is still the only means of verifying the accuracy of the information stored in the blockchain.

Networks that use BT for seamless end-to-end tracking are growing particularly in the food sector. Blockchain platform service providers such as IBM Food Trust and Provenance are integrating a growing number of players. With Provenance, local fishers send a text message to the blockchain with details of their haul. Other supply chain participants verify this information, creating a tamper-proof digital supply chain in the blockchain in addition to the analogue supply chain of the physical product. As the information is disseminated, individual stakeholders become more visible and gain their own voice within the supply chain process. In some cases, intermediaries, who were previously responsible for processing the prices and goods of smaller players, are no longer necessary.

Although BT adds significant value by facilitating management of data and information, these examples show that the technology does not solve the problem of data collection per se. This task has so far been carried out by the suppliers themselves and checked using audits, leaving it vulnerable to errors and tampering. Consequently, BT solutions are often supported by using the functions of the IoT, which connects physical products with smart information and communication technology services. The IoT allows analogue data to be automatically entered into the blockchain using serial numbers, barcodes and digital tags (e.g. radio frequency identification, RFID) which are attached to the physical product as electronic identifiers. In this way, the IoT removes the need for a central authority. This linking of the digital and analogue worlds could provide a potential solution for overcoming the problematic issue of digital-analogue links.

Walmart already uses the technology to track over 25 products and benefits as a result from greater food security and more efficient supply chain management. Its initiatives for tracking pork from China and mangos from the United States are flagship projects, which have attracted interest from other global players such as Nestlé and Unilever. For example, the traceability of mangos from consumer to harvest was reduced from seven days originally to 2.2 seconds using the blockchain solution. For pork, the process begins with marking each pig with a lasered barcode. From then on, this allows all relevant information concerning origin, rearing and processing to be stored in the blockchain. Additionally, RFID tags measure temperature and humidity within the refrigerated container and trigger an alarm if the critical threshold is exceeded.

Smart contracts (pre-programmed actions on the blockchain) also allow processes to be optimised. Smart contracts automate processes by means of pre-determined algorithms, which specify the subsequent transactions that must be automatically initiated.

Take Trade Lens, a blockchain-based supply chain of logistics group Maersk and IT company IBM with over 100 participants, for instance. It uses a combination of IoT sensors on containers, GPS tracking and manual data entry via mobile app to automate monitoring of shipping freight.

This allows ordering processes to be triggered and deliveries paid for automatically when trading goods, thus speeding up supply chain processes and enabling them to respond agilely to changes.

These examples show that BT is already practicable. When combined with IoT solutions in particular, it provides an efficient way to make supply chains traceable and thus to automate them with smart contracts, depending on the conditions to be fulfilled. In this way, the technology provides a cost effective way of auditing consumer goods for sustainability in supply chains, which is especially relevant in times of heightened consumer interest in production methods. Table 1 summarises the potential for using BT in the supply chain. Only sectors in which IoT solutions simultaneously safeguard the accuracy of the data entered in the blockchain are currently able to fully leverage the potential of BT in the supply chain.

In order to contribute to sustainable development and have a broad impact, an innovation as promising as BT needs to be implementable for all stakeholders right across the supply chain (Zambrano et al. 2017; Kshetri, 2017). BT would be especially effective in this respect if it strengthened the position of smaller suppliers in the global supply chain.

Potential and challenges

In interviews with Krings (2019), which analyse in detail the prospects for using BT in the supply chain, stakeholders stress time and again that BT could be a potential catalyst for digitalisation, facilitating broader use of conventional elements of digitalisation, such as electronic consignment notes. These elements further simplify trade.

However, there are challenges when it comes to using BT, including restrictions on the privacy front, increased energy consumption, ongoing power and information imbalances between supply chain stakeholders, and a reinforcement of the digital divide. The latter are examined in more detail below.

One fundamental problem with blockchain implementation is the lack of digitalisation in developing countries, where the initial steps of value chains are typically located. While experience has shown that lower bandwidths and ad hoc network access are sufficient for individual transactions, power and information imbalances within the blockchain network persist if it is not possible for all links in the chain to participate. By definition, it is difficult to establish BT in countries in which digital infrastructure itself poses a challenge. One example is a global coffee producer, the first section of whose supply chain in Ethiopia has not (yet) been documented, as coffee growers lack access to BT (Krings, 2019).

In order to enable broad implementation, the employed technology must be straightforward and cost-effective to access. In order for BT solutions to be used, there is a need not only for corresponding infrastructure and a willingness to use the technology, but also for technological expertise. The lack of expertise and capital in many developing countries means that they are not yet sparking innovation processes themselves and their participation in processes for developing digital solutions is limited.

Consequently, innovative BT applications are currently implemented largely by multinational concerns located at the end of the supply chain. They possess the economic and political resources and can drive innovations in line with their requirements. The different interests of the supply chain stakeholders could represent another hurdle on the way to a common blockchain solution.

Certain situations could also fundamentally hinder the implementation of BT solutions, preventing them from reaching their potential in the first place. Companies and certifiers that already have conventional tracking systems may not benefit from the supposed improvements of BT and hence not wish to invest in the necessary technology. Additionally, a number of supply chain stakeholders may fear that rapid technological progress in developing countries could give rise to competition. This could affect intermediaries, for instance, whose business model or pricing policy may be limited by the potential of smaller suppliers becoming increasingly autonomous. Consequently,

Table 1: Potential of BT in the supply chain

Functional benefits of BT		**Results of BT in the supply chain**	**Social impacts**
IMMUTABILITY	**Transparency of data**	**Traceability**	**Sustainable consumption** **Fair working conditions** **Averting environmental risks** **Inclusion and strengthening of SMEs in the supply chain** **Efficient economies**
	Trust	**Elimination of interim steps**	
	Compatibility and **interoperability**	**Improved coordination**, e.g. in stakeholder management, of production processes	
DECENTRALISATION	Real-time access to data due to increasing **dynamism and flexibility**	**Redressing of information imbalances**, allowing problems to be identified quickly in the supply chain	
	Auditability of data by all stakeholders within the network	**Improved monitoring**	
	Publicly accessible to all stakeholders in the network	**Redressing of power imbalances**	
	Automation through smart contracts and IoT	• **Simplified certification processes** • **Cost efficiency**	

Source: Krings (2019)

from the perspective of these stakeholders, it is especially important to avoid using BT in developing countries (Krings, 2019).

Developing countries could probably only benefit to a limited extent overall. Companies with financial resources and countries with sufficient technological capacity thus have an advantage as development locations, though local firms will primarily drive their own solutions. However, the desired development effects of BT in terms of the SDGs can only arise if infrastructure and technological knowledge is promoted at the same time and solutions are advanced jointly by all stakeholders.

How can the potential of BT be leveraged in the supply chain?

The introduction of BT could promote environmental and social sustainability in consumption and production, as well as more inclusive production. It could fundamentally change the way companies work in the future, the technologies they use, and what organisational and regulatory mechanisms look like within the supply chain. The potentials offered by the use of BT for making production methods transparent and thereby supporting sustainability in production and consumption is especially great in sectors in which production methods can be easily audited or even electronically recorded using IoT solutions.

Nonetheless, it remains unclear whether the use of BT could strengthen SMEs as suppliers and thereby also contribute in this context to the implementation of the 2030 Agenda. So far, economic and development policy has primarily promoted pilot projects of large firms, but this reinforces the trend of technical monopolisation and counteracts the use of BT for the common good, as the interests of powerful concerns and those of their suppliers can differ. Economic and development policy should thus support firms in particular with the development and deployment of user-friendly blockchain systems. They could also help to develop adaptable and scalable technology standards to guarantee interoperability of the systems, including at transnational level.

If BT is to drive sustainable and inclusive development, then policy-makers in developing countries and international development cooperation stakeholders need to promote the relevant general conditions. In addition to infrastructure, this includes technical and educationally dependent access options for smaller producers in the supply chain and a legal framework. It would therefore be helpful to involve the different stakeholders in the development of BT from the outset.

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Katharina Krings
Project Manager
"Development policy cooperation Hessen"
HA Hessen Agentur GmbH Innovations- und Nachhaltigkeitsprojekte

Dr Jakob Schwab
Researcher
"Transformation of Economic and Social Systems"
German Development Institute /
Deutsches Institut für Entwicklungspolitik (DIE)

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Tulpenfeld 6 · 53113 Bonn · Germany · Tel.: +49 (0)228 94927-0 · Fax: +49 (0)228 94927-130
die@die-gdi.de · www.die-gdi.de · twitter.com/DIE_GDI · www.facebook.com/DIE.Bonn · www.youtube.com/DIEnewsflash
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