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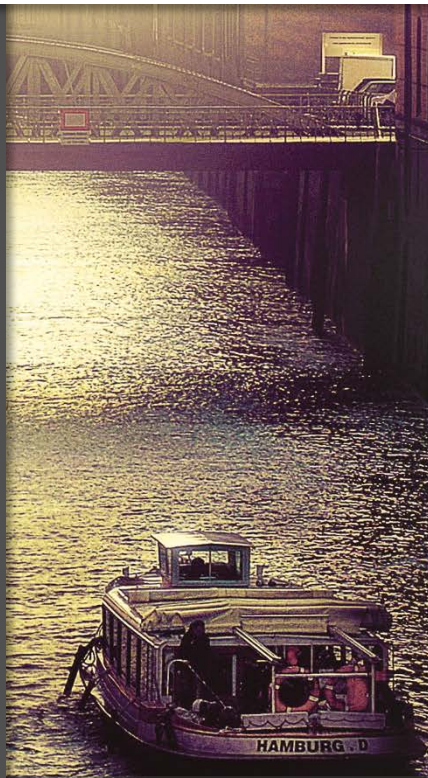

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Blockchain in Logistics and Supply Chain: Trick or Treat?

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Blockchain is an emergent technology concept that enables the decentralized and immutable storage of verified data. Over the last few years, it has increasingly attracted the attention of different industries. Especially in Fintech, Blockchain is hyped as the silver bullet that might overthrow today's payment handling. Slowly, the logistics and supply chain management community realizes how profoundly Blockchain could affect their industry. To shed light on this emerging field, we conducted an online survey and asked logistics professionals for their opinion on use case exemplars, barriers, facilitators, and the general prospects of Blockchain in logistics and supply chain management. We found most of our participants are fairly positive about this new technology and the benefits it offers. However, factors like the hierarchical level, Blockchain experiences, and the industry sector have a significant impact on the participants' evaluation. We reason that the benefits over existing IT solutions must be carved out more carefully and use cases must be further explored to get a rather conservative industry, like logistics, more excited about Blockchain.

Keywords: Blockchain; Logistics; Supply Chain Management; Use Cases

1 Introduction

Blockchain is everywhere. Invented by Satoshi Nakamoto, one or more mysterious individuals unmasked until today, it has been more of an insider's tip for the longest part of its existence. It became known to a larger audience in September 2015: nine financial companies – Goldman Sachs, Barclays, J.P. Morgan, and others – joined forces to build a new Blockchain-based infrastructure for financial services (Underwood 2016). By then, Blockchain had become the latest hype in Fintech, with almost daily announcements of new startups and corporate projects. It took longer until the logistics and supply chain management (SCM) community caught on and slowly realized the impact Blockchain might have on their industry. One major promise of Blockchain is to create transparency – every member of the network has access to the same data, providing a single point of truth (Tapscott & Tapscott 2016). Supply chain transparency is one of the most important and hardest to achieve improvement areas for logistics and SCM (Abeyratne & Monfared 2016). It comes as no surprise that some logistics experts consider Blockchain to offer "enormous potential" (O'Marah 2017), to be a "much-needed platform for economic renewal" (Casey & Wong 2017), and to "transform the supply chain and disrupt the way we produce, market, purchase and consume our goods" (Dickson 2016). Taken together, Blockchain might be nothing less than the "holy grail" (Popper & Lohr 2017). However, as it often is the case with emerging technology, the hype around Blockchain seems primarily driven by technology providers, consultants, and journalists. Logistics operators – especially small and medium-sized companies – declare to have little knowledge about Blockchain (Kersten et al. 2017). This can be explained through the novelty of the technology but also through the lack of convincing use cases that clearly show Blockchain's benefit over existing IT solutions. Logistics and SCM research on Blockchain is still in its infancy (Zhao et al. 2016) and ought to look into possible applications (Yli-Huumo et al. 2016).

The research questions for this paper emerge: *"What might be suitable applications for Blockchain technology in logistics and SCM?"* and *"Should Blockchain in logistics and SCM be considered a treat or rather a trick?"* The remainder of the paper is structured as follows: First, we summarize the basic features of Blockchain. Then, we introduce four use case exemplars explored in theory and practice. Subsequently, we present the findings of an international survey we conducted within the logistics industry to look into the prospects of the four use cases and expectations and apprehensions towards Blockchain. We conclude by discussing

the findings and daring a prognosis on the future of Blockchain in the logistics industry.

2 Basics of Blockchain

The Blockchain is a distributed digital ledger of transactions that cannot be tampered with due to the use of cryptographic methods (Pilkington 2016). This short explanation includes the three most important properties of a Blockchain: decentralized, verified, and immutable (see Figure 1). (1) It is decentralized because the network is entirely run by its members, without relying on a central authority or centralized infrastructure that established trust. To add a transaction to the ledger, the transaction must be shared within the Blockchain's peer-2-peer network. All members keep their own local copy of the ledger. (2) It is verified because the members sign the transactions using public-private-key cryptography before sharing them with the network. Therefore, only the owner of the private key can initiate them. However, the members can stay anonymous because the keys are not linked to real-world identities. (3) It is immutable through its consensus algorithm: One or more transactions are grouped together to form a new block. All members of the network can verify the transactions in the block. If no consensus on the validity of the new block is reached, the block is rejected. Likewise, if consensus exists that the transactions in the block are valid, the block is added to the chain. A cryptographic hash is generated for each block. Each block not only holds transaction records but also the hash of the previous block. This creates a block interdependency linking up to a chain – the Blockchain. Altering a

Figure 1: Basic Properties of Blockchain

transaction on the Blockchain retroactively would require not only to alter the local records on most of the networks members' devices but also altering the cryptographic hash of every block down the chain.

A distributed system, like a Blockchain, holds benefits over centralized architectures as it provides the same, verified information to all network members. It creates trust between the parties by eliminating the need for trust. Blockchain can record the transfer of assets between two parties, without the need of a trusted intermediary. Such assets could be digital money, but also carbon credits or other deeds of ownership (Tapscott & Tapscott 2016).

The Bitcoin Blockchain is the first implementation of the Blockchain principles and only supports simple transactions. It also shows how reliable Blockchain is, as it has run error-free since January 2009 and has a current market capitalization of over 35 bn. Euro. Centralized infrastructures, on the contrary, are increasingly hacked – classic middlemen, like banks or dating websites, provide ample examples (Tapscott & Tapscott 2016). Today, many more advanced Blockchain implementations exist. While most are open to the public (permissionless), there are also private (permissioned) Blockchain implementations, where the rights to read and write are controlled by a central authority (Pilkington 2016). Some Blockchain implementations support so-called "smart contracts" or applications living on the Blockchain (Christidis & Devetsikiotis 2016). Smart contracts are conditions written in code. The delivery of a parcel can serve as a simple example: To counter the risk of a loss, a smart contract can be designed such that the payment by the sender is only released once the shipping company confirms the delivery. This allows for a transaction to be automated, yet documented and controlled.

Of note, Blockchain provides not only benefits but also has challenges attached to it (Petersen et al. 2016; Yli-Huumo et al. 2016; Xu 2016). Most result from the early maturity phase of the technology. While these challenges (e.g., limited throughput) have to be addressed from a technological perspective, they should not distract possible users from evaluating the benefits of the underlying principles.

3 Blockchain in Logistics and SCM

As introduced, Blockchain is considered to offer large potential for improving processes and enhancing business models in logistics and SCM. However, accord-

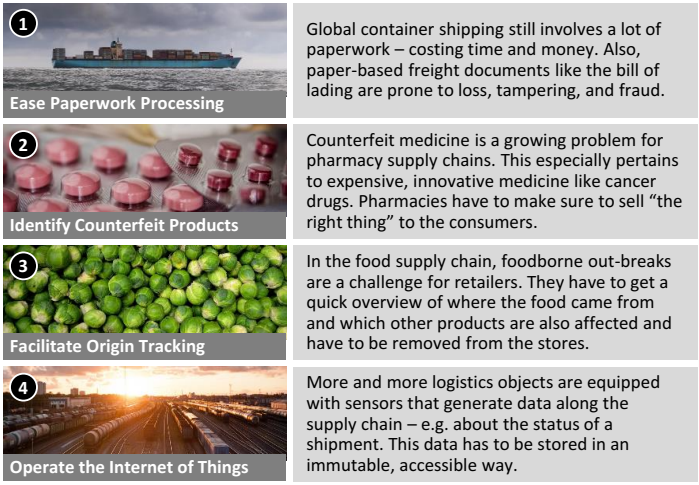

Figure 2: Overview of Use Case Exemplars

ing to a recent study on trends in logistics and SCM, Blockchain is only known to some logistics experts and even fewer pursue implementation plans (Kersten et al. 2017). In this section, we shed light on Blockchain's potential through introducing use case exemplars. These exemplars represent four major ideas currently explored in both theory and practice. They are also four single ideas out of a yet unmapped sea of opportunities. In choosing them, we tried to collate a broad and multifaceted picture later used for investigating the prospects of Blockchain for logistics and SCM. Figure 2 summarizes the use case exemplars. They are introduced in more detail in the following sections.

3.1 Ease Paperwork Processing in Ocean Freight

International container transports have a long trail of paperwork associated with them. For example, shipping refrigerated goods from East Africa to Europe requires stamps and approvals from around 30 people and organizations that must

interact with each other on over 200 occasions. Also, documents like the bill of lading might be subjected to fraud (Popper & Lohr 2017). Taken together, the cost of the trade-related paperwork processing is estimated to be between 15 and 50 percent of the costs of the physical transport (Groenfeldt 2017; Popper & Lohr 2017). To tackle such process inefficiencies and digitize paper records, IBM and Maersk joined forces in 2015. They eventually settled for a permissioned Blockchain solution as means to connect the vast global network of shippers, carriers, ports, and customs. The implementation details still must be worked out. However, a round of pilots in 2017 has succeeded. In these pilots, every relevant document or approval was shadowed on the Blockchain, meaning the legacy IT systems were not replaced but augmented. Using a standardized interface, every partner is empowered to have full visibility of the container status (Allison 2017). Until the end of 2017, Maersk hopes to shadow one in seven of their container shipments on the Blockchain – around 10 million boxes per year (Groenfeldt 2017). The problems associated with extensive paperwork are not limited to this specific use case but hamper all kinds of trade flows (Chu et al. 2016; Morabito 2017).

3.2 Identify Counterfeit Products

The provenance of high-value items often relies on paper certificates that can get lost or tampered with: whether a diamond's certificate is genuine or fake – and if the diamond was stolen – is not always easy to determine. The same holds true for expensive wine, watches, or handbags (Lomas 2015). Since, for example, a diamond's serial number can easily be cut, the startup Everledger takes an alternative approach and records 40 data points that uniquely identify a diamond. Using these publicly available records on the Blockchain, a potential buyer can clearly determine if the seller is the actual owner of the diamond and can also make sure he is not buying a "blood diamond" mined in a war zone (Underwood 2016). Everledger plans to extend this fraud detection system into a provenance platform for many high-value items (Lomas 2015). In the medical sector, counterfeit drugs are a known problem that – for example with anti-cancer drugs – can even have lethal consequences if patients do not receive the treatment as prescribed (Mackey & Nayyar 2017). Blockchain could improve patient safety through establishing supply chain transparency from manufacturers through wholesale and pharmacies to the individual patients. Through barcodes or auto ID technology, patients could be empowered to check whether they received the actual drugs (DeCovny 2017; Mackey & Nayyar 2017). Blockchain is considered to

make it much more difficult to tamper with products or to channel in products of illegal origin (Sutherland et al. 2017; Apte & Petrovsky 2016; Morabito 2017).

3.3 Facilitate Origin Tracking

If faced with a foodborne disease outbreak, retailers have a hard time figuring out where the bad ingredients came from and to which stores they were delivered (Tian 2016). Today, it can take weeks to track down the source of the contamination and restore consumers' confidence in food safety (Popper & Lohr 2017). To facilitate origin tracking for food items, Walmart partnered with IBM in 2016. Like with Maersk, Blockchain is used to augment the supply chain partners' existing IT systems through a transparent, superordinate ledger, tracking the movements of food items. This shared forum is considered a substantial improvement over Walmart's earlier trials involving barcodes or auto ID technology – solutions that required central databases and trust between the participants (Hackett 2016). In some first pilots, Walmart and IBM digitally tracked both domestic movements – pork from small Chinese farms to Chinese stores – and international movements – produce from Latin America to stores in the United States (Popper & Lohr 2017). In these pilots, data like the farm origin, batch numbers, factory and processing data, expiration dates, and shipping details were written on the Blockchain and instantly became available to all network members. With a foodborne disease outbreak, this data enables Walmart to track down the origin in a matter of seconds. During the year, further pilots with more data attributes are scheduled. Ultimately, Walmart believes Blockchain could also reduce food waste if the newly available data on shelf life is used as a parameter for supply chain optimization (Shaffer 2017).

3.4 Operate the Internet of Things

The Internet of Things (IoT) means everyday objects – essentially everything with a plug – get equipped with electronics and can exchange data over the internet. A Gartner report estimates there will be over 20 billion connected things by 2020 (Gartner 2015). However, the current internet architecture with its server infrastructure might not handle such an amount of devices and data (Eastwood 2017). Single servers represent a single point of failure and raise data security concerns. The public Blockchain ledger is considered a solution to connect and

manage IoT devices reliably (Pilkington 2016; Christidis & Devetsikiotis 2016). Given the large amount of possible IoT objects (vehicles, shipments, etc.), logistics might be one of the most promising applications for IoT and Blockchain (Zheng et al. 2017). First large companies start to work in this area. For example, Walmart was recently granted a patent that aims at improving last mile logistics through connecting delivery drones to the Blockchain (Hackett 2017). Such IoT devices connected to the Blockchain could also be provided with a digital currency. This would enable them to interact autonomously with other parties and – through smart contracts – to pay fees and duties by themselves, e.g., for priority access to restricted air corridors (Christidis & Devetsikiotis 2016; Petersen et al. 2016).

4 Survey about the Prospects of Blockchain in Logistics and SCM

To investigate how experts from the logistics industry evaluate Blockchain, we designed and conducted an online survey. This section describes its setup and the most important findings.

4.1 Setup and Data Collection

The survey was implemented using Typeform and had four major parts: First, we inquired the participants' general knowledge of logistics and SCM and Blockchain. Second, we introduced the four use case exemplars and inquired the participants' evaluation of Blockchain benefits and adoption likeliness. Third, we asked the participants about their general opinion on the main beneficiaries of Blockchain in logistics, likely adoption barriers, and the expected effect on established logistics processes. Finally, we inquired job and company details.

We collected the data between April 28th and June 13th, 2017. Participants were mainly recruited through social media, e.g., posts in logistics and Blockchain interest groups on LinkedIn, Xing, or Meetup. The BVL (Bundesvereinigung Logistik e.V.) shared our call for participants through their social media channels. We incentivized participation through small donations. After data collection was concluded, we donated 50 Euro to "Zeit für Zukunft" (Hamburg-based mentoring program) and 50 Euro to "Ingenieure ohne Grenzen" (Berlin-based aid organization) on behalf of our participants.

Especially for anonymous internet surveys, thoroughly examining the data is advised to identify careless responses (Meade & Craig 2012). We excluded three out of 155 initially collected data sets from the analyses due to clear answer patterns or answers that made no sense. Then, we prepared the data for statistical analysis following the guidelines of Hair et al. (2009). We used IBM SPSS Statistics 22 for the analyses.

4.2 Findings

We present the results of the study in the following, mainly through providing the mean values of the participants' evaluations. If our analyses proved them to be statistically significant at the 5%-level, we present more detailed findings and explore the differences between groups of participants.

Figure 3 shows an overview of the 152 participants: The clear majority works in consulting, followed by logistics services and sciences. More than half of the participants come from Germany, followed by the US, Switzerland, and France. Most participants work for small and medium-sized companies with a headcount of under 250 people and an annual turnover of less than USD 50m. This distribution is mainly caused by a high number of participants from small consulting companies. If considered on their own, around 60% of the participants from the logistics services industry work for large companies with over 3.000 employees and more than USD 500m turnover.

We then asked the participants about their company's stance towards Blockchain. Figure 4 summarizes the results. 43% declare they do not look into Blockchain just yet or observe the development from a distance. 37% of the participants investigate use cases, and 20% have implemented first Blockchain solutions. Again, this distribution is caused by consulting companies as almost three-quarters of them either investigate or implement Blockchain solutions. Looking at the logistics services companies alone, around 65% declare to be – if at all – watching from a distance. Only two experiment with Blockchain technology – one start-up and one logistics services behemoth.

Next, we introduced the four use case exemplars. We provided the information in Figure 2 and asked the participants to evaluate each use case regarding (1) the benefit of Blockchain and (2) the likeliness of adopting Blockchain. Figure 5 summarizes the findings through the mean values and standard deviations. Overall, Blockchain is evaluated to offer considerable benefits for all use cases (between

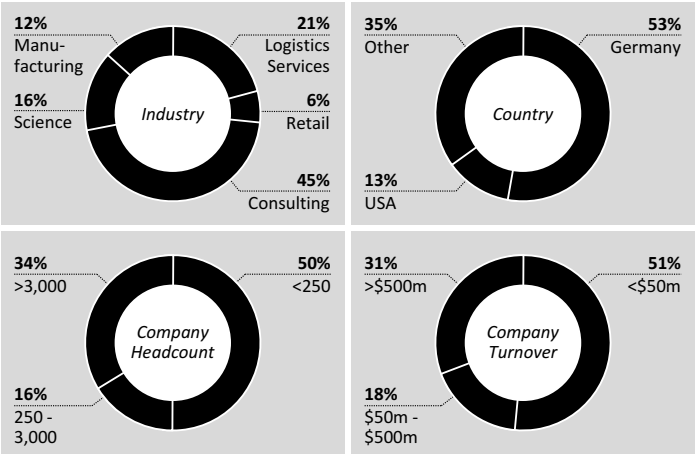

Figure 3: Overview of Participants and their Companies

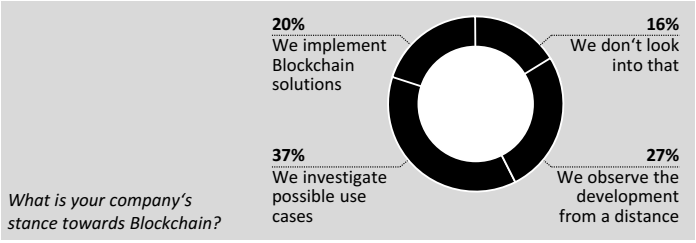

Figure 4: Company's Stance towards Blockchain

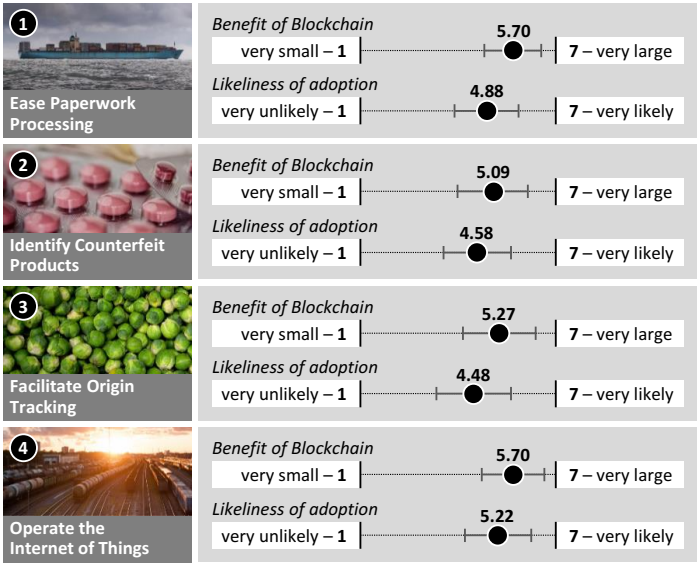

Figure 5: Evaluation of Use Cases

5.09 for the second and 5.70 for the first and fourth use case). In all instances, the likeliness of adoption receives lower ratings than the benefit (between 4.48 for the third and 5.22 for the fourth use case). However, the opinions are not uniform across different groups of participants. Middle managers rate both benefit and adoption likeliness lower than c-level executives do across all four use cases. Also, participants more experienced in Blockchain applications (for example, through own implementations) give better ratings than participants that only think about Blockchain. Finally, the participants' sector is also a differentiator. Especially regarding paperwork processing though Blockchain applications, employees from logistics service providers are more skeptical about the actual benefit than consultants or scientists.

After evaluating the use cases, we inquired the participant's opinion about the main beneficiaries of Blockchain applications in logistics. The findings are shown

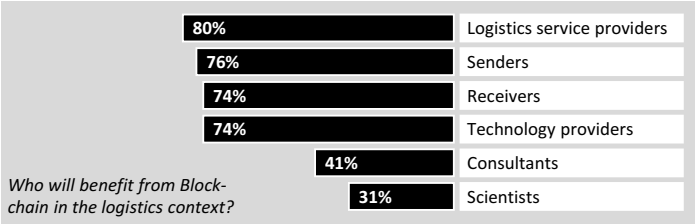

Figure 6: Beneficiaries of Blockchain

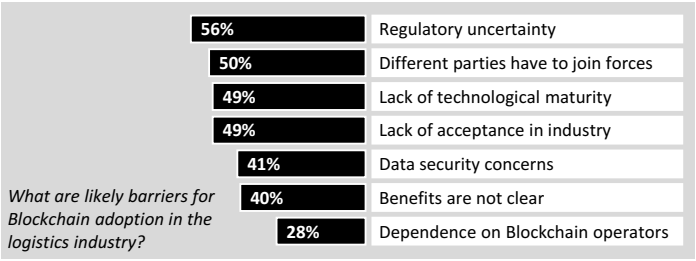

Figure 7: Barriers to Blockchain Adoption

in Figure 6. Around three-quarters of the participants expect logistics service providers, senders, receivers, and technology providers to benefit. Only 41% see consultants and only 31% see scientists as being beneficiaries. Again, these results are influenced by factors like hierarchical level or sector. Only one in five middle managers believes consultants will benefit from introducing Blockchain, while more than half of the c-level executives from the sample share this opinion. Further, a disproportionately high share of employees from logistics service providers believes technology providers will benefit, while consultants focus more on supply chain actors like senders and receivers.

We asked the participants about likely barriers to Blockchain adoption in the logistics industry. Figure 7 summarizes the findings. For 56% of the participants, regulatory uncertainty might be a barrier. Around half of the participants also refer to the fact that different parties must join forces, a lack of technological

Figure 8: Effect on Processes and Business Models

maturity, and a lack of acceptance in the industry as major barriers. Data security concerns (41%), unclear benefits (40%), and too much dependence on Blockchain operators (28%) are also named to be likely showstoppers. Again, the individual opinions significantly depend on factors like the hierarchical level, the sector, and the participants' experience with Blockchain.

Finally, we inquired the participants' overall evaluation of Blockchain's effect on established processes and business models in logistics. The result is shown in Figure 8. With an average evaluation of 7.08, the participants believe Blockchain would have a strong effect on the industry, even though the transformation might not be as radical as some trade press articles herald. No big differences can be found between any of the groups. The size of the standard deviation (1.88) proves there are skeptics and enthusiasts in the sample. However, they cannot be assigned to a specific group, like consultants or early adopters of Blockchain.

5 Discussion and Implications

Our study revealed valuable insights about Blockchain adoption in the logistics and SCM context. Despite realizing the impact Blockchain might have on their industry, companies seem hesitant to dedicate resources to look into possible Blockchain applications. Apart from that, the findings also provide insights into the perspectives of different participant groups. Taking the hierarchical level of the participants into account, our data suggests middle managers are much less enthusiastic about Blockchain than c-level executives or operational employees. They give significantly lower ratings on Blockchain benefit and adoption likeliness for the use cases, see fewer beneficiaries, and expect more showstoppers. For example, 60% of the middle managers raise concerns about data security, while

only 28% of c-level executives share this reservation. An explanation for this lack of enthusiasm might lie in the better overview middle managers have of their processes. Since they are likely responsible for implementing new IT solutions (at least from the business perspective), they might feel Blockchain is overhyped and is just another IT development praised as the silver bullet.

Our data suggests significant differences between logisticians (working for logistics service providers, manufacturers, and retailers), on one hand, and consultants and scientists on the other. These differences are striking in terms of beneficiaries and adoption barriers. Logisticians have difficulties getting a clear idea of the benefits and use cases, while consultants and scientists worry about the technological maturity of Blockchain. Our results underline the importance of carving out possible use cases for logistics and supply chain management. If people from a rather conservative industry, like logistics, are expected to buy into new technology, the benefit must be very clear. Just because something is new doesn't mean logisticians get too excited.

A third differentiator is the level of Blockchain experiences. Our data suggests the more experienced participants are (e.g., exploring use cases instead of just observing the development in the industry), the more positive they evaluate Blockchain. We find steadily growing ratings of benefit and adoption likeliness across the four experience levels shown in Figure 4. Also, more experienced participants identify more beneficiaries. Their perspective on possible barriers shifts: While only one fourth of the little-experienced participants expect collaborating with different partners to be a showstopper, around 60% of participants having implementation experiences indicate a high level of collaboration and commitment might be a barrier. Our findings show small-scale experiments with Blockchain applications are vital to understand the barriers and benefits of Blockchain. Logisticians should engage in experiments to find out if and how Blockchain could be of use for their own company.

6 Conclusion

In this paper, we presented a study on the current state of Blockchain in logistics and SCM. To shed light on the first research question pertaining to possible applications of Blockchain in logistics and SCM, we introduced four use case exemplars that are under exploration in theory and practice. To provide insights into the second research question about Blockchain being a trick or a treat for logistics

and SCM, we presented the findings of a survey. The survey was conducted in the logistics and SCM industry and investigated the participants' opinion on use cases, showstoppers, and benefits of Blockchain. As our findings show, Blockchain is expected to have a considerable impact on the logistics industry and should be considered a treat. However, our findings also show logisticians should start "chewing" on Blockchain soon. They are well-advised to find out how much of the overall Blockchain hype could be developed into a value-add for their service portfolio before someone else does.

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