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# Special Topic Forum: Blockchain: Applications and Strategies for Supply Chain Research and Practice

## Blockchain Applications in Supply Chain Transactions

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**B**lockchains, a disruptive technology with potentially many applications in modern-day supply chain (SC) transactions, have not been adequately reflected by theory. Researchers and business managers must understand where and when blockchains' application may be expected and investigated. The present study clarifies the discussion about blockchain application areas (BAAs) in SC transactions and their relevance for businesses. This study combines the findings from three methodological approaches: an extant literature review, a Delphi study, and a survey of 151 German machinery and equipment sector business managers. The results further our understanding of blockchains' business opportunities among SC transactions and verify and extend Iansiti and Lakhani's (*Harvard Business Review* 2017; 95: 118) blockchain adoption framework. Verified customer reviews and product quality certification are identified as the most relevant blockchain usages in SC transactions. Interestingly, we anticipate the least likely adoption of blockchains to occur for document-signing processes despite arguments within the literature that suggest otherwise. Two newly identified BAAs—logistics and delivery systems—and token-curated registries rank among the top four most relevant. The present study's valuation of BAAs advances theory and will likely affect business strategies by indicating where, when, and why businesses should participate in blockchain networks.

**Keywords:** blockchain applications; digitalisation; digital; supply chain; Delphi study; survey

### INTRODUCTION

The rise of the Internet has played an integral role in global economic development (Choi 2010). Internet usage has been demonstrated to provide new business opportunities and increase economic services as well as product trade figures (Bauer, Berne, and Maitland 2002; Rao, Goldsby, and Iyengar 2009; Choi 2010). While the infrastructure competition involved in the provision of Internet access has likely not comprehensively affected societal welfare (Höffler 2007), the Internet's positive effect on trade has formulated clear political demands that Internet access and use be facilitated for firms and customers alike; these demands are now mirrored in numerous political agendas around the globe (Singh, Alhor, and Bartikowski 2010; Datta 2011).

From the Internet's beginnings, however, online trade has been accompanied by three problem areas: privacy, security, and inclusion (Tapscott and Tapscott 2016). For example, a recent Statista (2017a) report reveals that e-commerce—despite its 8.8% share of the retail sector—is trusted by merely 72.4% of all European customers and by merely 57.8% of customers if the seller is visibly situated in another European country. The rise of secure socket layer (SSL) encryption and the dominant role of third parties, such as Alibaba, Amazon, or MasterCard, have contributed scarce change to this situation. These figures are also likely related to persistent distrust in online payment systems

among organizations and customers alike (Rinehart, Myers, and Eckert 2004).

The problem of lacking trust and its impeding effect on Internet usage as a platform for product and service exchange may provide a potential field of application for blockchain technology. The blockchain is a peer-to-peer network that in a way straddles the Internet and provides 'a distributed database, comprising records of transactions that are shared among participating parties' (Zhao, Fan, and Yan 2016, 2). Tapscott and Tapscott (2016, 16) describe the blockchain as similar to 'a global spreadsheet or ledger, which leverages the resources of a large peer-to-peer...network to verify and approve each...transaction'. A cyberattack on blockchains' decentralized structures and encryption algorithms is virtually impossible. Because transactions are permanently time-stamped and stored, attackers would need to reverse a blockchain's entire history while under the scrutiny of all users (Tapscott and Tapscott 2016). Blockchains provide the infrastructure necessary for firms and customers to conduct online transactions without the typical use of middlemen (who are traditionally used to ensure security), thus reducing transaction costs and the necessary time lags that middlemen usage involves. Blockchains may thus provide solutions to enhance trust and facilitate Internet trade along the entire supply chain (SC) (Treiblmaier 2018) in both its physical (buyer-supplier or supplier-customer) and support (carrier-supplier or financial institution-buyer) tiers (Carter, Rogers, and Choi 2015). The current public hype surrounding blockchains—combined with a limited understanding of the system's concepts and technology—bears certain dangers because this hype obscures the perspective of blockchain technology's real application potential (Kandaswamy, Furlonger, and Stevens 2018),

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given that many studies are conceptual and lack empirical evidence (Treiblmaier, 2018). A more prudent approach is needed to assess where blockchains can actually be employed and whether or not such usage would make sense in terms of performance gains.

As one of the first empirical investigations in this arena, the present study identifies potential blockchain application areas (BAAs) and assesses their relevance. The study thereby seeks to verify Iansiti and Lakhani's (2017) proposed blockchain adoption framework (BAF) and to extend that framework's scope from an economic and social systems level to an organizational SC level; the context is limited to transactions in the physical SC (Carter, Rogers, and Choi 2015). We believe the exclusion of support SC relationships facilitates a manageable study setting with the potential to achieve more meaningful results. The present paper's first objective is to identify potential applications of blockchain technology in the SC context. Specifically, we hope to answer our first research question (RQ1): *What application opportunities emerge in supply chain transactions for the selling firm through the rise of blockchain technology?*

The paper's second objective is to scrutinize and assess the applications we have identified in terms of their likelihood of implementation in business, the expected timeframe, as well as their expected business impact. Thus, RQ2 is: *Which blockchain application areas in supply chain transactions are most likely to be adopted, at what point in time, and to what impact?* The study's unit of analysis is the focal selling firm and its interactions with its customers (e.g., buying firms or end-consumers) along the so-called customer decision journey (CDJ); that is, the focus is on single transactions rather than long-term relational exchanges.

With the present study, we contribute to the literature and managerial practice by developing a deeper understanding of how blockchain technology can be relevant in SC relations and by providing a list of applications that are likely to be used and impact future businesses. The list was evaluated, revised, and extended by experts as part of our Delphi study. In addition, we provide insights into when each BAA is most likely to be implemented and where it is best suited in the CDJ, and we consider BAAs' corresponding economic impact and related performance gains. We answer the topic's complexity by offering a comprehensive approach that helps practitioners ask and answer the most important questions regarding blockchain adoption and diffusion.

We employ a multimethod approach to respond to the proposed RQs by combining a literature search with a subsequent empirical investigation of the findings via a Delphi study and a survey of 151 managers in the German machinery and equipment sector—the largest and strongest industry sector in Europe.

## THEORETICAL FOUNDATION

The present study builds upon, verifies, and extends two prominent SC and marketing concepts and frameworks. First, the study's conceptualization builds upon the aforementioned CDJ and the 'customer touchpoints' concept (Kotler and Armstrong 2010; Court et al. 2009; Dhebar 2013). Second, Iansiti and Lakhani's (2017) BAF, as published in the *Harvard Business Review*, was verified and extended to the SC context. Touchpoints along the CDJ depict the individual points when buyers

and sellers interact in the dyad. We build upon the assumption that buyer–seller interactions at these touchpoints often suffer from inefficiencies (e.g., the mentioned use of intermediaries). As a distributed ledger technology, a blockchain can theoretically be integrated at any touchpoint and thus potentially enhance security, transparency, and, consequently, trust and efficiency. Such dyadic applications can then be implemented in entire supply chains and may even span across several tiers (White, 2017). The following sections provide an overview of these concepts and frameworks and discuss how they aid this study.

### The customer decision journey (CDJ) and customer touchpoints

The study of customers in the Internet-enabled SCs is central to logistics and marketing research alike (Dadzie, Chelariu, and Winston 2005; Rabinovich 2005; Zinn and Liu 2008; Lemke, Clark, and Wilson 2011). Researchers have dedicated considerable effort toward both identifying the customer touchpoints that occur within the buying process and theorizing about holistic architectures (Dhebar 2013). The concept of customer touchpoints suggests that a firm's ability to optimize every touchpoint will drive its success.

Dewey (1910) initially suggested that the theoretical customer journey toward a purchase comprises five decision process stages. Over time, others extended and adapted this five-stage process to more efficiently reflect processes in modern business transactions. For example, Kotler (1967; and later, Kotler and Armstrong 2010) proposed a linear buying process model that was often referred to as the 'buying funnel' and vastly enhanced our theoretical understanding of the customer journey from the very beginning—that is, the moment of attention/attraction to the point of action (i.e., the purchase). The steady increase of online purchases has led to further adaptation of the stage process. Court et al. (2009), in a study administered by McKinsey & Company, argued that the hitherto linear concept of the customer journey toward a purchase was no longer sufficient for explaining the dynamics of modern customer buying behavior. The authors criticized the concept for failing to include decision factors that emerge from increased product choices and digital selling channels, as an increase of choices and channels leads to a surge of increasingly complex interactions at the touchpoints. Jansen and Schuster (2011) later corroborated this observation in their investigation of seven million records from a major US retailer's search engine-based marketing campaign.

The study of Court et al. (2009) concerning 20,000 customers' purchasing decisions in the automobile, skin care, insurance, customer electronics, and mobile telecom industries revealed that the modern-day customer journey toward a purchase is a circular process that includes loops and two-way interactions between firms and customers. This finding has led to the adaptation of this journey to modern processes and the labeling of the modern journey as the CDJ (Hudson and Thal 2013; Rosenbaum, Otolara, and Ramírez 2017). The modern-day CDJ consists of five steps—(1) initial consideration, (2) active evaluation, (3) moment of purchase, (4) postpurchase experience, and (5) the loyalty loop—that depict the stages in which firms engage with and fight for customers. The modern-day circular customer journey clearly indicates increased complexity at customer touchpoints (e.g.,

multichannel orders); to handle such complexity (also in the entire SC; cf. Mena, Humphries, and Choi 2013), intermediaries are usually employed at the intersections (e.g., call centers, e-commerce platforms). The services provided by intermediaries, however, result in costs and extended lead times (Popp 2000), thus further complicating information flows, reducing or at least lacking transparency, and amplifying trust issues (Popp 2000; Childerhouse et al. 2003; Meijer et al. 2006).

In summary, we believe blockchain-based applications have the potential to mitigate the abovementioned issues and increase firm's efficiency. Blockchain-based applications can either replace nonvalue adding intermediaries or aid intermediaries at complex intersections to increase transparency and foster trust in the services provided. The blockchain's distributed ledger technology ensures transparency and prevents information barriers, while its tamper-proof implementation avoids trust issues regarding traceability and, consequently, data quality. Along the CDJ process steps, multiple BAAs exist, some of which have already been identified in the literature; others will be newly identified and explained in this study. In addition, the present study seeks to shed light on which BAA will be implemented (first) in SC transactions and how strongly it is likely to impact businesses.

### The blockchain adoption framework (BAF)

Technology is commonly known as a potentially strong weapon in business competition (Powell and Dent-Micallef 1997), but identifying the 'right' technology that is both easy to use and useful is key for success in this competition (Legris, Ingham, and Collette 2003). In recognizing these two selection attributes, information systems researchers have developed the widely known technology acceptance model and the theory of planned behavior to explain technology usage (Taylor and Todd 1995). However, these theories have also drawn widespread criticism because their ability to predict technology usage and applications is solely based on the assessment of a technology's perceived ease of use and usefulness (Turner et al. 2010; Marangunic and Granic 2015).

Due to this criticism, and alongside the recognition of a blockchain's potential to create new foundations for economic/social systems—also called 'foundational technology'—Iansiti and Lakhani (2017) proposed a new framework in which the *degree of novelty* and the *amount of complexity and coordination* are the two key dimensions that determine the adoption of groundbreaking technologies (e.g., blockchains) and their applications. Considering the five process steps along the CDJ, we expect to find multiple application areas at the touchpoints with the potential for being improved by blockchains (Korpela, Halikas, and Dahlberg 2017). In this respect, the BAF may help us more thoroughly understand which BAAs are likely to gain traction first.

The BAF postulates that the newer a technology is, the greater difficulty potential users will likely encounter in understanding which problem the technology may solve; thus, the greater number of parties required to work together to produce value with the new technology, the longer the technology will take to become established. Iansiti and Lakhani (2017) identified four quadrants along these two dimensions—each of which represents a cluster of the technology's application areas—as well as the required technological development stage: *single use*,

*localization*, *substitution*, and *transformation*. Reading from left to right, technology application areas in the *single-use* quadrant depict non-novel technological applications that require scarce coordination with other economic entities, while the final *transformation* quadrant depicts entirely novel applications that require major social, legal, and political engagement.

In summary, the blockchain provides a promising technology that mitigates existing issues in modern-day SC transactions (see Section 2.1), and the characteristics of the technology's application areas are likely to suit the BAF's classification dimensions and inherent implications. To verify this assumption, we employed a manager survey to solicit each BAA's time-dependent likelihood of implementation. Such 'timelines for implementation' will subsequently be used to classify the identified BAA in the BAF, as both the timelines and the BAF should help predict which BAA gains traction first. Recognizing that the BAF was designed to predict adoption on an economy level, we seek to verify its applicability on a firm level. Concurrent with the BAF's adoption prediction on an economy level, we expect those application areas with a low degree of novelty and complexity to be adopted in the business context first, and vice versa. Concurrent with the BAF's adoption prediction on an economy level, we expect those application areas with a low degree of novelty and complexity to be adopted in the business context first and those with a high degree of novelty and complexity to be adopted last.

The following sections discuss the data collection and analysis processes employed in this study.

### 3. RESEARCH DESIGN AND METHOD

This study employed a multimethod approach to answer the RQs. A literature review was first conducted to identify BAAs that fit the CDJ. Second, a subsequent Delphi study was employed to verify the list of BAAs, identify hitherto missed BAAs, and develop an initial ranking of the BAAs' potential implementation likelihood and impact. Each round of the Delphi study gathered data via an online survey and semistructured interviews. However, to this end, we believe the BAAs' implementation likelihood and impact are likely industry sector specific. While the Delphi panel is ideal for verifying and extending the list of BAAs due to its diverse set of blockchain stakeholders, the panel may at best be capable of providing a cross-industry view of the BAAs. Thus, as the next methodological step, limiting our view to a selected industry sector may help identify more valuable insights. As a third and last method approach, we thus conducted a survey among 151 business managers in Germany's largest industry sector (machinery and equipment). This survey allowed us to verify the BAAs' sector-specific likelihood to be implemented, assess when and if the implementations are likely to occur, and understand their expected business impact.

The following sections outline each of our methodological steps.

#### Identification of BAAs via literature search

Three databases were selected for the literature search—Business Source Complete (via EBSCO), Emerald Insight, and ScienceDirect—because they have some of the largest repositories of

business research and are typically used in reviews of logistics and business studies (Wagner and Kemmerling 2010; Durach, Wieland, and Machuca 2015; Carter, Kaufmann, and Wagner 2017). A simple Boolean keyword search was executed using the keywords “blockchain AND application.” We limited our initial search to academic peer-reviewed outlets, with no further limitations. Because of the limited results this search yielded, we then opted for a broader search. This expansion was reasonable, as the literature review was simply an interim step in our study process; the BAAs were further scrutinized during the Delphi study. The search was then expanded to include other research articles, magazines, trade publications, reports, and book chapters. This final search yielded 442 results. Table 1 provides a brief overview of the literature and hints at the increasing interest in blockchains; for example, the number of articles published in Q1 2018 is nearly equal to the total number of articles published in 2017.

All 442 articles were read and analyzed for their mentions of BAAs within transactions of physical SCs. A total of 43 BAAs were initially identified by restoring to the full text of the literature. Decisions were based on the content of the texts and were inclusive, rather than exclusive. The team of authors then sorted and categorized the 43 application areas to develop clusters. To reduce subjectivity, the authors used the Q-sort approach as applied in Durach, Wieland, and Machuca (2015). Two authors were presented with the 43 application areas printed on small cards and instructed to independently arrange the cards to clusters along the CDJ. They were further instructed to not allow the same application area to be grouped into multiple clusters to obtain separate BAA groupings. After no further clustering of the cards was possible, the two participants explained the placing of their cards to the team. Similarities among the Q-sorts were then determined and consolidated. In situations where overlap could not be avoided, we carefully discussed each case in the team of researchers before making a final decision. A total of 10 largely distinct BAAs were eventually identified and assigned to the five steps of the CDJ (see section 2.1).

### Verification of BAAs and deepening of insights via Delphi method

Facing the risk that substantial empirical evidence on BAAs in SC transactions is absent from the literature, we next triangulated our results using the Delphi method. This approach may help us to gain additional insights on the BAAs and add BAAs to the list

**Table 1:** Relevant literature retrieved by database and year of publication

Date	BS via EBSCO	Emerald Insight	ScienceDirect	Total
Q1/18	30	24	123	177
2017	52	45	87	184
2016	34	6	13	53
2015	8	2	14	24
2014	2	0	1	3
2013	0	0	1	1

that have so far been missed. The identification of BAAs is a complex issue that requires knowledge from multiple stakeholders’ perspectives, something that the Delphi method can provide. Prior logistics researchers have also employed the methodology, for example to identify the application areas for additive manufacturing in SCs (Durach, Kurpjuweit, and Wagner 2017) or enterprise resource planning’s impact on SCs (Akkermans et al. 2003) or for identifying popular research topics in the logistics domain (Wieland, Handfield, and Durach 2016).

### Constructing the Delphi panel

We sought to identify potential panelist that have some profound expertise in both blockchain technology and its potential for SC applications (Okoli and Pawlowski 2004). In our view, obtaining a comprehensive view on BAAs necessitates perspectives from multiple stakeholders: people with an overview on business needs (i.e., consulting and industry managers) as well as people with technological expertise (i.e., academics engaged in blockchain technology research and blockchain solution providers). The search for experts was conducted via LinkedIn.com (the platform provides a broad coverage of European business professionals). Specifically, we conducted a people-profile search with the key term ‘blockchain’ or ‘block chain’ in the stakeholder areas of academia, management consulting, and all manufacturing industries. In an iterative process, we developed a list of candidates from the profiles from which we subjectively expected both profound blockchain knowledge as well as an understanding of blockchains’ link to SCs. Forty-three suitable candidates were identified and subsequently contacted. Twelve candidates responded positively within five days after initial contact for an initial turn-around rate of 28%, which is substantially higher than the rates reported in comparable studies (Förster et al. 2014; White 2017). We then contacted the candidates via phone to obtain a more thorough (though subjective) understanding of the panelists’ expertise and assess their command of English (the intended research language). In this step, we removed four candidates from the panel, achieving a total of eight. Table 2 provides a brief overview of the Delphi panel’ demographics. The average age of the panelists was between 25 and 34 years of age. Considering Livingstone and Helsper’s (2007) research on the early age frequency of Internet usage and later progression in the take-up of digital opportunities, finding mainly young managers to be experts on topics such as blockchain does not seem to be particularly surprising. After all, many of the latest and greatest blockchain-based technologies are being driven by younger people. Vitaik Buterin, the founder of Ethereum, was born in 1994. Branden Blumer, the inventor of EOS.IO was born in 1986.

### Delphi method data collection

We employed a two-round Delphi method, which Gary and von der Gracht (2015) consider adequate, as the two rounds help to reduce dropout rates. (See Wieland, Handfield, and Durach 2016 and Durach, Kurpjuweit and Wagner 2017 for other applications of two-round surveys.) The approach proved to be reasonable, as all eight panelists completed both Delphi rounds. Each round of the Delphi study employed two means of data collection. Quantitative data were collected via an online survey, while qualitative data were simultaneously gathered via semistructured interviews. The combination of structured data collection with qualitative

**Table 2:** Delphi panel member demographics

Panel Member (PM)	Age Range	Gender	Main firm location	Education	Stakeholder Group
A	25–34	Male	Germany	PhD	Academia
B	25–34	Male	Denmark	Master's	Management consulting
C	18–24	Male	Switzerland	Master's	Management consulting
D	25–34	Male	Germany	Master's	Management consulting
E	25–34	Male	Germany	Master's	Blockchain solution provider
F	25–34	Male	Belgium	Master's	Industry manager
G	25–34	Male	Italy	Master's	Management
H	18–24	Male	Germany	Bachelor's	Blockchain solution provider

methods has various merits (Rowe and Wright 1999). First, the approach can be understood as a means of data triangulation (Yin 2009), thereby enhancing data reliability and validity (de Vos et al. 2011); second, the combination may contribute to the understanding of phenomena by investigators and panelists alike (Jick 1979).

For the first-round quantitative data collection, the panelists were informed about the ten BAAs via short informative texts. The panelists were asked to rank the ten BAAs on two dimensions: (1) the BAA's *likelihood of implementation in business* and (2) its *impact on business if successfully implemented*. Rank 1 indicated *most likely* or *highest impact*, whereas 10 indicated *least likely* or *lowest impact*. For the first-round qualitative data collection, a guideline for the semistructured interviews (see Appendix 1) was conceptualized according to the standards provided by Gläser and Laudel (2010). Semistructured interviews were used for their ability to leave more room for new discoveries than quantitative analyses do. Since the main objective of the interviews was to discover additional BAAs that were not yet part of the academic literature, this approach was deemed reasonable. Both the surveys and the interview guideline were first pilot-tested and refined with one of the panelists.

Interview durations varied from 15 to 30 min and were conducted and recorded in English via Skype. In the round-one *exploratory phase* Delphi interviews (Ziglio 1996), two key areas were explored using open-ended questions: First, we asked about the validity of the BAAs and their categorization within the CDJ; second, new or additional BAAs were sought that had not been captured through the literature review. Each panel member was also asked about the current state of the blockchain industry, which gave the investigators an overview of the topic. The panel members were assured of complete anonymity, both with fellow panelists and with anyone outside the investigation team.

The first-round interviews were then transcribed and coded to extract the newly identified BAAs and to validate their proposed categorization. We employed the selective coding method from Lowe's (1991) qualitative coding matrix. Eventually, four newly identified BAAs were added to the existing list (i.e., *token-curated registries*; *loyalty programs*; *logistics and delivery systems*; *alternative use of tokens*). The semistructured first-round interviews with the panelists also guided us in making changes to three of the BAAs, as identified in the literature review. We deemed these changes reasonable, as the panelists' critical opinions about these three BAAs were univocal. We thus first excluded the before identified BAA of *medical bill payment* from

the list, because it was thought to be overly specific. Second, *independent product quality certification* was renamed *product quality certification*, because a third independent certifier was argued to be not always necessary. The blockchain can verify the origin of a product independently even in a direct business-to-customer context. Third, *escrow service for goods* was renamed *escrow service*, because more than goods can be transferred using blockchain-based escrow services. The final set of 13 BAAs was eventually structured according to the CDJ (see Table 3).

In the second round, this list of 13 BAAs was employed to construct the second online survey and to develop the second set of interview guidelines (see Appendix 2). The main purpose of the second round was to communicate the results of the first round and to see whether the panelists had adjusted their views considering the anonymous results from the first round. For this purpose, the new augmented list of application areas was presented and explained to the panel members. The second round commenced with the semistructured interviewers requesting the panelists' feedback on the new BAAs and inquiring about the possibility of additional, to-date unregarded areas. No additional BAAs were identified. In a subsequent online survey, the experts were then asked to rank the augmented list of blockchain applications according to the same two dimensions used in the first round. This ranking was of course a very generic process and had no concrete relation to a dedicated area or topic, although soliciting such a ranking helped us understand whether or not we may have early on perceived an overarching consensus in this diverse group of experts—which finally proved to not be the case (see Appendix 3 for more information on the Delphi study's results). This finding motivated us to conduct a much more focused survey as our next and final methodological step.

#### **Timeline of BAA implementation and impact assessment via survey research**

Thus far, the Delphi experts have helped identify new BAAs, develop an in-depth understanding of the thirteen BAAs, structure the BAAs along the CDJ, and establish an initial understanding of the BAAs' comparative implementation likelihood and importance. Provided with this knowledge (excluding the ranking, which may have a biasing effect), business managers in specific industry sectors should be able to further assess such BAAs with regard to their implementation timeline and their potential impact on businesses.

**Table 3:** Blockchain application areas (BAAs) along the customer decision journey (CDJ)

CDJ	BAA	Main sources*	Supporting sources*
1. Initial consideration	Pay for performance Pay for attention	Epstein (2017)	Constantinides (2014), Confessore (2018), Rondinella (2018)
2. Active evaluation	Token-curated registries	(newly identified)	Wei Chun (2018)
3. Moment of purchase	Product quality certification	White (2017)	Due.com (2018)
	Alternative currencies	Bott and Milkau (2017), Holotiuk, Pisani, & Moormann (2017)	
	Transfer of contracts, bonds, deeds, or stocks	Tsukerman (2015), Tapscott & Tapscott (2016)	Fung (2014)
	Document-signing processes	Wan, Deng, and Lee (2015)	Wesley (2017)
	Escrow services	Goldfeder et al. (2017), Epstein (2017)	
	Alternative use of tokens	(newly identified)	
4. Postpurchase experience	Transparent performance management systems	White (2017)	Wesley (2017)
	Logistics and delivery systems	(newly identified)	
	Verified customer reviews	White (2017)	Saleh (2017), Wang, Wenzel, & Forgues (2016)
5. Loyalty loop	Loyalty programs	(newly identified)	

\*The list of reference details can be obtained from the authors.

Business managers are likely to have the most favorable vantage point when assessing whether and when businesses will eventually adopt and what they expect from the identified BAAs in terms of business impact. Hence, an additional survey was conducted among business managers as a final methodological step. As such insights are likely context specific, the survey was limited to the German machinery and equipment sector, the largest and strongest sector in Europe with a nominal turnover of EUR 226 billion in 2018, 6,500 firms, and more than one million employees (GTAI, 2019). In addition, we expect managers in this sector to be particularly knowledgeable because, since 2013, Germany's Industrie 4.0 initiative has encouraged managers in this sector (among others) to assess the new digital technologies and their business impact.

A pretargeted sample of 275 managers was developed with a market research firm. The sample's blend was a close match to the firms' distribution in the German machinery and equipment sector in terms of region and number of employees. A pretargeted sample was utilized to minimize nonrespondents and provide a more favorable quality of panelists. A 'manager' was defined as an individual in the position of middle, department, or higher management. Among those 275 managers in the sample, 151 provided usable responses to the survey, which resulted in a total response rate of 54.9%. Two different attention checks were implemented to ensure that participants paid attention to and exerted effort toward the instructions we provided (Lonati et al. 2018; see Appendix 4 for survey questions and attention checks). The first check was placed at the beginning of the survey, while the second check was positioned at the end; this way, we hoped to identify participants who were attentive the entire way through. If participants did not pass both attention checks, we deleted their responses.

On average, the respondents had 22.92 (std 10.5) years of general work experience, and more than 62% worked at the executive/senior management level or higher (for respondent and firm

demographics, see Table 4). Participants were also asked to describe the business units of the firms in which they were employed. The average unit purchases 48.09% of the purchasing volume from international suppliers and sells 36.5% of the production directly to end-consumers. The latter information was retrieved as a proxy for the firms' SC position.

The original short informative texts for each BAA were translated from English into German following the recommendation of Sperber, Devellis, and Boehlecke (1994). The descriptions were then presented to our sample of business managers via an online survey. Questions regarding these BAAs consisted of structured, closed-ended questions. The managers were first asked about the time horizon—that is, when they expected the respective BAA's implementation. They assigned percentage points (100 total points) to the following options: 0–5 years, 5–10 years, 10–15 years, >15 years, or never. Next, they were asked to assess the BAA's performance impact on their business if implemented using a Likert scale that ranged from –5 (extremely negative impact) to +5 (extremely positive impact). Each respondent was confronted with a partly randomized selection of three BAAs from the set of thirteen. We chose this approach to reduce the risk of respondents experiencing fatigue. Due to randomization, we obtained between 28 and 41 responses per BAA for a total of 450 assessments. It needs to be pointed out that the chosen surveying approach does not expose all respondents to all BAAs and thus limits the comparability of the BAAs, since, given the small sample size, randomization might not have fully equalized all influencing factors. Further, the BAAs' assignment was insofar not completely randomized, as respondents were required to indicate their managerial area of expertise in terms of sales, purchasing, both, or none prior to taking the survey. BAAs that did not match an individual's field of expertise were deselected for that individual. We manually associated the BAAs with the different areas of expertise, based on the literature review and Delphi study findings. Table 5 lists each BAA along

**Table 4:** Demographics of survey informants and firms

Respondent Position		Firm size (number of employees in business unit)		Firm Supply Chain	
Company owner/founder	20	≤ 10	19	Supply chain position (proxy)	
Executive/ senior management	74	10–50	32	Avg. sales volume to end customers	36.50%
Middle manager/ department manager	48	51–250	39	(STD)	27.94%)
Junior manager/supervisor/ team leader	9	251–500	14		
		501–2000	19	Globalized supply chain (proxy)	
		2001–5000	9	Avg. purchasing vol. from Int'l suppliers	48.09%
		> 5000	19	(STD)	36.74%)

with the number of respondents, their job positions, and work experience.

As is the case with all self-report research, we must assess how the present study's setting is susceptible to biases embedded in the reported data as a result of the subjects' social desirability (Robinson, Shaver, and Wrightsman 2013). To reduce exposure to this bias and assess whether or not our sample is particularly susceptible to this issue, we implemented two procedures. First, we informed the respondents of the project's academic nature, and prior to starting the online survey, they were also guaranteed complete anonymity. Second, we checked for whether or not social desirability was a severe issue with these informants by visually inspecting their mean responses to three items from the

**Table 5:** Number of respondents (responses), job positions, and work experience per blockchain application area (BAA)

BAA	Number of respondents (owner, exec., middle, junior)	Work experience Avg (STD)
Verified customer reviews	39 (4, 19, 12, 4)	20.88 (10.73)
Product quality certification	36 (5, 18, 11, 2)	23.30 (11.06)
Document-signing processes	38 (5, 20, 12, 1)	24.99 (10.81)
Transparent performance mgmt systems	30 (5, 14, 9, 2)	22.63 (9.81)
Token-curated registries	40 (2, 24, 12, 2)	21.90 (10.02)
Transfer of contracts, bonds, deeds, or stocks	37 (5, 20, 10, 2)	22.16 (11.84)
Logistics and delivery systems	29 (3, 13, 11, 2)	23.10 (9.24)
Pay for attention	28 (5, 15, 7, 1)	22.29 (11.98)
Loyalty programs	32 (5, 12, 13, 2)	23.06 (11.88)
Alternative currencies	32 (3, 17, 10, 2)	25.18 (9.55)
Escrow services	37 (4, 18, 13, 2)	24.35 (9.12)
Pay for performance	34 (6, 16, 9, 3)	22.83 (11.31)
Alternative use of tokens	28 (2, 16, 8, 2)	21.79 (10.59)

Crowne and Marlowe (1960) social desirability scale. The means were 2.97, 3.30, and 4.09 on a seven-point Likert scale, with higher values indicating higher social desirability. Given that the average mean's value was below 4.0, we concluded that social desirability was not overrepresented in this sample (see Appendix 4 for the employed scales).

## RESULTS AND DISCUSSION

The following sections will present the results of the multi-method approach along with a discussion and interpretation of the results. Before presenting the survey results, we highlight the thirteen BAAs identified for SC transactions in the order of their respective categorizations in the CDJ steps (Table 3). In introducing the BAAs, we adopt an organizational lens to provide answers to how organizations can apply blockchains during the various CDJ steps.

### Description of identified BAAs in SC transactions: results of the literature review and Delphi method

#### *Pay for performance*

Organizations often employ online and performance marketing agencies, and the bureaucracy for such cooperation may take several months as well as tie up resources. According to Epstein (2017), blockchain technology can provide fully automated smart contracts between organizations; for example, a smart contract between a customer and a marketing agency can autonomously query Google with particular keywords to determine the PageRank of a given URL at a given time and then transfer a certain number of Bitcoins to the agency's Bitcoin address if the page reaches the desired segment (i.e., the top ten) that was agreed upon in the smart contract (Epstein 2017). This example showcases one specialty of smart contracts, which can contain business logic that hitherto requires time-consuming and error-prone manual effort. 'Pay for performance' is categorized in the initial *consideration* phase of the CDJ because firms can use these contracts to improve the way they reach their customers and suppliers during the initial consideration process.

#### *Pay for attention*

Online and social media marketing today builds upon platform users' personal information (e.g., Facebook or Instagram). These



platforms sell this information to advertisers, who may therewith target specific users (Constantinides 2014). The scandal surrounding Cambridge Analytica in 2018, wherein millions of Facebook users' personal data were used by a third party without the users' consent, spurred mistrust in data security (Confessore 2018). Blockchains may allow users to regain control over their personal information. Blockchain platforms such as BitBounce, 21.co, and TV-TWO allow users to sell their guaranteed attention; in other words, selling firms directly pay users for their attention and solely gain access to data the users have approved (Epstein 2017). This blockchain 'pay for attention' model also solves ad fraud, which is a persistent problem in online marketing. Advertisers possess scarce transparency if the money they spend on third-party platforms actually results in targeted advertisements; for instance, IBM announced a cooperation with Unilever in February 2018, in which Unilever agreed to use IBM's blockchain technology for its media purchases (Rondinella 2018). 'Pay for attention' is categorized in the *initial consideration* phase because it represents a new way for firms to reach potential customers.

#### Token-curated registries

Token-curated registries come into play in the *initial consideration* phase, as panel member (PM) E (Table 2) stated:

*...when a customer wants to buy a good and has demands, the question is where to get the best information sources from. Currently...centralized services like a Google link list or Forbes or other centralized links [are used. Thinking about] decentralization, everybody could be a part of a source. It's about the decentralization of opinions and quality...Imagine Google without listed pages, or Amazon without ranked products, how good they'd be. But all participants or sellers would rank themselves, so they'd have to find a consensus.*

If firm were to cheat and rank themselves highest, then the list's quality would suffer and customers would no longer use it. Therefore, as PM E asserted, the participants '*have to...rank [themselves] fairly, so the market by itself gets a good reputation*'. To ensure the list's quality, firms can buy tokens (blockchain-based shares) from the list, and as part-owners, they are incentivized to create a high-quality list (Goldin 2017). As an example, PM E mentioned that '*...in the online world, for example, GoogleAds and...AdSense [are the main registries people visit when searching for products]. In the blockchain world, we have...adChain, which is doing exactly [the same thing]*'.

#### Product quality certification

The trustworthiness of third-party product certifications is often debated (Dranove and Jin 2010) and usually connected with high costs (White and Samuel 2016). By providing direct origin traceability—and thereby providing proof of quality—blockchain technology may overcome the issue of product authenticity. In the same way, blockchains may provide greater transparency for certification providers such as Fairtrade (White 2017). In 2016, Walmart launched a blockchain-based food safety center in Beijing in collaboration with IBM. The center performed a traceability test for a package of mangos in 2.2 s, which took 6 h and

18 min without blockchain-based processes (Chun 2018). This BAA is listed under the CDJ's *active evaluation* phase, wherein customers actively evaluate their initial consideration set and seek additional information. Thus, the trustworthy certification of a product's quality can help firms design more meaningful touch-points during this phase.

#### Alternative currencies

Security, anonymity, decentralization, higher speed, and lower transaction fees may lead to blockchain-based currencies as alternative payment methods for customers; Microsoft, PayPal, and Subway already offer these alternatives (Nasdaq 2018). Cryptocurrencies can have many benefits, as previously excluded customers who lack a bank account or credit card can now pay in a secure and anonymous manner. International payments can be executed at a much lower cost without the overhead of intermediaries. This BAA is listed in the *moment of purchase* phase since it plays a role while customers purchase products.

#### Transfer of contracts, bonds, deeds, or stocks

This BAA is mainly concerned with ownership. New selling methods become possible when ownership is included in a smart contract. Blockchain technology has massive potential specifically for ownership titles because transferring processes of authorities and institutions can be automated in the contract. Marc Andreessen, the cofounder of Mosaic and Netscape, provided the following example in *The Washington Post*:

*You get a digital title on a car, attached to a digital key, where you own your car on the Bitcoin blockchain and on your smartphone. The key to opening your car and starting your car is tied to that title. And if I sell you my car, you automatically get the title, and you get the key that lets you operate the car (Fung 2014).*

This BAA is categorized into the CDJ's *moment of purchase* phase due to the time at which the transfer occurs.

#### Document-signing processes

Especially in business-to-business transactions, document-signing processes often involve multiple parties (Wan, Deng, and Lee 2015), and the respective sale cycles are typically long due to the required coordination effort and document-signing processes. This situation becomes especially complicated and costly in industries that involve cross-border transactions and contracts based on different law systems. A strong example of this condition is container shipping; in this sector, the blockchain can identify, record, validate, and time-stamp every interaction as well as process transactions, thus facilitating the vast flow of documents and document changes (Wesley 2017). In the CDJ, this BAA is also most accurately categorized into the *moment of purchase* phase.

#### Escrow service

One of the oldest problems of online transactions is the lack of trust between parties. Simply speaking, which should be sent first—the goods or the money? In present day, the following two solutions exist: Either large retailers establish a solid reputation or smaller sellers employ a trusted third party to act as a

payment intermediary, and credit card companies usually behave in a similar fashion (Goldfeder et al. 2017). In the future, these third parties may be eliminated through blockchain technology (Epstein 2017). Because escrow services facilitate the *purchase* process (similarly to the *transfer of contracts, bonds, deeds, or stocks* areas of blockchain usage), this BAA falls into the *moment of purchase* CDJ phase.

#### Alternative use of tokens

This additional BAA was mentioned by PM D (Table 2) regarding a blockchain application that is:

*...like a smart contract, which is turning Ether and other cryptocurrencies into new tokens, and those tokens are representing something. This is very helpful to see the automation of sales. For example, tokens...don't have to represent just money. They could represent a plane ticket, as well. So, instead of going through the whole organization of Lufthansa, I could buy tickets directly from the plane—a plane that's a decentralized, autonomous organization, where I have to transfer one Ether—which is currently €300—and get a token, which allows me to enter the plane for that flight. Here, we have an example where a token has a versatile use and is not just crypto sending money.*

Similar to *alternative currencies*, the 'alternative use of tokens' is categorized into the *moment of purchase* because this BAA can potentially change how transactions are facilitated in the CDJ.

#### Transparent performance management systems

Current methods of attributing sales efforts to the appropriate team member can often be opaque and unfair because the individual closing the sale usually receives the firm's sole recognition. By efficient and cost-reducing tracking, blockchains may support the development of transparent performance management systems (White 2017) that evaluate and track all data through every customer journey and can impartially account for each contribution (Wesley 2017). This BAA is attributed to the *post-purchase experience* phase because it improves customer service agents' performance, thus leading to more pleasant customer service experiences. Further applications are additionally possible, such as human resource management.

#### Logistics and delivery systems

Blockchains can be used to decentralize logistics and make delivery more efficient and transparent. According to Leuschner and Lambert (2016), an increase in logistic performance leads to greater customer satisfaction; as PM E explained:

*We trust...DHL to deliver fast, on time, and with high quality [and] not to lose our packages too often. But with a decentralized trust system like a blockchain, you can have a stake in [the delivery]. For example, [you can bet] money that they will deliver fast and get good reviews. In this way...trust [develops] through the value of money.*

This BAA is categorized into the *postpurchase experience*, as it relates to purchased product delivery and is thus an after-sales activity.

#### Verified customer reviews

Saleh (2017) reports that 90% of all customers read online reviews before making purchases. Although online reviews are undoubtedly popular, their integrity is questionable due to customers' incapacity to differentiate between real and fake reviews (Wang, Wezel, and Forgues 2016). Blockchain technology can offer an independent verification process that may lead to more trustworthy customer reviews (White 2017). This BAA is in the *loyalty loop* CDJ phase because customers express their loyalty to specific brands during this phase, which firms can subsequently build upon.

#### Loyalty programs

Two PMs mentioned loyalty programs as an application area in which blockchain technology has great potential. PM E provided the following example:

*Right now, we have a lot of loyalty programs...In Japan, for example, you have the messenger Kik, which is leading the market, like WhatsApp here or Line in other countries...All on...a blockchain token. The loyalty programs [must be] interchangeable...Think of an airline. [You] don't have [specific] airline loyalty programs; you have [them for] alliances, [such as] Star Alliance and others.*

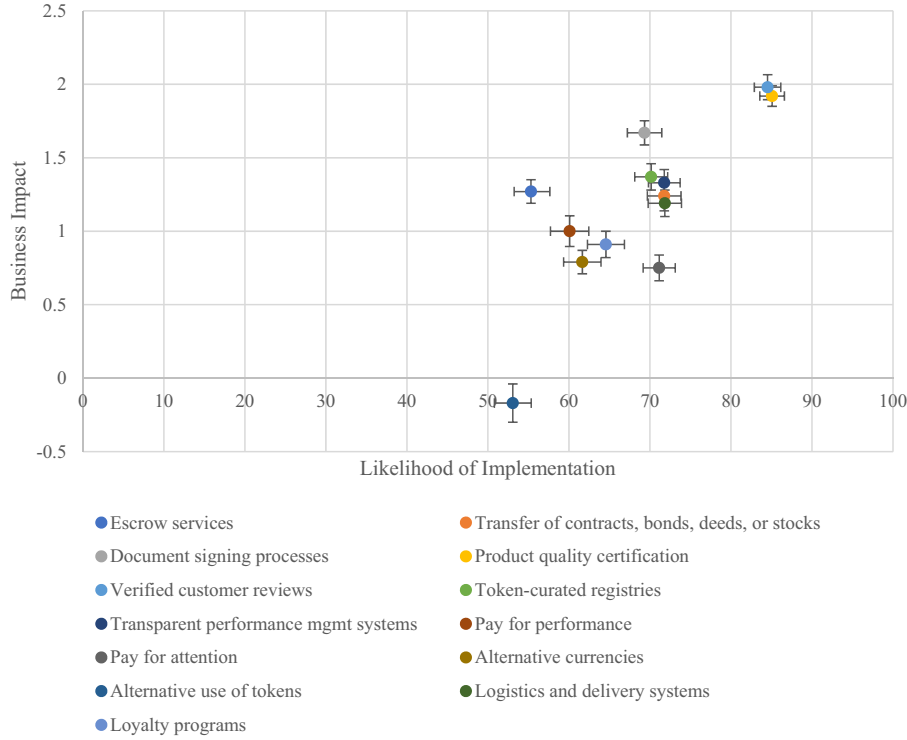
The Japanese e-commerce giant Rakuten plans to offer blockchain-based rewards programs (Custodio 2018), and this BAA is categorized into the *loyalty loop* CDJ phase because it results in enhanced customer loyalty by rewarding customers through a facilitated process.

#### Expected likelihood of implementation and impact on business

The following sections present the results of the multimethod approach alongside a discussion and interpretation of the results. The above-described list of BAAs and their informative texts provided the basis for our survey of 151 business managers in the German machinery and equipment sector. Figure 1 depicts the BAAs identified in SC transactions alongside the quantitative results for the researched dimension of each BAA's *likelihood of implementation in business* and *business impact* if successfully implemented. The dimension *likelihood of implementation* depicts the probability of BAA's implementation irrespective of when they will be implemented. In this section, we will highlight five findings we believe to be most interesting in terms of their managerial and theoretical value.

First, all identified BAAs have a likelihood of greater than 50% to be adopted in future SC transactions in the machinery and equipment sector, which clearly emphasizes blockchain technology's potential in our domain and the need that it be paid close attention from both a research and a management perspective. Thus, it becomes clear that blockchains that build upon distributed ledger technologies are more than merely the technology

**Figure 1:** BAAs in SC transactions: Means of expected likelihood of implementation and impact on business (crosshairs indicate one-tenth of one standard deviation).



behind Bitcoin, but are also a disruptive technology to modern-day SC management.

Second, the ‘logistics and delivery systems’ BAA was initially not identified in the literature search and only surfaced during our Delphi study, yet Table 6 demonstrates that it nevertheless ranks among the top three BAAs in terms of application likelihood. We perceive this result as an indication that the literature has not yet grasped all key BAAs and that the present findings help us not only more thoroughly understand but also identify hitherto missed BAAs. Similarly, ‘token-curated registries’—another BAA that was solely identified in the Delphi study—is ranked fourth in terms of impact. In sum, we find that at least two of the four additionally identified BAAs are relevant to the managerial practice.

Third, the ‘product quality certification’ BAA has the highest likelihood of being adopted in the machinery and equipment sector, which seems to be an intuitive finding given that this sector primarily provides input products to other manufacturing sectors. Firms in this position are often more dependent upon recurring business and long-term relationships than are firms in sectors that supply the end-customer.

Fourth, the ‘document-signing processes’ BAA—under the umbrella of ‘smart contracts’—has been traditionally understood as a key contribution of blockchain technology to modern-day SC management (Tapscott and Tapscott 2017). It is projected to significantly increase trust in SC partners and thus facilitate trade. This BAA is ranked third in terms of impact, thus supporting the preconception of its relevance. Most surprisingly, however, responding managers rank the likelihood of implementing blockchains for ‘document-signing processes’ in SC transactions

as merely eighth of thirteen, which may initially seem counterintuitive; although given the presence of other comparative solutions that are relatively easier to implement and the obvious need for comparative solutions (Tapscott and Tapscott 2017), it is likely that managers will first implement the already available solutions. For example, cryptography solutions based on the so-called pretty good privacy (PGP) employ infrastructures that are quite similar to a blockchain’s distributed ledger regarding perceived transparency and security. A new blockchain-based implementation would possess a low degree of novelty and would need to communicate additionally unique selling points to substitute existing, established systems.

Fifth, lending credibility to our data, ‘alternative use of token’ has been identified as both the least likely BAA to be adopted and the BAA with the lowest business impact—a pattern that is largely (but not completely) consistent across all BAAs, suggesting that managers consider impact and probability not separately but rather as a combined product. This also supports our assumption that BAAs have an inherent performance gain/business impact that is explicated in a business context (Section 2.2).

Next, to develop a final assessment of each BAA’s relative relevance, we utilized an approach that is frequently employed for risk ranking. The ‘risk priority number’ approach sorts risks according to their relevance and need for managerial attention (Norrman and Jansson 2004). In following this approach, we multiplied the likelihood ( $L_M$ ) and impact ( $I_M$ ) to arrive at an overall relevance ranking ( $Rank_N$ ) of the BAAs among SC transactions (see Table 6). We calculated standardized values of likelihood (1 minus ‘likelihood of BAA never being adopted’) and impact (Likert scale ranging from  $-5$  = extremely negative

**Table 6:** Overall relevance of blockchain application areas (BAAs)

BAAs	$L_M$	$I_M$	$L_M \times I_M$	Rank <sub>N</sub> *
Verified customer reviews	3.66	3.37	12.32	1
Product quality certification	3.72	3.27	12.17	2
Document-signing processes	2.09	2.89	6.03	3
Transparent performance mgmt systems	2.34	2.36	5.52	4
Token-curated registries	2.17	2.42	5.26	5
Transfer of contracts, bonds, deeds, or stocks	2.34	2.22	5.20	6
Logistics and delivery systems	2.35	2.14	5.03	7
Pay for attention	2.28	1.46	3.33	8
Loyalty programs	1.59	1.71	2.73	9
Alternative currencies	1.29	1.52	1.97	10
Escrow services	0.64	2.27	1.44	11
Pay for performance	1.13	0.32	0.36	12
Alternative use of tokens	0.40	0.04	0.02	13

\*Please consider the limitations of the surveying approach, as pointed out in the method section, when interpreting this ranking.

impact to 5 = extremely positive impact) to account for differences in the units of likelihood and impact (percentage vs. absolute values) and extreme values. We then shifted those results up by two units to obtain meaningful results when calculating  $L_M \times I_M$  (see Table 6).

Two BAAs ('verified customer reviews' and 'product quality certification') rank among the top two in both their likelihood and impact dimensions; consequently, they are listed as the top two in the relevance ranking. This situation may be interpreted as a clear hint of these applications' relevance in future SC applications, although both BAAs can easily be added or integrated into existing system architectures (e.g., a document-signing process).

### Timeline of BAA implementation: results of the survey research

Figure 2 depicts the BAAs identified in SC transactions along a timeline to indicate when each BAA is most likely to be implemented. When interpreting the findings, please note that the survey was conducted in May 2019, and that not all managers responded to all BAAs, thus Figure 2 may not be interpreted as a ranking.

Interestingly, we identify very few outliers or erratic movements in the timeline, suggesting that the implementation likelihood seems to increase largely consistently across the BAAs as time passes; for example, within a ten-year frame, 'product quality certification' remains the most likely to be implemented. The steepest increase of implementation likelihood among all BAAs is observed in the timeframe of five to ten years and decreases from there.

The steepest increase in terms of implementation likelihood is detected for 'transfer of contracts, bonds, deeds, or stocks', while this BAA has a low likelihood to be implemented within five years, it shows a steep increase to be implemented within five and ten years. We take this result as an indication that the

average firm in the sample already prepares the BAA's implementation, and we assess that the delay is more a problem of current regulations and formal rules rather than technical implementation. This assessment is supported by the fact that related technologies are already existent in other uses and are thus waiting for adaptation (e.g., cryptocurrencies such as Bitcoin provide functions for transferring ownership). Subsequently, changing the owned objects from, for instance, 'coins' to 'assets', is not excessively complex.

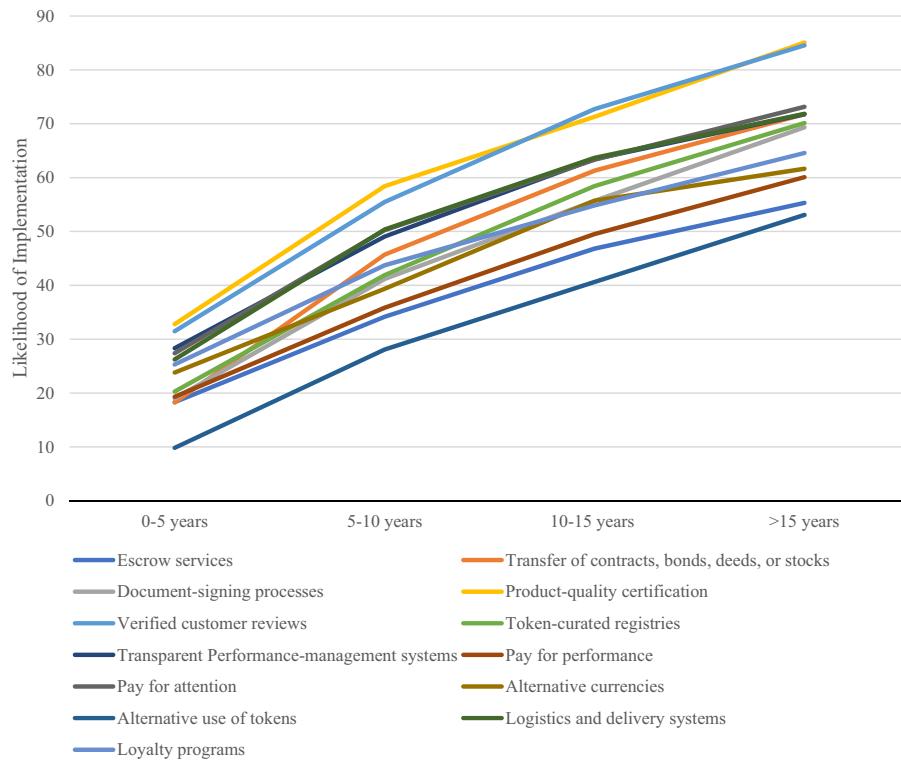
### Verification and extension of the blockchain adoption framework

In the last step, the assessed BAAs were inserted into Iansiti and Lakhani's (2017) BAF to assess the framework's predictive value in the SC transaction context. The assessment is a critical reflection of the framework given the present findings and not a formal testing. The following discussion therefore reflects our personal interpretation of the outcome.

We used our survey informants' assessments of each BAA's implementation likelihood within five years as a proxy for assessing which BAA will gain traction first. Iansiti and Lakhani (2017) postulated that their framework predicts exactly this: the order of implementation, primarily driven by each BAA's complexity. The BAF states that applications in the *single-use* quadrant will be implemented first, as they require the least amount of implementation effort; however, they may also have the least potential for contributing to organizational performance gains. The leading applications in terms of potential for performance gains can be identified in the *transformation* quadrant. Their implementation will occur comparatively at a later time due to their complexity and requirement of a significant amount of coordination.

Our classification of BAAs in the BAF, as depicted in Figure 3, suggests the BAF's strong predictive strength in the present context at the extremes—that is, the outer quadrants (*single-use* and *transformation*). BAAs that have been identified by our informants with the highest likelihood of implementation in the next five years (thus categorized into the *single-use* quadrant) are generally relatively easy to implement. Increased implementation complexity exists with BAAs in SC transactions that are predicted to be implemented at a later time and thus fall into the *transformation* quadrant.

However, while the BAF's predictive value in the present context is relatively strong at the extreme cases, it is weak in the less extreme cases. The BAF suggests that a BAA's implementation complexity is directly intertwined with its potential impact—an assumption that is not completely supported by our findings because it suggests that the BAF would also predict our BAAs' relevance, as indicated by the ranking presented in Table 6. However, we find that, while the classification is robust at the outer quadrants, the classification in the two inner quadrants differs when using our Rank<sub>N</sub> order rather than the implementation likelihood order: Three BAAs switch places between *localization* and *substitution* and one BAA moves from *substitution* to *transformation*. In total, seven of ten BAAs in the two inner quadrants would be differently classified, indicating that, while timeliness and impact might harmonize soundly on an economic

**Figure 2:** Timelines for implementation in business.

scale (as is the BAF's original context), they are less strongly linked in a business context (i.e., the present context).

Two patterns emerge when comparing the consolidated rankings illustrated in Table 6 with the original BAF. First, the initial ranking that is based on the timeliness of implementations almost perfectly aligns with the categorization into the BAF quadrants, thus providing support for the framework's applicability in the present context. Second, while the initial framework is economic in nature, an extension of the framework to more efficiently explain why and with what impact BAAs will be implemented at the organizational level is needed. Based on our discussion of BAAs and the classification differences between exclusively using 'likelihood of implementation within five years' and in combination with the BAA's business impact, we postulate a third dimension that depicts the potential for *performance gains* in an organizational context. This claim is also supported by the interview results collected for the Delphi study. While *single-use* BAAs are easier to implement, the panelists assessed that some of these applications as fairly unlikely to be implemented in organizations due to their scarce potential to achieve substantial performance gains in organizations. In contrast, BAAs in the *transformation* quadrant appear to share the degree of novelty and the need for high levels of coordination, but they were also jointly evaluated as potentially leading to substantial organizational gains upon implementation. The model's proposed extension also extends the BAF's explanatory power.

Managers should decide if they want to focus on either applications that quickly gain traction (*single-use*) or riskier but potentially more effective applications (*transformation*). If the decision lies somewhere between the two application types, then we must acknowledge that the BAF has likely not yet developed

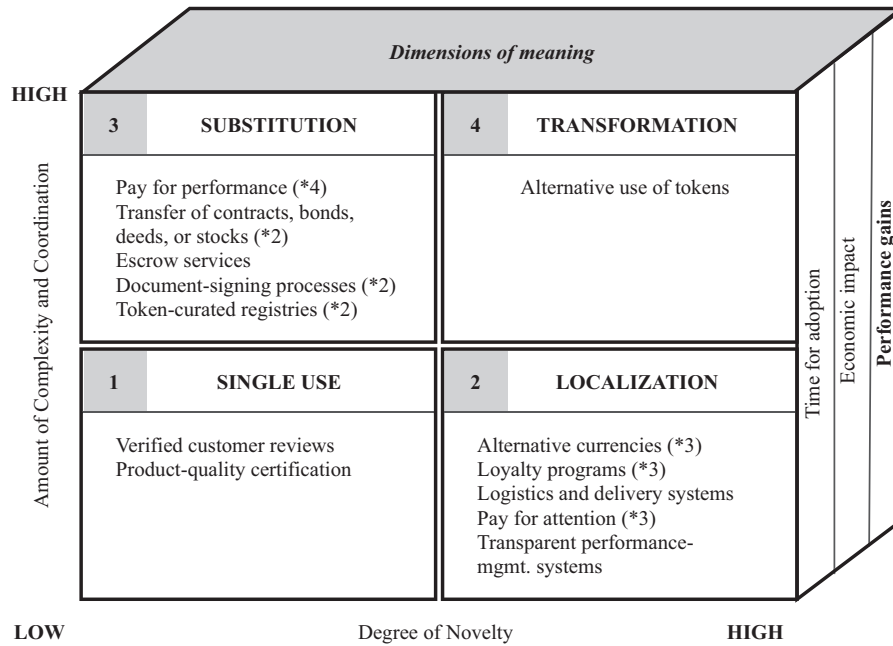
a level of theoretical solidness that facilitates sound recommendations in an organizational context.

## IMPLICATIONS AND CONCLUSION

This study contributes to the few studies in the literature that exist at the intersection of blockchain technology and SC management. The study is a direct response to Zinn and Goldsby's (2017a, 2017b) calls for research that addresses the disruptive force of new technologies and thus enhances our discipline's bonds with practitioners.

Following Gartner's latest hype cycle, blockchain technology has moved from the *peak of inflated expectations* to the *trough of disillusionment* (Kandaswamy, Furlonger, and Stevens 2018); in other words, the time has come to find answers regarding for what purpose we can use the technology and where we might benefit from distributed ledger technologies. Media and literature have provided various examples that showcase how blockchains can, for instance, help firms and customers in following products and goods. However, we must admit that our understanding of the technology and its true potential for imposing a disruptive impact upon SC transactions has remained limited. A current survey by Statista (2017b) issued in the first quarter of 2017 reveals that the term 'blockchain' is only known to about 36% of German medium-sized enterprise decision makers. Therefore, in considering blockchains as a distributed network that follows given structures and procedures, familiarizing oneself with all the related concepts, steps, and processes by applying them directly becomes increasingly important—but where should one begin? In this respect, the present study attempted to provide a deeper

**Figure 3:** The blockchain adoption framework (BAF) among the supply chain (SC) transactions. *Note:* (\*#) indicates the quadrant the BAF would be classified into when using our Rank<sub>N</sub> order.



understanding of which blockchain applications may facilitate SC transactions and how they can simplify related processes.

In response to our first research question, we identified and specified thirteen BAAs, all of which provide opportunities for blockchain applications in modern-day SC transactions (Table 3). These BAAs resulted from an in-depth screening of extant literature, along with qualitative data collected over the course of a Delphi study. To structure the findings and ensure that the entirety of the modern SC transactions' process stages would be covered, we drew upon the CDJ concepts and customer touchpoints (Court et al. 2009). As a result of our research, managers are now provided with the said list of BAAs and their varying importance to SC transactions. Managers should now be more efficiently equipped for embarking on blockchain journeys.

Through our second research question, we sought to assess and rank the BAAs according to their business relevance. The 151 managers assessed all identified BAAs on the dimensions of *implementation likelihood* (along an implementation timeline) and *impact if implemented*. The key findings in response to this question are depicted in Table 6 and Figure 2. Lastly, the findings were used to verify Iansiti and Lakhani's (2017) recently proposed BAF. As a result, a new (third) dimension was added to their framework. This new dimension not only examines the *degree of novelty* and the *amount of complexity and coordination* needed to achieve a technology's widespread application, but also examines the organizational *performance gains* that can be expected from its instantiation; thus, this newly proposed dimension moves the economic/societal framework to the organizational level. In addition, our data on BAAs both confirm and reject application areas identified from prior literature and add four new application areas to the discussion.

The relevance hierarchy of the BAAs we have developed for SC transactions should direct SC managers toward those

applications that are most likely to grow in the future and will be most effective for their businesses. Our attempt to categorize the application areas into the modern CDJ will facilitate the managerial understanding of where blockchain opportunities among the customer touchpoints may arise. Low-ranking applications should not yet be abandoned completely, as the complexity of implementing new technological solutions implies that the most relevant application areas may be more reasonable to pursue first.

Our study results need to be interpreted with the following limitations, which in part also provide future research opportunities. As previously mentioned, the Delphi study was conducted with relatively young panelists that deliberately constituted a heterogeneous group of blockchain stakeholders. This initial approach was deemed reasonable for discussing our list of BAAs that resulted from the literature review and helped identify BAAs that have thus far been neglected by the literature. The lacking consensus among the panelists regarding the BAAs' implementation likelihood and business impact must, however, be interpreted, as responses to specific research questions in this new technology field are likely specific to industry contexts. Our provision of a focused survey of 151 managers in the German machinery and equipment sector was determined to partly address this shortcoming, and the results supported our assumption of industry specificity. The results of the focused survey also need to be interpreted with due care, given that not all managers responded to all BAAs; the approach was chosen to reduce the risk of respondents experiencing fatigue. Nonetheless, given the interesting results, future researchers may benefit from bringing further industry sectors into the analysis of BAAs in SC transactions. The same contextual analysis can and should then be extended to national and cultural differences, as our findings are likely limited to the German context in which our data was collected.

In terms of future research, we strongly believe it would prove interesting to study the simultaneous redistribution of power and trust in SCs following the introduction of blockchains, as the technology will affect those whom organizations select as future trade partners. As a partner selection criterion, trust—or a firm's public prominence—may become less relevant once it arises from the mere use of blockchain technology; for example, small firms that are not traditionally early adopters of new technologies should consider blockchains as tools that will help them become more trustworthy business partners. Furthermore, because some relationships identified in support SCs—such as the supplier–broker–buyer relationship—are likely to be substituted by blockchains, an investigation of the reshaping of support SCs once blockchains gain traction would be additionally worthwhile.

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## APPENDIX 1

### DELPHI ROUND ONE: INTERVIEW GUIDELINES

Provide information about:

- interview duration (15–30 min)
- anonymity and confidentiality
- recording of the interview
- interview language (English)
- interviewees not needing to answer questions they do not wish to answer
- the Delphi methodology and the importance of participation in a second round
- the aim of the interview (evaluating the likeliness of implementation and impact of previously identified application areas and identifying new areas)
- the customer loyalty loop
- the CDJ model (ideally, the model should be available for reference during the interview)

General questions:

- In which ways have you been exposed to blockchain technology?
- What is the current state of the blockchain industry right now? Where do you see opportunities, and what needs to happen in order for blockchain to become mainstream?

Specific questions:

- Please elaborate a bit more on why you ranked the application areas in this way.
- When you think about the CDJ, and the application areas from the literature, does this categorization make sense?
- What are additional BAAs in sales?
- In which step of the CDJ can these application areas be categorized?
- Do you see any application areas that are relevant for sales but do not fit into the CDJ?

## APPENDIX 2

### DELPHI ROUND TWO: INTERVIEW GUIDELINES

Provide information about:

- interview duration (10–15 min)
- anonymity and confidentiality
- recording of the interview
- interview language (English)
- interviewees not needing to answer questions they do not wish to answer
- aim of the interview (explaining the results of the first-round Delphi study and asking for feedback)
- the need to do the final ranking after the interview

Specific questions:

- What surprised you about the ranking?
- What is your opinion about the additionally identified application areas?
- What is your general feedback on the new model?
- Do any additional application areas come to mind that have not yet been mentioned?

### APPENDIX 3

#### DELPHI STUDY: QUANTITATIVE RESULTS AND RESPONSE CONFORMITY

Kendall's W was used to measure the degree of agreement among the expert panel in each Delphi round (Field 2005). Kendall's W, which ranges from 1 (complete agreement) to 0 (complete disagreement), is typically used to assess the level of

concordance of rankings among multiple judges. While researchers have yet to agree on which W values are adequate in Delphi studies, the W values did provide a useful indicator to compare answer conformity within our panel.

Table A1 depicts the BAAs identified in SC transactions, along with the quantitative results for the researched dimension of each BAA's *likelihood of implementation in business* and *impact on business* if successfully implemented after round two. SDs and Kendall's W were computed for both rounds to assess response conformity. In the first round, Kendall's W (1 = complete agreement, 0 = complete disagreement) indicated a moderate degree of concordance for the *likelihood* dimension ( $W = 0.46$ ) and the *impact* dimension ( $W = 0.55$ ) among the panelists. In round two (below), Kendall's W was computed as *likelihood* ( $W = 0.48$ ) and *impact* ( $W = 0.46$ ). Considering the increase in BAAs from 10 to 13, the data showed slightly more conformity than in the first round; yet, we conclude that Kendall's W is still not high enough given the small sample and the noisiness of the data to infer a certain degree of agreement from the ranking.

**Table 7:** Quantitative results from Delphi round two

Panel member	A	B	C	D	E	F	G	H	Sum	Mean	Var	SD	Kendall's W
Likelihood of implementation													
Document-signing process	2	5	1	4	2	1	2	1	18	2.3	2.2	1.5	k 13
Transfer of contracts, bonds, deeds, or stocks	1	4	5	3	8	3	3	5	32	4.0	4.3	2.1	m 8
Escrow service	5	1	2	6	5	6	10	2	37	4.6	8.6	2.9	W 0.48
Alternative currencies	3	7	7	2	4	4	9	6	42	5.3	5.6	2.4	MSD 2.7
Alternative use of tokens	8	3	6	1	6	7	5	8	44	5.5	6.0	2.4	SSD 0.9
Logistics and delivery systems	4	9	12	5	10	5	4	4	53	6.6	10.3	3.2	
Product quality certification	11	8	13	10	7	2	1	3	55	6.9	19.8	4.5	
Token-curated registries	9	6	8	9	3	8	8	12	63	7.9	6.7	2.6	
Loyalty programs	12	10	3	8	1	9	13	9	65	8.1	17.3	4.2	
Pay for performance	6	2	10	12	11	11	6	11	69	8.6	12.6	3.5	
Verified customer reviews	7	12	4	11	9	10	12	10	75	9.4	7.4	2.7	
Pay for attention	10	13	9	7	12	12	7	7	77	9.6	6.3	2.5	
Transparent performance mgmt systems	13	11	11	13	13	13	11	13	98	12.3	1.1	1.0	
Impact if implemented													
Transfer of contracts, bonds, deeds, or stocks	2	5	1	3	1	2	5	6	25	3.1	3.8	2.0	k 13
Alternative currencies	1	2	3	1	6	1	9	2	25	3.1	8.4	2.9	m 8
Document-signing process	5	6	10	5	7	3	1	1	38	4.8	9.4	3.1	W 0.46
Escrow service	9	3	4	4	5	8	10	3	46	5.8	7.9	2.8	MSD 2.9
Alternative use of tokens	8	4	7	2	4	10	3	10	48	6.0	10.0	3.2	SSD 0.48
Product quality certification	12	7	2	8	10	5	2	4	50	6.3	13.4	3.7	
Logistics and delivery systems	3	9	5	9	12	4	4	5	51	6.4	10.3	3.2	
Token-curated registries	7	1	9	6	3	9	8	9	52	6.5	9.1	3.0	
Pay for performance	4	12	8	10	9	7	6	12	68	8.5	8.0	2.8	
Pay for attention	6	13	13	11	11	6	7	7	74	9.3	9.4	3.1	
Verified customer reviews	13	8	11	12	2	11	12	8	77	9.6	12.8	3.6	
Loyalty programs	11	10	12	7	8	13	13	11	85	10.6	4.8	2.2	
Transparent performance mgmt systems	10	11	6	13	13	12	11	13	89	11.1	5.6	2.4	

K, No. blockchain applications; m, No. PM's; MSD, mean standard deviation; SSD, standard deviation from MSD; W, Kendall's W.

## APPENDIX 4

### SURVEY QUESTIONNAIRE (EXCERPT)

When do you expect your business unit to implement [BAA name] the first time (please assign percentages, summing up to 100%):

- Within 5 years
- In 5–10 years
- In 10–15 years
- In more than 15 years
- Never

Please assess the impact on your business if [BAA name] is successfully implemented and used? (−5 = extremely negative impact; 0 = no impact, 5 = extremely positive impact)

**(Attention check question 1 [not indicated as such])**

Please ignore the following question, that is, do not respond and skip it:

- I work together with exactly 354 purchasing colleagues (correct/wrong)

**(Attention check question 2 [not indicated as such])**

Please ignore the following question, i.e. do not respond and skip it:

- Is your birthday on February 30<sup>th</sup>? (Yes/No/Don't know)

**(Social desirability checks [not indicated as such])**

Please evaluate to what extent you personally agree to following statements: (1 = totally–7 = not at all)

- 1 I sometimes feel resentful when I don't get my way.
- 2 It is sometimes hard for me to go on with my work if I am not encouraged.
- 3 I like to gossip at times.

### SHORT BIOGRAPHIES

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