D4.2 Taking stock of existing trends and forward- looking scenarios in the application and governance of distributed ledger technologies (working paper)

WP4 Governance and Technologies: interrelations and opportunities

Grant Agreement n° 822735, Research and Innovation Action

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement nº 822735. This document reflects only the author's view and the Commission is not responsible for any use that may be made of the information it contains.

TRIGGER

TRends in Global Governance and Europe's Role

Deliverable name:	D4.2 Taking stock of existing trends and forward- looking scenarios in the application and governance of distributed ledger technologies (working paper)
WP / WP number:	WP 4 Governance and Technologies: Interrelations and Opportunities
Delivery due date:	31.05.2020
Actual date of submission:	29.05.2020
Dissemination level:	Public
Lead beneficiary:	ETLA
Contributor:	Juri Mattila
Reviewers:	Balazs Bodo, Andrea Renda

Changes with respect to the DoA

Not applicable

Dissemination and uptake

Public

Evidence of accomplishment

Report

Content

Index of Figures

Executive summary

The potential of blockchain technology and distributed ledgers have received a lot of attention in the public discussion in recent years. Since the advent of the first widely known use case of blockchain technology in 2008, the concepts in the field have gone through a number of evolutionary phases, expanding in breadth and taking on new meanings. The expansion in terminology has largely led to inflated and erroneous beliefs about the revolutionary effects of the phenomenon.

Several public and private institutions have taken an interest in blockchain technology and distributed ledgers lately. Multiple public and private research and development initiatives, as well as combinations of the two, have been established in Europe, just as in the United States and China. However, despite the hype and a multitude of announced initiatives, published documentations of the development projects—successful or otherwise—are extremely few and far in between. Furthermore, descriptions of lessons learned and practical insights, usually available for other developing technologies, seem virtually inexistent with blockchain. The lack of evidence indicates that companies have not been able to execute on the promise of blockchain and distributed ledger technology (DLT) (Burg, Murphy, and Pétraud 2018).

The lack of evidence for successful development projects, as well as the rhetoric of how blockchain and DLT are being discussed in the business and policy realms suggests that blockchain technology is still largely not well understood amongst these groups. Moreover, due to the ambiguous terminology, the differences between blockchain and DLT systems are not always properly acknowledged.

By describing blockchain technology first and foremost as an alternative method for deploying digital platforms and fostering their network effects through a grassroots level approach, this report makes an effort to provide a better understanding of the strengths and challenges as well as the opportunities and threats to global governance from blockchain and DLT. As a case example of the potential benefits, the realm of product life cycle management in global supply chains is examined.

From a global governance standpoint, the key implication is that blockchain technology has enabled a new kind of a distributed computational paradigm for rethinking how to organize human collaboration and interaction. Despite the technological possibilities, the governance of these alternative applications is complicated by the fact that established social paradigms of interaction taking place on top of blockchain-platforms have not yet fully manifested amongst the general public. For example, while the forceful execution of binding contracts is possible in blockchain platforms, the underlying technical mechanisms means that the process of entering into a contract in a blockchain environment requires different kinds of steps and attention needs to be paid in different details than in a contemporary setting. However, the mere existence of an alternative technology environment in itself may be sufficient to drive innovations regarding governance in the more conventional realm of technological execution environments.

While an increase in the adoption of blockchain systems by the general public could reduce the relative cohesion of global governance entities, such as the European Union, by enabling more liberty in the choosing of the social constructs and contracts in which one wants to voluntarily participate, blockchain systems could also manifest new non-state entities of stronger cohesion and actorness. For example, some initiatives have been founded which aim to establish the first globally decentralized virtual nations (*e.g.* BitNation see Section 4.5.2).

If successful, the new peer-to-peer-based[1] paradigm of blockchain could purport innovations with a wide range of benefits to the economy and society at large. However, the traditional control mechanisms of governance may be largely inefficient against blockchain platforms, much in the same way as has been the case with many other manifestations of peer-to-peer network technology. Nonetheless, the importance of functional regulation in fostering platform innovations and innovation ecosystems has only been thoroughly understood in recent years (Chander 2015).

As a consequence, a new, dual-sided global governance approach is required to foster and control the innovation development in blockchain platforms. On one hand, the emerging new paradigm calls for adaptation and new strategic approaches to governance on a more global level. On the other hand, the governance efforts of blockchain networks and the phenomena around them should be based on the acknowledgement of the fact that regulators within Europe, as well as outside it, are engaged in a competition for innovation ecosystems. In this effort, collaboration between the European regulators is key in order to level the playing field, to increase regulatory clarity, and to reduce barriers of entry into the European innovation market, much in the same way as with other aspects of the Digital Single Market in a wider context.

So, while presenting some new challenges for global governance, blockchain systems have also enabled new tools for governing global open collaboration. A key transformation is the new kind of ability to deploy open ecosystems by starting out with the incentivization schemes for collaboration. Some have argued that the technology itself could be used to mimic institutional processes to facilitate social constructs and elements such as currency, property regimes, and even democratic voting processes. However, whether such technological underpinnings could truly be used to establish an actual social contract by alternative means, as understood in social philosophy, remains highly questionable.

[1] In this context, peer-to-peer refers to an ahierarchical network typology where every participant of the network is in an equally privileged position.

1. Understanding the technology

1.1. Blockchain data structure

Despite a decade of research and development, no clearly defined and widely accepted definition for blockchain still exists in academia. The usage of the terminology varies a great deal depending on the context, and similar expressions can be used to refer to completely different technology compositions and phenomena.

Originally the term ‘blockchain’ was used in reference to the cryptographically concatenated append-only data structure utilized in the first applications of the technology, *e.g.* the Bitcoin cryptocurrency network (Nakamoto 2008). In this kind of a data structure, all database modifications are added to the database as cryptographically chained blocks (See

Figure 1).

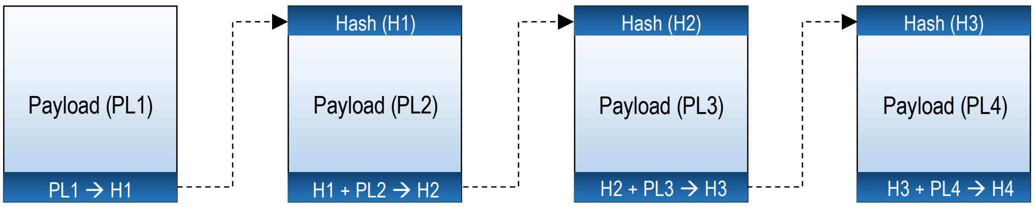

Figure 1. Cryptographically concatenated blockchain data structure (Mattila et al. 2019).

While the append only data structure requires a lot more storage space, one benefit of such a method is that alterations to the modification history of the database can be detected by comparing different file versions of the blockchain database, more specifically, by examining the hash values used to concatenate the data structure. Hash values are the product of an algorithmic process known as hashing in which data of arbitrary size is mapped onto data outputs of predetermined size. By using the hash value of the most recent data block as a part of the calculation for the hash value of the next data block, any attempts to tamper with the contents of the blockchain's data are immediately evident, and discarded by the participants of the network.

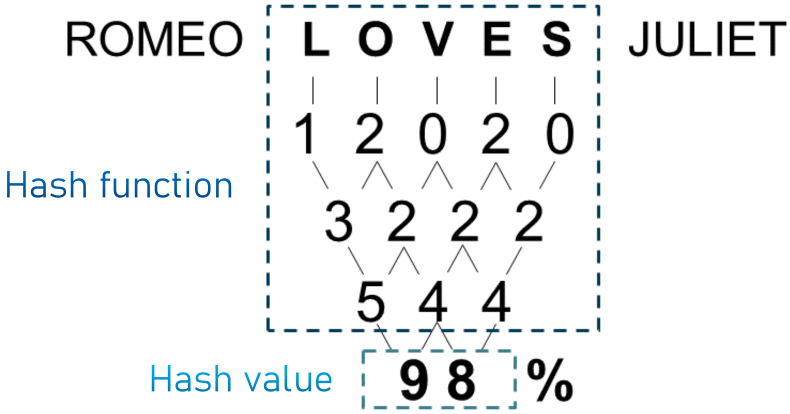

Figure 2. An example of a simple hash function where first names are mapped onto a two-digit hash value on the basis of how many specific letters are present in the input values combined. (Mattila et al. 2019).

The noteworthy fact about hash functions is that it is one-directional. In other words, the input used to calculate an output cannot be inferred from the output value itself. Therefore, finding inputs which produce a specific desired output is laborious, whereas checking the output for any input values is quick and easy. This property gives rise to one of the key characteristic features in blockchain systems—data is difficult to falsify, while verifying the authenticity of the contents is easy.

1.2. Peer-to-peer networking

The append-only data structure cryptographically chained with hash values would be of little point if simply stored in one device. This is due to the fact that in order to detect any alterations to the modification history of the data base, the hash values need to be compared to another copy of the same database. Therefore, blockchain databases are replicated and distributed across an ahierarchical open access peer-to-peer network of equipotent and equally privileged peers.

By comparing different file versions against the rules laid out in the network protocol, and by actively engaging in managing the database, the network is able to achieve multi-version concurrency control—or *consensus*—regarding the one single state of the shared network database. In other words, all participants can simultaneously make interdependent modifications to the database without losing synchronization regarding the content, and without any party having explicit authority over another. A consensus mechanism is used to determine which version of the modification history is considered authentic by the network. For example, in the proof-of-work mechanism, the chain of blocks with the largest total amount of computational effort is considered valid.

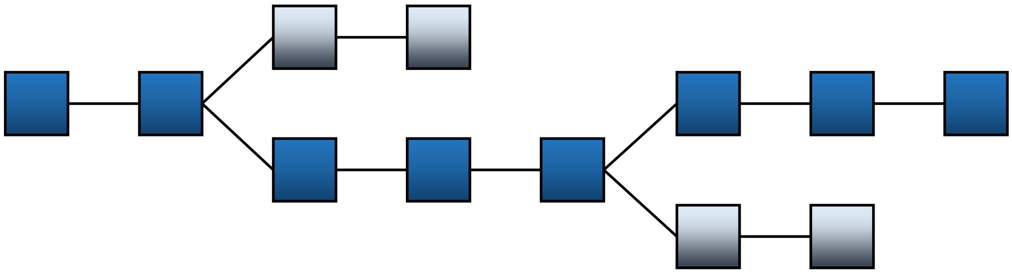

Figure 3. An illustration of the proof-of-work consensus mechanism. The chain constituting the largest amount of computational work is considered the authentic modification history of the network database. (Mattila et al. 2019).

1.3. Tokenized protocol

In blockchain networks which are *permissionless*—that is, ahierarchical, open source, and open access—collaboration needs to be somehow incentivized between the unbeknownst participants in order for the system to hold together. For this purpose, permissionless blockchain systems employ cryptographic tokens of value, more colloquially referred to as *cryptocurrency*. Despite its name, however, cryptocurrency does not resemble conventional currency, insomuch as some kind of an amalgamation of a digital substitute for gold, crowdfunding equity, and commodity money, constituting a new speculative asset class essential to the workings of permissionless blockchain networks.

As a combination of the peer-to-peer network, the blockchain data structure, and the system of cryptographic tokens, blockchain systems employ a positive causal feedback loop in order to foster network effect and instigate growth (see Figure 4). By incorporating database modification rules into the protocol of the underlying peer-to-peer network, blockchain system are able to harness the system database to create cryptographic tokens, and enforce rules on how those tokens are minted, stored and transferred. Since, in a sense, blockchain systems scale linearly for security, additional participants to the network make the system database more secure. The more secure the database, the more reliable—and hence fundamentally valuable—the system of cryptographic tokens[2]. Finally, since the tokens are used to incentivize participation and collaborative behaviour on the protocol level, the more valuable the cryptographic tokens fundamentally become, the stronger the incentives for further participation, potentially leading to further growth of the network, and so on.

[2] It should be noted, however, that in actuality, the market exhange prices of most cryptographic tokens fluctuate heavily due to the significant speculative component in the price levels.

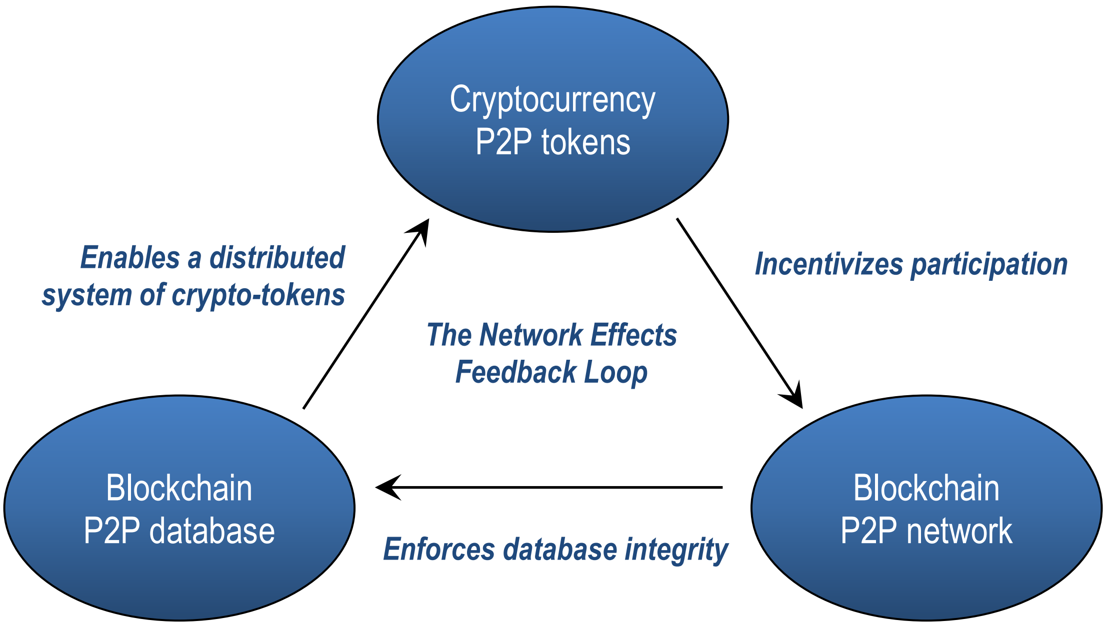

Figure 4. The positive feedback loop of network effects in blockchain systems (Mattila et al. 2019).

From this perspective, blockchain systems can essentially be characterized as tools for fostering network effects and the growth of peer-to-peer ecosystems. The positive feedback loop of network effects creates a new kind of a monetization mechanism for open-source development in peer-to-peer networks. Instead of the top-down model practiced by contemporary digital platform providers, the positive feedback loop allows for peer-to-peer network ecosystems to be designed with a bottom-up design principle. Laying down the blueprint for the incentivization mechanisms of the ecosystem in early stages of development enable the designers to define the value capture parameters much earlier and more specifically than in contemporary platform models (see Figure 5)

Figure 5 This positive causal feedback loop of network effects constitutes a key differentiating factor between permissionless blockchain systems and distributed ledgers, the latter of which will be delineated in greater detail later in this document. As open systems, blockchain networks live and die by their network effects, and for the most part their entire existence has been designed to foster growth as much as possible in all aspects of the ecosystem in question. Distributed ledger systems, however, more appear to resemble the growth logic of contemporary digital platforms, exhibiting a more controlled and hierarchical governance of growth efforts.

The positive feedback loop of network effects can also be understood as a monetization mechanism for open source development in permissionless blockchain ecosystems. By acquiring some of the native cryptographic tokens of a blockchain network and holding them as an investment, anyone can line up their incentives in such a way that anything contributing to the growth of the network effects in the ecosystem will benefit them financially. As the number of the cryptographic tokens which can be minted in such systems is usually limited by the network protocol, in accordance with the quantity theory of money it can be stipulated that the more transactional activity and circulation of tokens there is in the network, the higher the value of the tokens will become, at which point the tokens held back as investment can be sold back into circulation (Mattila and Seppälä 2018).

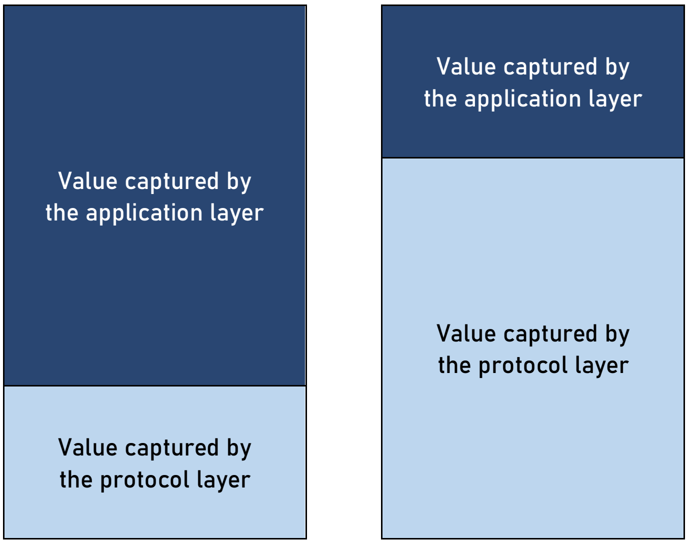

Figure 5. The transformation of value capturing in the digital service stack (Mattila et al. 2019).

1.4. Blockchain technology stack

As mentioned earlier, technically the term ‘blockchain’ refers to the data structure employed in blockchain systems. In the early days of blockchain development, however, only a handful of applications existed. Thus, the term ‘blockchain’ naturally became associated with the entire technology stacks comprising such applications (Mattila 2016).

Relative early on, it became evident that open permissionless solutions were ill-suited to be incorporated into existing business processes and value chain structures. Therefore, the development of alternative solutions was undertaken at every layer of the stack in various different forms. As a result, the nomenclature became fragmented and the spectrum of technology components associated with blockchain technology was expanded many-fold (Hukkinen et al. 2019; Mattila 2016). As one illustration of this development, some systems nowadays employ an alternative data structure known as 'directed acyclic graphs'. In this structure, data blocks are not concatenated in a single linear succession (see Figure 1) but in several interwoven streams for better scalability (see **Error! Reference source not found.**).

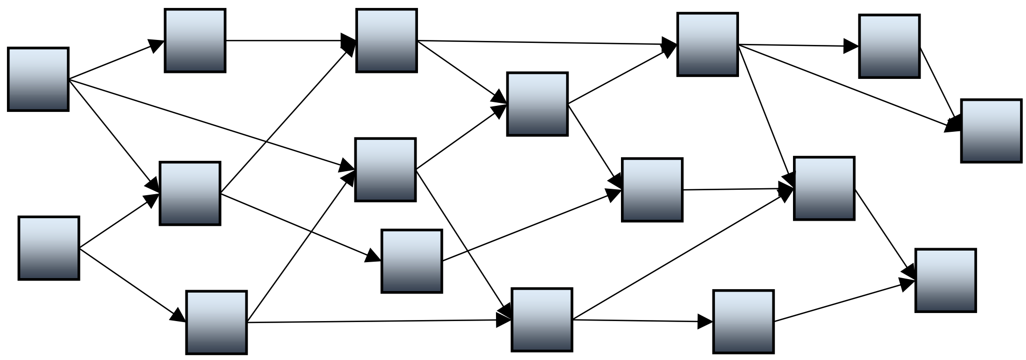

Figure 6. An illustration of a directed acyclic graph data structure.

Recently, the industry has also seen the emergence of so-called layer 2 solutions (e.g. Lightning Network, Rootstock, Raiden Network), implemented in the pursuit of better system scalability and other additional benefits. By selecting mutually supporting properties for each individual layer, the enhanced features can be implemented without the sacrifices of a single-layered solution. While some of the proposed solutions maintain a full permissionless design in all layers, others also introduce permissioned qualities to the system design in the process.

1.5. Distributed ledger technology

As a concept, the term *distributed ledger* was introduced into the discussion a few years after the emergence of the first blockchain applications. While the terminology still remains ambiguous, 'distributed ledger' can be generally understood as a more loosely defined, wider concept, in comparison to 'blockchain'.

The emergence of the concept of distributed ledgers stemmed from the observation that open permissionless blockchains were poorly suited for implementation as a part of existing value chains and business processes due to their ahierarchical nature and limited throughput capacity. To overcome these issues, the concept of *permissioned blockchains* (also *private blockchains*, *federated blockchains*, *consortium blockchains*, etc.) was developed. However, such systems did not necessarily contain a feedback loop of network effects, protocol-level incentivization mechanisms, or even an actual blockchain data structure or any form of hashing.

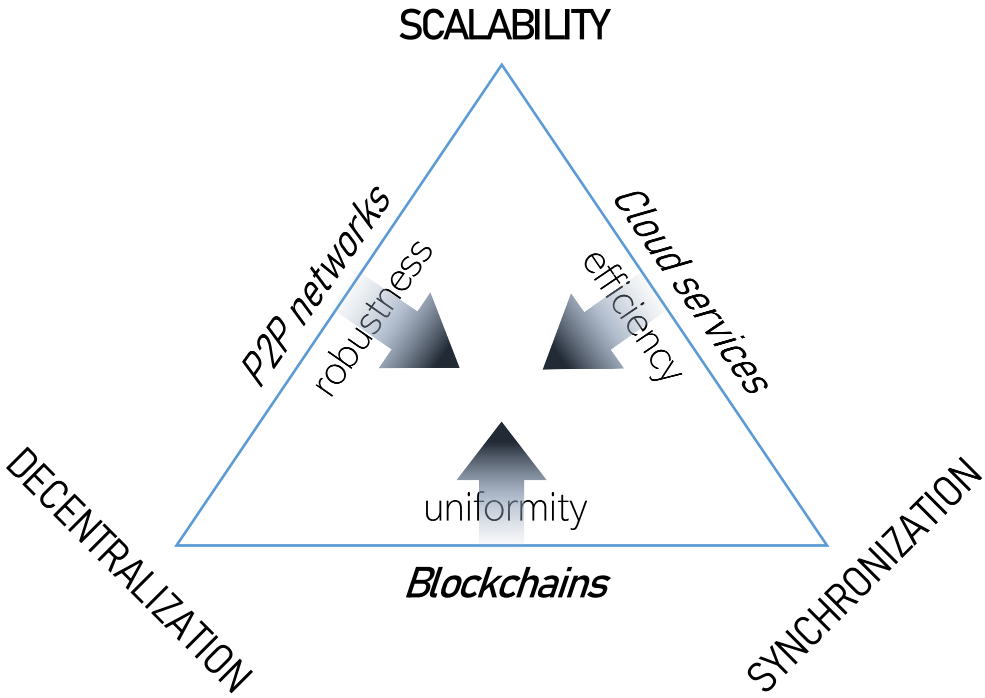

Figure 7. The trilemma of network databases (adopted from McConaghy 2016).

One way to illustrate the relationship between blockchain technology and distributed ledgers is a trilemma pertaining to the obtainability of various properties in network databases (see Figure 7). It stipulates that of the three properties, synchronization, decentralization, and scalability, two a maximum of two properties can ever fully be obtained. In this context, perfect synchronization refers to a situation where the network database always appears to be in the same state, no matter from where in the network it is being observed. Respectively, perfect decentralization refers to a system which has no single points of failure or structures of hierarchy. Perfect scalability, in turn, refers to a configuration where the system scales linearly in terms of through-put capacity of database writes in relation to network growth.

The current state of development in the industry in large is described by the arrows presented in **Error! Reference source not found.** While blockchains have provided a novel solution as a c ombination of decentralization and synchronization to the trilemma, due to the limited scalability associated with public permissionless blockchains, the practical applicability has been limited in existing value chain structures. Therefore, various initiatives have emerged which, by starting from different sides of the trilemma triangle with varying configurations, have set out to find a suitable combination of properties, striking a balance capable of generating tangible benefits and exploitable use cases for value creation. As a concept, distributed ledger, in other words, sits somewhere between blockchain technology and generic integration of data systems as an ordinary part of digitalization, somewhere at the convergence of the trilemma-solving initiatives.

To be clear, several fundamental differences can be pinpointed between the definitions of blockchain systems and distributed ledgers in this paper. For example, as the most obvious difference, DLT systems do not necessarily use a data structure containing blocks, nor are they necessarily cryptographically chained together. Thus, DLT systems do not necessarily contain an algorithmic process of consensus formation through hashing. DLT systems do not also necessarily employ protocol level incentives, facilitated with the native cryptographic token of the network, nor do they necessarily involve such tokens in the first place.

In addition to the ahierarchical peer-to-peer network structure and the protocol-level incentive mechanisms quintessentially characteristic of blockchains, another difference between the holotypic definitions of blockchain and DLT in this paper has to do with open source codebase and the right to fork code—a pivotal mechanism and a fundamental paradigm in open source development. As blockchain systems are built on open source code in an open environment, anyone can take any part of the programming code of the network, and develop it further or modify it as they see fit to launch a new alternative system. Through such a developmental mechanism, the development of the industry is linked together in a much more intertwined manner, as any system features developed and implemented in one platform can often be copied and incorporated in all the various platforms in existence. In most cases, DLT systems appear to be built in a more permissioned manner, often (but not always) implemented using proprietary code, not open to the general public.

1.6. Blockchains and distributed ledgers as a technological narrative

Deep down in its core, digitalization can be understood as comprehensive integrational development between data systems which enables new modes of value generation. However, recent studies have shown that integration beyond individual systems and supply chains has proven challenging (see Figure 7). The reasons for this are many-fold. For example, the strategic benefit of connecting data systems is not always evident to decision-makers. Furthermore, there haven't necessarily been any competitional drivers for change. Rehauling old data systems, built on top of layers of legacy architecture can be expensive and risky. Furthermore, in most industries, no best practices and industry standards have yet been formed for data-sharing through integrated systems on a cross-industrial level (Tähtinen 2018).

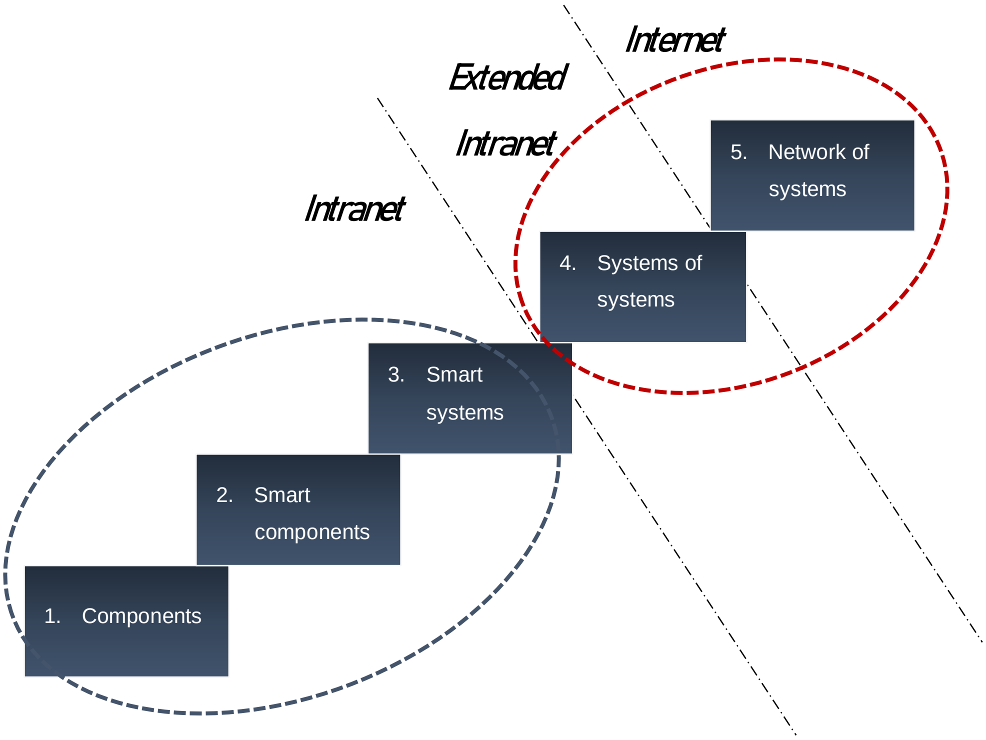

Figure 7. In the levels of smart system Integration, industries have not managed to break out from the level of individual systems and supply chains (blue circle) to integrated systems of systems and beyond (red circle) (Porter and Heppelmann 2014; Seppälä et al. 2015).

As stated earlier, utilizing blockchain systems for added value creation has proven problematic in existing business and value chain structures. In cases where blockchain technology could be utilized, its superiority over other possible technical solutions has at least some of the time been questionable (Hukkinen et al. 2019; Mattila et al. 2019). Due to the ambiguity of the concept of blockchain technology, and the expansion of its terminological use, the mysticism of blockchain technology has become harnessed as a part of the digitalization narrative; By veiling traditional data systems integration and long over-due system overhauls in the cloth of cutting edge frontier technology development, getting different parties at the same table and cooperating to defend themselves against an external disruption to the industry, is easier.

The same kind of narrativization can be observed with the concept of distributed ledgers. While it is relatively easy to delinate the differences between blockchain technology and distributed ledger technology, it can in fact be more perplexing to try to differentiate between distributed ledgers and ordinary IT system integration pertaining to digitalization in an ordinary sense.

Especially in enterprise contexts, the DLT narrative as in many cases boiled down to the idea of 'decentralized' integration platforms. One of the hindrances in building higher level system integration is that companies are reluctant to submit into operating on information systems which they do not unilaterally control (Tähtinen 2018). By leveraging the decentralized peer-to-peer structure essential to blockchain systems, and by creating the impression that DLT systems are in a similar fashion decentralized, the platform providers are able to create a mental mindset that the governance of such integration platforms would also be decentralized (Walch et al. 2019).

In the light of this perspective, one thought-exercise worthy of consideration here is this: If permissionless blockchains had never been invented, and only DLTs had ever emerged in their current form, would there still have been a technology hype, or would DLT simply be perceived as one ordinary programmatic tool for data system integration? While this is not necessarily the case, a compelling argument can, nonetheless, be made that the overflow of the grassroots blockchain hype to enterprise IT development has, in many industries, acted as a catalyst for the integration development of digitalization taking place ever since the 90s.

2. Blockchain and DLT in product data management

2.1. The role of product data in supply chain management

DLT and blockchain solutions offer interesting avenues of research and development for product data tracking in international supply chains. The latter contribute to improving performance and efficiency in a variety of economic sectors but have become extremely long and complex. As supplier networks are becoming more complex and the products are becoming increasingly customized, tracking goods is becoming increasingly difficult (Rajala et al. 2018).

Blockchain and DLT systems offer a chance to overcome these problems through radically improved supply chain traceability and supply chain integration. These technologies may make it possible to share the information regarding each individual product in its complete form between all parties involved, throughout the life cycle of the product. With access to the shared product database, the operational focus is shifted from process-level optimization to reconfiguring and optimizing the service provision for individual product items, with significant improvements to streamlining and customizability (Rajala et al. 2018).

Besides the obvious cost-efficiencies and added versatility, from an industrial ecology perspective, product data systems can also boost the sustainability of industrial ecosystems. By enabling the creation of more intelligent goods, wide-spread product data platforms can enable the creation of more circular closed-loop ecosystems that are more environmentally friendly (Rajala et al. 2018).

2.2. Product data management today

In today's complex supply network structures, product traceability is an essential capability. Furthermore, as products and their life cycles are becoming increasingly specialized, individual product data is becoming increasingly valuable. Understanding product behavior at the level of individual product items can yields many benefits, much in the same way as digital platforms in the consumer market have greatly benefited from pinpointed visibility into the behavior of individual users (Anke and Främling 2005; Auramo and Ala-risku 2005; Corallo et al. 2013; Fox 1994; Främling and Ala-Risku 2007; Juran and Godfrey 1998; Mattila, Seppälä, and Holmström 2016; Mont 2002; Prosser and Buchanan 1994; Töyrylä 1999).

However, storing the data relating to individual products over their entire life span has so far proven problematic: as products are moved from one owner to another throughout the product's life cycle, the product data becomes decoupled and fragmented in the various information systems of the involved parties. Needless to say, this decoupling can have a multitude of negative effects on operational efficiency, e.g. delivery disruptions, increased waste, and unnecessary processing of overlapping data (Främling et al. 2007; Helaakoski et al. 2006; Kärkkäinen, Holmström, et al. 2003; Kärkkäinen and Holmström 2002; Rönkkö, Kärkkäinen, and Holmström 2007; Tajima 2007; Vermeer 2001). Moreover, due to the information asymmetries between the unintegrated systems and their respective owners, there is a significant risk that parties end up destroying data useful to one another because its value is not recognized (see Figure 8).

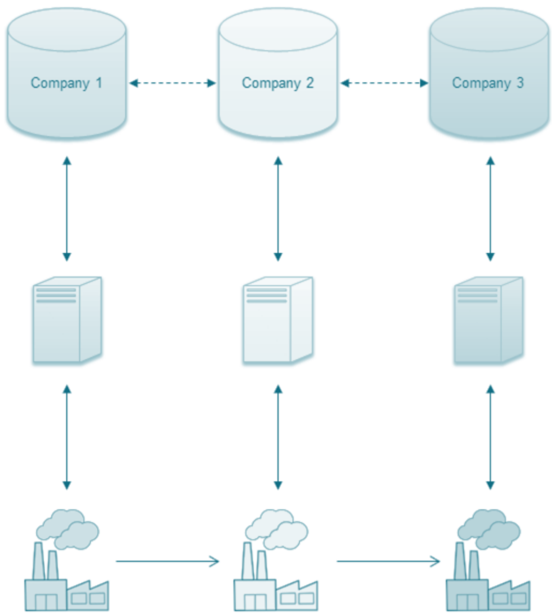

Figure 8. An illustration of a supply chain with no shared product data platform (Mattila et al. 2016).

While system integration is obviously the key solution in addressing these problems, conventional means of establishing such integration have been considered insufficient due to the complexity and speed of modern supply networks. Simply pushing vast amounts of product data forward at each step of the supply chain will lead to information overflow and not accomplish the set goals in this respect (Ameri and Dutta 2005; Corallo et al. 2013; Feng et al. 2007; Främling and Ala-Risku 2007; Kärkkäinen, Ala-Risku, and Främling 2003; Subrahmanian et al. 2005; Tursi et al. 2009; Weber, Werner, and Deubel 2003).

The establishment of intra-supply-chain data-sharing platforms has also been suggested in research literature (Kärkkäinen, Ala-Risku, et al. 2003; Meyer, Främling, and Holmström 2009; Tang and Qian 2008). The idea in this approach is that the information regarding a product individual is shared throughout the supply chain in its complete form with all participating parties through a data platform governed by a party or a consortium of parties in the supply chain (see Figure 9).

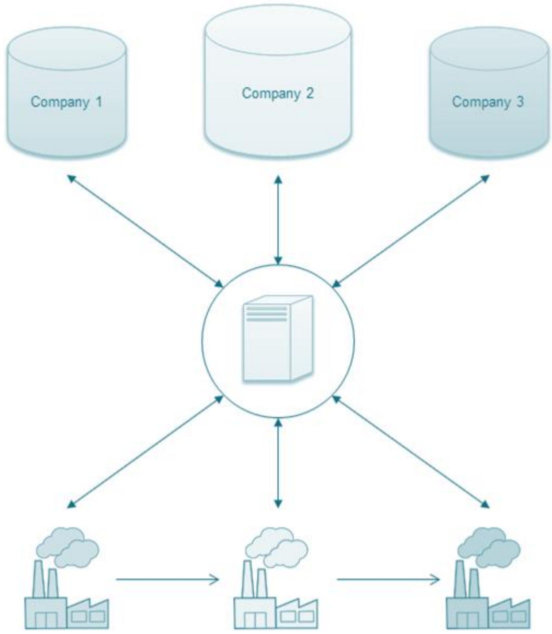

Figure 9. A data platform governed by a party or a consortium of parties in the supply chain (Mattila et al. 2016).

Several case studies have shown that by shifting the operational focus from process level optimization to the reconfiguration of provided services from the standpoint of individual products, significant improvements can be achieved. As the operational focus is shifted from process-level optimization to reconfiguring and optimizing the service provision for individual product items, significant improvements have been observed in case studies. To name a few examples, in one case applying the platform approach to a logistics operation resulted in increased product traceability, improved service customization, and enhanced real-time control over dynamic rerouting decisions (Rönkkö et al. 2007). Another study found that introducing the approach into project management in the telecom industry eliminated false assumptions in the supply chain and helped to realign performance metrics better to reflect customer demand fulfilment (Ala-Risku et al. 2010). The approach has also been found suitable for expediting inter-organizational governance in the construction industry (Xue et al. 2005) and in transport logistics (Davidsson et al. 2005).

The centrally governed data platform approach can also enhance recycling performance by providing a complete history of use, proper recycling protocols, and information on valuable components and materials for each specific product individual (Hribernik et al. 2006). An agent-based control system implemented in the automotive industry through the discussed approach increased the robustness and the scalability of production (Bussmann and Sieverding 2001). One recent study discovered that applying the centrally governed product data platform to the digital manufacturing of hose assemblies lead to a reduction of waste, simplified planning, and improved customer responsiveness (Lyly-Yrjänäinen et al. 2016). Furthermore, multiple other cases of beneficial application with various efficiency gains have been presented, e.g. reduced downtime, reduced excessive maintenance, and increased detection of system anomalies (Främling et al. 2013).

Despite the perceived benefits, implementing large-scale systems on a cross-industrial level reaching beyond individual supply networks has proven problematic, due to issues such as initial costs and scalability (Leitão 2009; Trentesaux 2009). Moreover, it has proven difficult to get parties to perform in a manner necessary for the system to function. Some of the reasons for this are strategic. For example, companies do not always see the relevance of such data-sharing for their own business. Also, unlike consumers perhaps, companies are not usually readily willing to submit into operating on data platforms which they themselves do not control. As the pressure for change is yet to hit some of the industries in full force, motivationally the general sentiment has been less than eager to implement such systems (Tähtinen, 2018).

Some of the reasons are also related to the social conventions around data portability—or rather the lack thereof. For example, it is not common for companies to categorize their data on the basis of its shareability, and the judicial and legal practices around data ownership and data sharing are still very much under development (Tähtinen, 2018).

2.3. Product data management with blockchain and DLT

As a solution to the issues of the conventional contemporary approaches, the use of peer-to-peer network architecture has been proposed (Främling, Kubler, and Buda 2014; Kärkkäinen, Holmström, et al. 2003; Kubler, Främling, and Derigent 2015). However, the application of peer-to-peer networks as a solution to the problems explained in the previous chapter introduce a whole variety of new challenges, *e.g.* establishing trust, organizing governance, maintaining version control throughout the system (Mattila and Seppälä 2018; Petkovic and Jonker 2007; Trentesaux 2009). Prior attempts in overcoming the problems of implementing a product data platform as a distributed solution have mainly focused on interoperability and openness (Kubler et al. 2017; Raggert 2015). In recent years, however, the problem of platform control and platform ownership has more and more become recontextualized as a problem of viable system-of-systems-level deployment, especially in the research domain of cyber-physical systems (Alam and El Saddik 2017; Porter and Heppelmann 2014).

Blockchain systems contain many features potentially beneficial in establishing a product data platform as a distributed solution. Firstly, they enable the creation of financial incentive structures by embedding them directly into the base protocol of the P2P network. This fosters network effects and can help in attracting a critical mass of users, developers, and other important platform participants, and in the process also ensuring effective network deployment and the permeation of the network protocol itself.

Secondly, on the level of participant interaction data access needs to be somehow delegated between the peers of the network, without exposing the content to unauthorized parties (Ardagna et al. 2007). Also, one of the key problems in creating a fully distributed product data system is that it is difficult to obtain guarantees of near-optimal or satisfactory system performance in distributed networks. When decisions are made on a distributed basis and information is scattered, evaluating the global state of the system, and thus predicting system behaviour, is difficult (Trentesaux 2009).

In blockchain systems, persistent computer programs known as *smart contracts* can be stored and executed in a decentralized manner. Residing in the blockchain network, these smart contracts enable the utilization of more versatile distributed workflows, involving transfers of crypto-token assets. A smart contract can be written to automatically grant access to product data in exchange for a payment of crypto-tokens. Conversely, the workflow can be coded to automatically reward participants for making product data available. In other terms, instead of just providing standard APIs, blockchain smart contracts can be used to add financial incentives and market structures into the mix, giving rise to application *contracting* interfaces.

From a governance perspective, this is an example of a use case where the governance of open interaction economic collaboration can be delegated to algorithmics through game-theoretical system design. By designing and deploying workflow structures where spontaneous machine-to-machine payments can be facilitated between any two transacting parties—whether the transaction be pre-planned or not—system-of-systems level integration becomes more obtainable, since collaborative participation can be incentivized by the network in any role, such as data sharing or the facilitation of platform provision functions.

Another issue regarding product-centric information management is that even if all the parties involved are fully motivated to co-operate to their best ability, product data can easily become fragmented due to the difficulties relating to multi-version concurrency control. The benefit from decentralization in such a case would be that the preserving of product data and the service of the marketplace would not be reliant on any single operator. Therefore, product data could be preserved and accessed even if the entire supply chain of a formerly manufactured product seizes to exist (see Figure 10).

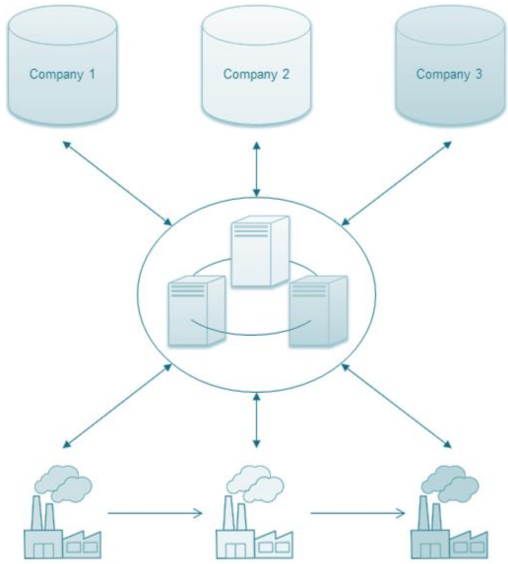

Figure 10. A product data platform with decentralized control (Mattila et al. 2016).

3. Opportunities and risks for major stakeholders

3.1. Technology and the transformation of social paradigms

In the study of how a certain technology may impact human society in the future, the technological composition of digital platforms is naturally not very interesting in itself. Rather, the interesting point of observation is how technology changes the social constructs of human society. However, from a regulatory standpoint of global governance, neither technology nor the change of social paradigms provides meaningful insights. Rather, it is the interplay between the shift in social paradigms and their underlying technology which determines whether the contemporary governance systems are applicable, or no longer sufficient.

From the perspective of technology and social paradigms, contemporary digital platforms have instigated a paradigm shift in various social constructs in the digital era. For example, they have facilitated instant access to global product and service markets, for individual consumers as well as businesses irrespective of size or location. (Teece 1986; Gawer 2009; Boudreau 2010) In doing so, they introduced a new business model where the development of business and contracting rules and the supplying of the platform infrastructure became more decoupled from application development than before. Through services such as AliBaba's website, Apple's AppStore or Google Play, vendors could allocate all their resources into designing targeted niche products and services for global audiences from the very beginning, without having to front the infrastructure costs of building global access to their potential customer base.

Along this tangent, over the past decade, blockchain technology has enabled global access to distributed and replicated tamper-resistant single-state records. Consequently, it has provided a completely new approach to deploying digital platforms, with its unique set of protocol rules and boundary resources. The first widely known application of blockchain technology, namely the Bitcoin cryptocurrency network, was established in 2008. While in many respects Bitcoin still represents an important element in blockchain development, the possibilities of the technology have since been vastly extended, and nowadays the potential of these distributed single-state machines is considered to reach far beyond the kinds of payment processing networks which Bitcoin represents.

Especially from a governance standpoint, the key point is that blockchain technology has enabled a new kind of a computational paradigm for rethinking how to organize human collaboration. As a technology platform, it has enabled novel ways of creating, managing and maintaining alternate systems for social constructs such as of voting rights, property rights, and legal agreements of various kinds. (Reijers, Brolcháin, and Haynes 2016) In a sense, blockchain technology has also enabled instant access to global capital and investment markets. Through distributed ledgers, non-duplicable tokens can now be created, owned and transferred by anyone. The technology seems to have lead to the emergence of new kinds of asset classes, some of them, for example, resembling some sort of an amalgamation of crowd funding investments, venture capital, and commodity money (Mattila, Seppälä, and Lähteenmäki 2018).

Despite the technological possibilities, the governance of these alternative platforms is complicated by the fact that the social paradigms of human interaction taking place on top of blockchain-platforms have not yet fully manifested—if they ever even are to see the light of day. However, the mere existence of an alternative technology environment in itself may be sufficient to drive innovations regarding governance in the more conventional realm of technological execution environments.

Case: P2P filesharing — a catalyst for a new social paradigm?

In essence, one might argue that the implications to global governance from blockchain technology could be viewed as somewhat similar as the implications of peer-to-peer filesharing to the media industry in the early 2000's. Back then, the development of the Internet and the World Wide Web meant that a technology platform had emerged which enabled new social constructs for sharing and consuming media content. However, the lack of legal high-quality streaming services drove people in masses to exploit the utility made available by this new technology platform through alternative social paradigms. In 2008 it was estimated that illegal filesharing constituted 95 % of all distribution of music online globally (IFPI 2009) .

In a similar fashion, if the global governance efforts of nations are inadequate to empower people to fully engage in the global social constructs enabled by blockchain technology and state-of-the-art technology platforms, people may be inclined to build those social constructs outside of the realm of national barriers and existing paradigms, just as they did with peer-to-peer filesharing platforms.

Eventually, the pressure from the disruption by alternative technology environments lead to the development of legal high-quality streaming services, *e.g.* Netflix, and the situation in terms of regulation and governance was eventually largely normalized. With blockchain technology, the hope is, of course, that in the same way as peer-to-peer filesharing acted as a catalyst for the development of the legal streaming services we have today, the availability of alternate means for the production of various constituents of a new social contract will drive the development of better global governance practices and a more seamlessly governed dimension of supranational social paradigms.

3.2. Redefining cohesion in the digital era

Digital platforms have provided people with vastly improved access to markets and other hubs of human interaction. As a result, individuals have become more empowered in terms of defining the social constructs by which they are willing to operate, rather than simply being constrained by the prevalent paradigm of society, whatever it happens to be.

However, so far this new empowerment has been constrained by at least one critical “choke point” or a gateway of control in the technological underpinnings of the system. For example, in contemporary digital multi-sided platform arrangements, the most common and prominent enabler of control appears to have been the payment processing service layer and access to capital in large. By enabling the circumvention of this choke point through a decentralized and replicated system of cryptographic tokens of value, blockchain systems has vastly extended the realm of possibilities for individuals to resign from social constructs, perhaps even entire social contracts which they do not agree with.

Thus, one could argue that blockchain systems reduce the relative cohesion of global governance entities, such as the European Union, in the traditional sense. On the other hand, by enabling more liberty in the choosing of the social constructs and contracts in which one wants to voluntarily participate, blockchain systems may manifest new non-state entities of strong cohesion and actorness. For example, some initiatives have been founded which aim to establish the first globally decentralized virtual nations, albeit their success so far seems to have been minimal (*e.g.* see Section 4.5.2).

It is obvious that in a scenario where virtual nations were a reality, the actorness of traditional nation states, for example, would be challenged in an unprecedented way. However, the interesting question in this regard is what constitutes cohesion for global influence in such an environment in the first place, and whether actorness, in a sense, would need to be approached entirely from another point of view. For example, how to exert global governance through something which cannot be migrated into the digital realm, *e.g.* the physical environment.

3.3. Improved digital perception and the reconfiguration of influence

Economists have pointed out that quantifying the digital economy is problematic for a variety of reasons (Kotiranta et al. 2017). Furthermore, research suggests that the total consumer welfare generated by digital services is not accurately reflected by the GDP in its current form (Brynjolfsson, Collis, and Eggers 2019). Firstly, defining ‘digital’ in itself can be elusive, but the definitions of ‘goods’ and ‘services’ have also become more difficult to delineate in the digital era. In the world of freemium business models and closed-loop circular economy, money does not always exchange hands. Moreover, even when it does, the current structure of payment processing services in the financial industry does not always enable transparency into how the flows of capital are linked to digital goods and services (Mattila et al. 2018).

The fact that the benefits of the digital economy are easily undervalued and overlooked in the traditional economical metrics can without a doubt lead to uninformed decision-making and weakened actorness for global governance entities. From the perspective of the European Digital

Single Market initiative, for example, transparent and realistic quantification of the digital economy and its benefits is a necessity for a successful effort of influence by the European Union. For decades, academia has discussed the importance of establishing *product holons* or so-called *digital twins* for better supply chain visibility. However, so far these efforts have had little success with mainstream adoption due to problems related to coordination and incentivization of participants (Tähtinen 2018; Trentesaux 2009).

The elusive nature of digital utility can also be viewed from the perspective of transformation of work in the digital era. In the early 1900s, as agricultural jobs became automated, vast proportions of the workforce migrated to the industrial sector. Midway through the century, as automation started eradicating industrial jobs, the workforce stated migrating into the service sector. In the past couple of decades, attention has been increasingly drawn to the fact that the service sector is becoming automated. Moreover, if anything, this service automation can only be expected to pick up its pace, as digitalization and the applications of artificial intelligence become more widespread and commonplace. (Rifkin 1995)

In many ways, the key question in this regard is what will happen to the workers whose jobs are being eradicated by automation in the service sector. In other words, what is the future of labour and how will work be defined in the digital era? (Rifkin 1995; Scholz 2012) For example, it is not uncommon for individuals to essentially act as content producers for each other on social media. Respectively, users of social media frequently consume and enjoy media content produced by their peers. At the moment, however, these efforts are not fully reflected in the traditional contemporary metrics of the economy.

It has been suggested that some applications of blockchain technology could help to establish metrics for this hidden digital work and to quantify it. Thus, blockchain technology exhibits properties which may help reinforce the conscious effort of influence of global governance entities in this regard. For example, 2nd layer solutions may yet enable new micro- and nano-payment-based business models for digital goods and services, bringing these new modes of work into the realm of quantified economic activity. As such, blockchain systems might provide greater insight into the hidden consumer welfare as well as new manifestations of work in the digital era (Mattila 2016).

Case: ChangeTip

ChangeTip was a cryptocurrency-based micropayments platform which allowed attaching real monetary value to online social interaction. The idea was that instead of simply pressing a like-button to express appreciation towards a blog post, for example, ChangeTip allowed people to send tiny tips on any social media service, just as easily as pressing a like-button. By significantly lowering the threshold of rewarding content and small services, such as providing a quick answer to someone's question on the social media, ChangeTip's vision was that small tips of individual cents could become as common and casual as "likes". In such a scenario, the tips received from active social media participation could amount to a free beverage at the end of the day, for example, or even a notable part of the daily income for a popular social media personality.

While ChangeTip shut down in 2016 after being acquired by AirBnB, the fundamental idea behind the service could have wider implications on how we perceive and valuate the digital economy. Currently, there is a lot of work and content creation happening online which doesn't show up in any financial metrics of the economy at all. Largely, this is due to the decoupled nature of digital goods/services from their respective cash flows, but one factor in the problem has been that there is no objective measure for the value of gratuitous social media interaction. Blockchain-based micro- and nanopayments could, in theory, provide a market-driven solution to such valuation problems, thus providing improved metrics and a more detailed picture of the new forms of economic activity in the 21st century.

(Mattila 2016, Carson 2016)

4. The current landscape

4.1. Public research and development initiatives in the European Union

The European Union has assumed a holistic approach to distributed ledger technologies. In addition to specific initiatives and partnerships, in its approach the European Union also looks at distributed ledgers in the context of a digital single market and examines whether aspects such as the legal framework is sufficient to facilitate technology innovations such as smart contracts in full capacity. Likewise, the importance of ensuring interoperability between various systems has been emphasized. The aim in this regard is to ensure that the European Union will be at the forefront of blockchain innovation.[3] Some of the initiatives taking place in Europe are listed in this section.

4.1.1. EU Blockchain Observatory and Forum

On the 1st of February 2018, the European Commission established an initiative known as the European Union Blockchain Observatory and Forum. As the name suggests, the purpose of this initiative is to increase European perception and reactiveness regarding developments in the field of blockchain technology and distributed ledgers. By establishing a knowledge hub, European stakeholders could map and track key initiatives and developmental trends, address emerging issues—such as privacy, sustainability, and interoperability—and inspire actors to engage in use case development.

The European Union Blockchain Observatory and Forum aims to map existing initiatives in Europe and beyond, to monitor developments in the field of blockchain technology, to analyse trends, and to address emerging issues. Furthermore, the initiative aims to promote European actors and to reinforce European engagement regarding the technology. For global governance and Europe's actorness, the forum functions as a communication opportunity where Europe can set out its vision and global ambition. Through these discussions, the aim is also to inspire common actions on specific use cases deemed useful and interesting from Europe's point of view.

The EU Blockchain Observatory and Forum has also established working groups to identify and to research the efforts currently undertaken in regards to blockchain technology in the European Union as well as elsewhere in the world. Currently, there are two working groups in action: the Blockchain Policy and Framework Conditions Working Group which focuses on looking at the cross-technological and cross-industrial issues to define conditions for policy, and the Use Cases

[3] < https://ec.europa.eu/digital-single-market/en/blockchain-technologies>

and Transition Scenarios Working Group which focuses on exploring the most promising use cases with transformative potential for the public sector.[4]

4.1.2. EIT Digital

EIT Digital is European digital innovation and entrepreneurial education organisation which focuses on driving digital transformation in Europe. It facilitates open innovation collaboration between over 200 European companies, universities and research institutes. EIT Digital also makes strategic investments to accelerate the market uptake of research-based digital technologies in fields such as digital cities, digital industry, digital well-being and digital finance. The organization also support education and research on blockchain technology as a part of its digital finance agenda, for example in the form of face-to-face and online master's and doctoral courses, and by developing PhD theses on blockchain-related theme, as well as announcing calls and tenders related to digital finance.[5]

4.1.3. European Digital Currency & Blockchain Technology Forum

The European Digital Currency & Blockchain Technology Forum is an independent public policy platform for virtual currencies and distributed ledger technology based in Brussels. Its objective is to assist in shaping a sound regulatory agenda for policy makers in the European Union regarding virtual currencies, distributed ledgers, and blockchain technology. In addition to offering consultation and advice as well as providing briefing papers, the forum also organizes events, such as, roundtables, seminars and workshops at its hometown all year around.[6]

In addition to European supranational research initiatives, several countries in Europe have also seen the establishment of national forums and advisory groups for blockchain and distributed ledger technologies. Amongst others, these include the Nordic Blockchain Association, the British Blockchain Association, the German Blockchain Bundesverband, the Dutch Blockchain Coalition, the Blockchain Association of Ireland, and the European Blockchain Center based in Denmark.

4.1.4. European Blockchain Partnership

In April 2018, the European Union member states, Norway, and Lichtenstein signed a declaration stating that they will form a European Blockchain Partnership (EBP) and work together to realize the potential of blockchain-based services in Europe. As a part of this collaboration, the members have committed to establishing a European Blockchain Services Infrastructure (EBSI). The idea of this infrastructure is to enable the provision of EU-wide cross-border public services by making

[4] <https://www.eublockchainforum.eu/>
[5] <https://www.eitdigital.eu/>
[6] <http://edcab.eu/>

use of blockchain technology. In 2020, the partnership will deploy a network of blockchain nodes across Europe in order to support the development of applications around selected use cases.[7]

In late 2019, the European Commission also engaged in open market consultation in order to prepare for the European Blockchain Pre-Commercial Procurement. The idea is to find and to identify improved blockchain solutions which could be integrated as a part of the European Blockchain Services Infrastructure at a later point.[8]

4.1.5. International Association for Trusted Blockchain Applications

In order to unlock the disruptive potential and the benefits of blockchain technology for the European society, the aim of INATBA is to develop a framework for promoting public-private-partnerships, regulatory compliance, legal clarity, as well as system integrity and transparency.[9]

In detail, INATBA has defined several main objectives for itself. Firstly, the association will aim to promote open, transparent, and inclusive models of governance for blockchain systems. Secondly, INATBA will support the development of interoperability guidelines and global standards for trusted user-centric services. Lastly, the association will develop sector-specific guidelines and specifications which will support the development and acceleration of services in specific sectors.[10]

Several leading international organizations have given their support to INATBA. For example, the European Commission, the World Bank, the OECD, the UN World Food Program, UNFCCC, UNICEF, the European Investment Bank, the European Bank for Reconstruction and Development, and the OECD have joined the advisory board of INATBA.[11]

4.2. Public research and development initiatives in the United States

In the United States, the public sector has taken an interest in blockchain technology, most visibly in the regulatory front at state level. Several states have taken steps to enact legislation which touches upon blockchain technology. At the federal level, several organizations have also paid attention to blockchain technology by establishing research and development initiatives, quintessentially in the form of public-private partnerships. Some of the most relevant ones to our viewpoint are listed below in this section.

[7] <https://ec.europa.eu/digital-single-market/en/news/european-countries-join-blockchain-partnership>
[8] Ibid.
[9] https://ec.europa.eu/digital-single-market/en/news/launch-international-association-trusted-blockchain-applications-inatba
[10] https://inatba.org/news/inatba-launch/
[11] Ibid.

4.2.1. The U.S. Federal Blockchain Program

The U.S. General Services Administration's Emerging Citizen Technology Office has launched a Federal Blockchain program to assist federal agencies and companies interested in blockchain technology and to explore its possibilities and to support implementation. The program collects blockchain use cases for evaluation in areas such as finance, supply chain management and foreign aid delivery, smart contracts, patents, certificates, government-issued credentials, and so on.[12]

The General Service Administration has also piloted the use of blockchain technology with the objective of automating and expediting the reviewing process of contracts in the FASt Lane procurement system dedicated to IT projects, potentially reducing the waiting time from months down to a few days. Other blockchain-based efforts listed under the Federal Blockchain Program that are especially interesting from our supply chain management perspective include proofs of concept regarding data management in crisis situations by the Center of Disease Control, as well as a point-of-use digital supply chain development by the Department of Defense making use of blockchain technology and additive manufacturing.[13] Furthermore, pursuing a slightly different interest, the National Aeronautics and Space Administration (NASA) has also issued funding towards establishing a new resilient network and computing paradigm for space communication environments by making use of blockchain-based methods.[14]

4.2.2. Department of Treasury's pilot program

The Department of Treasury's Bureau of Fiscal Service has established a pilot program in order to determine whether blockchain technology could be utilized to enhance supply chain management in governmental processes. The project will test whether an agency's physical assets can be tracked in real time as the assets are transferred from person to person during the pilot. During the pilot, the department also aims to identify other potential applications of distributed ledger technology which could be utilized to improve the financial management of the government.[15]

The department has also launched initiatives with the aim to improve anti-money laundering and combating the financing of terrorism (AML/CFT) legislation regarding blockchain-based cryptocurrencies. Furthermore, public-private partnerships have been formed between the Department of Treasury and financial institutions to share information regarding how the

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[12] <https://www.gsa.gov/technology/government-it-initiatives/emerging-citizen-technology/blockchain>
[13] <https://emerging.digital.gov/blockchain-programs/>
[14] < https://www.nasa.gov/directorates/spacetech/strg/ecf17/RNCP/>
[15] <https://fiscal.treasury.gov/fit/blog/innovative-pilot-projects.html>

technology could be utilized to more effectively combat money-laundering and the financing of terrorism.[16]

4.2.3. The U.S. State Department's partnership

The United States State Department has initiated a public-private partnership with Coca-Cola with the aim of utilizing blockchain technology to combat forced labour and child labour in their supply chains. Currently, the lack of transparency in the practices of hiring employees, combined with the inability to monitor contracts and labor agreements accordingly means that workers often have no *de facto* power to terminate their agreements. Moreover, workers face the threat of losing their land in disputes due to the lack of notarized documentation required in bureaucratic processes (Liebkind 2019).

The group working on the project is plans to employ a blockchain-based system to deliver greater transparency and record-keeping regarding laborers and their contracts. By utilizing blockchain-based smart contracts, the joint working group is working to establish a secure registry for labour agreements and employee verification. While a secure database of this kind does not in itself guarantee compliance, the hope is that better provenance and more transparent supply chain transparency will make compliance more likely. (Liebkind 2019)

4.3. Public research and development initiatives in China

In recent years, China has endorsed blockchain technology at the top leadership level. For example, the head of state Xi Jinping has referred to blockchain technology as a "breakthrough technology" and a top priority in lifting China to the global centre of innovation and scientific research. In 2016, blockchain technology was specified as one of the strategic key technologies in building China's technological competitive advantage in the 13th five year plan. In response, the governments of local administrative regions have invested $3.5 billion USD to establish their own regional initiatives, with varying focuses and objectives. Some of these local initiatives most relevant to our research interest are next discussed in this section.

4.3.1. Shanghai Blockchain Industry Development Research Alliance

Shanghai Blockchain Industry Development Research Alliance was established for the purposes of progressing blockchain research, technological development, education, and the coordination of collaborative efforts between the government and blockchain organizations. The alliance functions as an incubator for businesses interested in engaging in blockchain development. Furthermore, the alliance aims to provide a platform for cooperation between companies, public

[16] <https://home.treasury.gov/news/press-releases/sm0251>

institutions, and research organization with blockchain-related interests (Global Blockchain Business Council n.d.).

In the wake of the collaboration, several other initiatives have come to exist in the region of Shanghai. For example, Chinaledger Alliance led by Wanxiang Blockchain Labs is working to create an open source blockchain protocol on top of which developers could build their own applications related to the development of Internet of Everything. As another example, the China Blockchain Technology and Development Forum is working with the National Electronics Standardization Committee of China to establish national standards regarding blockchain technology and distributed ledgers in order to enhance the development of innovations around these technologies in China.[17]

4.3.2. China Blockchain Technology and Development Forum

In October 2016, the China Blockchain Technology and Industry Development Forum (hereinafter referred to as the Forum) was established in 2017 under the guidance of the Ministry of Industry and Information Technology Information and Software Services Division and the National Standardization Administration Committee Industry Standards Division II. In May of the year, the first China Blockchain Development Competition was successfully held. In June 2018, the second China Blockchain Development Competition also ended successfully. In order to further cultivate blockchain application solutions and promote the development of China's blockchain technology and industrial ecological environment, the Forum and related units held the third China Blockchain Development Competition with the theme of “Standard Leading, Application Innovation”

4.3.3. Guangdong, Hong Kong and Macao Dawan District Blockchain Alliance

Initiated by the Guangzhou City Blockchain Industry Association, the Hong Kong Blockchain Industry Association, and the Macau University Innovation Center, the Guangdong, Hong Kong and Macao Dawan District Blockchain Alliance was founded in order to jointly promote blockchain-based development to enhance synergies and innovation between the regions. In addition to actors from the public sector, the alliance also comprises 54 companies and mainly focuses its efforts on the financial industry, although the Innovation Center of the University of Macau has been thought to also explore use cases in the areas of education, health, tourism, and logistics. The intention is to develop four different blockchain platforms in total: a general development platform, a “double creation” platform, technology innovation platform, and an industry service platform. In the Greater Bay Area, the Fintech Association of Hong Kong is also planning on utilizing blockchain technology to improve traceability for the origin of food (Lindsay et al. 2019).

[17] <www.blockchainlabs.org>

4.4. Global standardization efforts

In recent years, multiple various standardization schemes have emerged in the field of blockchains and distributed ledger technology. While some initiatives are more governance-related, others have a more technical orientation. To name a few, organizations such as the International Organization for Standardization (ISO), the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC), the European Standards Organization (ETSI), the United States National Institute of Standards and Technology (NIST), the Institute of Electrical and Electronics Engineers (IEEE), the International Telecommunication Union (ITU), and the World Wide Web Consortium (W3C) have engaged in blockchain and DLT standardization efforts, alongside with various commercial consortiums and industrial organizations such as the Blockchain in Transport Alliance (BiTA) and the Mobility Open Blockchain Initiative (MOBI). Furthermore, many high-level organizations such as the European Commission, OECD, and the UN have established working groups and initiatives to gather information and to draft policy recommendations regarding blockchain technology and distributed ledgers. (Laikari et al. 2018; Lesavre et al. 2020; Mattila et al. 2019)

The motives behind such standardization schemes stem from the fact that despite a decade of development, publicized practical use cases are few and far in between and the terminology in the blockchain technology space remains ambiguous and incoherent at best (Burg et al. 2018; Mattila 2016). Through standardization, the initiatives aim to clarify and unify the use of terminology in the blockchain technology space and ensure compatibility and interoperability between different technology components.

4.5. Private consortiums

4.5.1. TradeLens

The software company IBM and the logistics company Maersk have collaborated to develop a platform called TradeLens in order to enhance governance in cross-border supply chain networks. According to their website[18], TradeLens is an open and neutral digital platform that empowers businesses and authorities along the supply chain with a single, secure source of shipping data, enabling more efficient global trade. The system comprises a three-layered stack where TradeLens provides the network, the platform, and the applications and services.

The platform is designed to receive trade data from industry partners and integrate it to a common, secure business network. This way, TradeLens aims to provide real-time, secure access to end-to-end supply chain information to all the parties involved in a global shipping transaction. The

[18] <www.tradelens.com>

goal is that the supply chain participants could publish events related to a consignment or transport equipment and get notifications when events occur which are significant to their cargo.

TradeLens states that its ecosystem comprises over 100 organizations, including carriers, ports, terminal operators, shipping forwarders, and many others. According to Maersk, the platform is currently processing over 10 million discrete shipping events and thousands of documents each week (Palmer 2019).

4.5.2. Bitnation

Bitnation is a blockchain initiative with the goal of building the world's first decentralized borderless voluntary nation. The system is built on top of a highly resilient, blockchain-agnostic mesh network, with the idea of enabling a free market of voluntary opt-in governance services.

In December 2015, the Estonian government announced its collaboration with Bitnation to offer public notary services to Estonian e-Residents. By signing in with their electronic IDs, Estonian e-Residents from all over the world could officially notarize birth certificates, marriage arrangements, testaments, business contracts, land titles, or any other such documents through Bitnation's service.

According to the initiative's website[19], Bitnation currently has a approximately 15000 "citizens". The development timetable is not entirely clear, but the project seems to have grown and progressed slower than originally anticipated. Nonetheless, Bitnation is an illustration of the types of social constructs which have been envisaged that could be built on top of blockchain architectures.

[19] <tse.bitnation.co>

5. Implications for governance and actorness

5.1. Governance of blockchain technology

Blockchain systems are based on open distributed peer-to-peer networking technology. As such networks do not have single points of failure, or any kind of a system hierarchy, they can cause many kinds of problems for global governance. For example, the Bitcoin cryptocurrency network—*i.e.* the first prominent application of blockchain technology—has posed new challenges for the enforcement of anti-money-laundering and know-your-customer requirements in the financial sector, as well as taxation, to name a few of these problematic aspects.

It seems that many of the problems associated with combining blockchain systems with the requirements of the legal environment have to do with the fact that, so far, many of the prominent systems have not required their users to authenticate their identity in any manner. In many system designs, the user is not required any proof of identity, other than the provision of a valid personal cryptographic encryption key to validate their authority over a given set of tokens. Due to the distributed nature of blockchain systems, traditional simple solutions to identity management are not directly applicable. Conceptual designs and models for distributed identity management are currently development, however (see *e.g.* Koshutanski, Ion, and Telesca 2007; Lesavre et al. 2020).

One potential way how the European Union could attempt to increase its actorness through the governance of blockchain technology would be to support and engage in the development of functional distributed identity management applications which would be applicable in established and emerging blockchain systems. One would have to recognize and accept, however, that by doing so, the European Union might be strengthening its actorness in the realm of blockchain systems—but simultaneously potentially weakening the market power of the current identity management industry. From actorness perspective, the question is: what kind of an identity management landscape can ensure the best possible actorness for the European Union?

Of course, some may argue that the whole attraction of blockchain systems in the first place is specifically this anonymity. Thus, the development distributed identity management applications may not lead to an increase in the actorness of the European Union, if the parties on both sides of a transaction do not wish to implement such services, and coercion in the environment where the transaction takes place is technically not possible. One could pose the question, however, if, at least to some extent, the desire of the users to attempt to hide their identity might be due to the unclear legal framework in regards to operating on blockchain platforms. If this were the case, increasing the regulatory clarity around blockchain systems and their applications and social practices may provide a way to strengthen the actorness of the European Union, if so desired.

Another issue related to blockchain platforms is that by enabling supranational protocols for circumventing both national and international regulatory constraints, blockchain platforms have expanded the unregulated cyberspace where more eccentric investments, contracts, transfers of value, as well as many other kinds of interactions can take place outside the reach of contemporary control mechanisms of global governance (Mattila et al. 2019, 2018; Reijers et al. 2016). While speculative investment booms in the past have lead to many investors losing out on blockchain-related investments, so far, two factors have been in favour of the European Union maintaining strong actorness over the financial market in general.

Firstly, due to the fairly early stages of maturity in which most of the prominent blockchain systems still currently are, there is a natural technological barrier of entry into these precarious markets. While technological literacy does not automatically correlate with financial savviness, the relatively high level of technological know-how required in order to speculate on blockchain platforms and the crypto-tokens involved in their design limits—at least to some extent—the risk that users would be entering into the blockchain token market without acknowledging the high level of the financial risks involved.

Secondly, the relatively high technological barrier of entry has had the effect that, so far, not many blockchain systems in general has managed to reach critical mass for mass adoption by the general public. The low adoption rate of blockchain systems in general means that their impact—while perhaps significant in certain individual cases—remains low for the general public, and for the European Union's actorness in regards to digital platforms.

While the traditional control mechanisms of governance may be largely inefficient against these kinds of manifestations, the new peer-to-peer-based paradigm of open-access platforms can also, however, purport innovations with benefits to the economy and society at large. In this respect, the situation shares many similarities with the development with other manifestations of peer-to-peer network technology. As an example, while the innovation of torrent-based filesharing networks continues to act as an enabler for online media piracy, it has also acted as a catalyst for the development of better legal entertainment streaming services. Furthermore, in more recent years, peer-to-peer filesharing in itself has also produced many legally sound applications with considerable business value.

As a consequence, a new, dual-sided global governance approach is required to foster and control the innovation development in blockchain platforms. On one hand, the emerging new paradigm calls for adaptation and new strategic approaches to governance on a more global level. As a considerable proportion of blockchain initiatives and the organizations behind them have not established themselves in any particular geographical location, more active and wide-spread global collaboration is necessary for the effective control of the transitional choke points between digital and the physical realm.

However, on the other hand, the importance of functional regulation in fostering platform innovations and innovation ecosystems has only been thoroughly understood in recent years (Chander 2015). Thus, the governance efforts of blockchain networks and other similar open source phenomena should be based on the acknowledgement of the fact that regulators within Europe, as well as outside it, are engaged in a competition for platform innovation ecosystems. In this respect, the European regulators may wish to collaborate with one another in order to level the playing field, to increase regulatory clarity, and to reduce barriers of entry into the European innovation market.

In other words, the *ex post* regulatory approach formerly popular with platform innovations and other such new technologies might no longer be sufficient with disruptive peer-to-peer and open-source-based innovations. Regulators should acknowledge that industry innovators may be reluctant to establish business operations within jurisdictions where the regulatory take on the technology with which they are engaging is merely neutral. Instead, innovators may seek to favour regulatory environments that have shown clear positive signs of a benign, lenient, and supportive regulatory approach.

5.2. Governance by blockchain technology

While potentially presenting some new challenges for global governance, blockchain systems could also enable new tools for governing global open collaboration. As described before in Figure 4, blockchain systems have enabled a new kind of ability to design open ecosystems by starting with the incentivization scheme first. For a global governance scheme to be sustainable and successful in creating traction amongst the citizens, the model needs to be self-reinforcing. By facilitating game-theoretical incentives at the network base protocol level, blockchain platforms can algorithmically set a negative price on aberrant behaviour in open social networks, warping the game theoretical incentives in such a way that collaboration is the preferable option despite the lack of direct trust in one's counterparty (Lauslahti et al. 2018; Mattila 2016; Mattila and Seppälä 2018). As an example, it is a common practice in cybercrime to harness the computing power of hijacked digital devices to participate in securing blockchain networks rather than to attack against them because even in such malevolent circumstances, collaboration is usually the more lucrative option.

Due to the core features of blockchain technology, some have argued that the technology itself could be used to mimic institutional processes to facilitate social constructs and elements such as currency, property regimes, and even democratic voting processes. However, whether such technological underpinnings could truly be used to establish an actual social contract by alternative means, as understood in social philosophy, is highly questionable. One of the key problems in this regard is that blockchain is not a neutral technology but in fact deeply political in its basic underpinnings. Whether such a system could genuinely engage in a process of truly democratic governance for the common good is in many respects highly dubious (Mattila and Seppälä 2018; Reijers et al. 2016).

To offer an example of the challenges of applying blockchain systems to facilitate democratic processes, let us consider the fact that blockchain technology is largely based on open source code, along with the right to fork code. Essentially, what this means is that all parties involved have the right and the ability to take the system protocol, modify it, and to establish their own versions of the network with a new, modified set of system rules—a practice known as *forking*. Consequently, no minority is in any way obligated to follow any majority decision in any matter. If a minority refuses to implement a software update proposed by the majority, or implements one without the support of the majority, the software clients of the two factions will simply seize to recognize each other as the members of the same network, and the network will split into two smaller networks. Moreover, in case a fork occurs, in theory, all factions are equally justified in claiming their version is the authentic, actual extension of the original database record—just like different animal species would be equally justified in claiming that they are all true descendants of their one shared common ancestor.

While it is a common notion that blockchain systems through their protocol design can make governance more transparent due to its algorithmic nature, it should be noted that this is not entirely the case. In addition to creating some new governance problems while helping to eradicate others, blockchain systems in themselves can make governance structures *less* transparent and *less* well defined. As some of the power structures around the system are social in nature rather than algorithmic, and since all the participants are not necessarily known, at least in open permissionless systems, these kinds of systems can be characterized as quasi-anarchistic with somewhat opaque and clandestine power structures (Mattila and Seppälä 2018). For example, in the case of the crypto-token platform Bitcoin, the system is held together by an intricate web of different forms of platform control, not all of which are openly perceivable to other members of the network (see Figure 11).

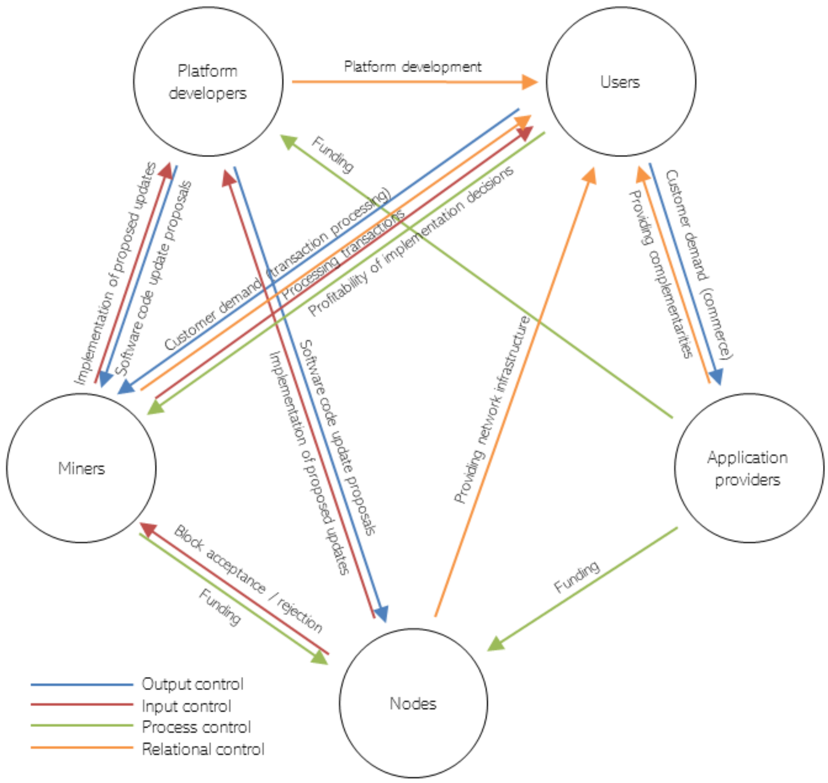

Figure 11. Tiwana's platform governance framework applied to the examination of one application of blockchain technology, namely Bitcoin (Mattila and Seppälä 2018).

5.3. Governance of distributed ledger technology

As described earlier in this report, distributed ledger technology is not a very clearly defined term in today's technology landscape. While formerly the problematic aspect of focus was drawing the delineation between blockchain and DLT, recently it has become evident that in fact differentiating between DLT systems and other contemporary decentralized platform endevours towards higher levels of system integration is an even bigger challenge. As such, it is difficult to explicitly give clear guidelines on how such a cohort of more or less ambiguous technology platforms should be governed from an EU actorness point of view.

However, one cannot say that one would be completely in the dark in terms of what this technology phenomenon implies for governance and actorness. It would appear that whereas blockchain systems represent a landscape of more disruptive development scenarios, DLT systems appear to be more reflective of incremental innovation development. Therefore, the European Union's ability to increase its actorness through the governance of such platforms seems to follow the trend of contemporary digital platforms in general.

Due to the fact that the trend of DLT systems is not entirely dissimilar from the system integration formerly referred to as 'digitalization', this would also imply that the implications for governance are not entirely dissimilar either. In other words, in single-provider or consortium-based DLT platforms, the choke points, industry structures, the roles of the incumbent players mostly have seemed to remain unaltered without radical transformation. As such, from the perspective of the European Union's actorness, the ability of the EU to govern DLT platform development can be seen comparable to that in regards to its influence on contemporary digital platforms.

5.4. Governance by distributed ledger technology

As also stated before earlier in this report, if nothing else, the narrative of blockchain and distributed ledger technology seem to have acted as a catalyst, inspiring companies to engage in the integrational development of digitalization which in many industries has been long overdue. Supported by the founding of several different kinds of blockchain and DLT development initiatives on many different levels within the EU, the same kind of inspiredness can also be heuristically sensed in many public administrations within various European countries.

If such momentum is indeed present, the European Union has an opportunity to harness this positive energy provided by the narrative to expedite the integration of public information pools and services along the lines of digitalization in general. Consequently, it is possible that DLT technology may help in that better and more seamless digital public services can be provided to European citizens. In case the European Union is successful in transforming the technological capabilities into tangible better services for its citizens, this, of course, would also then translate into stronger capabilities for governance and actorness by the said technology. However, it should also be noted that there is no clear indication that this same technological leap towards better governance and higher powers of actorness could not be achieved by more conventional technology choices.

Nonetheless, if distributed ledger technology can successfully expedite and increase the level of digitalization, it can be seen to hold potential for better incorporation of European values, such as digital sovereignty, into public services. Higher degree of system integration would, for example, translate into more seamless data portability, better in accordance with the European value of invididuals being in control of their own data. Furthermore, better data transparency could translate into more participatory public decision-making, and empowering the consumers to make more informed decisions due to more transparent public oversight of products and services and their provenance.

So, while the benefits of employing distributed ledger technology may to an extent be indistinguishable from more conventional technology platform choices, they are still benefits, all the same. However, it is important that the European Union acknowledges the possibility that the *additional* benefits which can be achieved by distributed ledger technology and this technology alone, may be more slim than initially anticipated. While not necessarily a significant point in itself, the lack of additional benefits could be meaningful in case the costs of implementing distributed ledger technology turned out to be drastically higher than other technology choices.

One noteworthy point is also the possibility that if the European Union was successful in developing seamless and functional public service infrastructure by utilising distributed ledger technology, this could imply economic opportunities for the European DLT platform providers, and the European Union in general. Not to mention the obvious benefit of a well-functioning public infrastructure, and its importance for a thriving entreprenurial culture, the development could also benefit the European Union in the form of exporting opportunities for software and the technological know-how in software consultancy. Moreover, emphasis on permissioned DLT systems could also strengthen EU actorness in the realm of digital platforms, by making the EU less dependent on US or Chinese technologies, in particular the top 5 cloud operators.

5.5. Implications on the actorness of the European Union

5.5.1. Authority

As a component of actorness, as defined in the TRIGGER project (see deliverable 3.1), *authority* refers to the legal competences which the European Union has in a specific policy area, as laid out in treaties on specific issues. Within the European Union, several declarations of understanding and support have been drafted and signed between various European actors on different levels. For example, in 2018, the European Parliament passed a resolution to support distributed ledger technologies and blockchains. Respectively, many national-level initiatives have been established in both public and private sectors. It would appear that the European Union's authority to act has a mandate from the member states, but national initiatives would imply that this authority is somewhat shared with the national level. Whereas in some sectors and ares member states may lead certain developments with their own goals and ambitions, many national supervisory authorities, e.g. in finance, seem to have taken the stand of waiting to see what the European Union does first before regulating on a national level, underscoring EU's authority in the governance of blockchain and distributed ledger technologies.

5.5.2. Autonomy

As a constituent of actorness, *autonomy* refers to the capacity of the European Union to set priorities and to act independently of the member states. It is unlikely that blockchain technology and distributed ledger technologies would be exhaustively directly legislated on by the European Union, simply for the fact that directly legislating on a given technology is seldom a good practice. Thus, the actorness of the European Union, somewhat hinges on the national supervisory entities in the matter. As stated above in the previous section, many national supervisory entities have given the helm to the European Union and awaited for its stand on relevant blockchain/DLT matters. However, as the European Union nonetheless has to rely on the national bodies to interpret and execute policies, its autonomy in the matter is good for the moment, but not set in stone.

5.5.3. Cohesion

According to TRIGGER's definition of actorness, *cohesion* has to do with the consistency of actions and arguments between the European Union and its member states. In Europe, member states have engaged in blockchain and distributed ledger technologies with varying levels of enthusiasm. The cohesion seems the strongest in the underlying sentiment that Europe needs to improve its innovative performance in the field of digital platforms and the platform economy, in comparison against the United States and China, for example. However, while clearly contradicting statements and actions between the European Union and its member states have not been prominent, at the finer level of genuine implementation, cohesion seems much weaker.

5.5.4. Credibility and trust

Credibility and trust, as a factor in actorness, refers to the reputation and the capacity of the European Union in achieving its set goals and its reliability and trustworthiness in sticking to agreements. Although blockchain technology has been in development for more than a decade, its maturity regarding genuine value generating applications remains limited (Burg et al. 2018). Therefore, it may be too early to say whether the European Union has managed to build a credible reputation in terms of blockchain technology and distributed ledgers.

As the terminology in the blockchain and distributed ledger technology space still remains in flux, one pivotal aspect in building credibility and trust is maintaining consistency in applied terminology. As discussed in Section 1.6 of this report, there is a temptation to slip into more general and less defined discussion regarding digitalization in a broader scope. Similarly, in the blockchain and distributed ledger technology discussions, it is easy to fall into the trap of invoking decentralization as a superior quality and an automatic justification for advocated design choices. However, as astutely pointed out by critics, the term 'decentralization' itself is often used in vague meanings (Walch et al. 2019). Thus, the concepts sold as decentralized are not necessarily as transformational in comparison to pre-existing solutions as sometimes lead to believe. In this respect, the European Union's actorness on the blockchain and distributed ledger technology space could be improved by invoking more clear and consistent definition of decentralization and distributed systems.

5.5.5. Recognition

In the mixture of factors comprising actorness, *recognition* refers to how an actor is perceived by others and whether it is recognized as a legitimate negotiator in a given domain. In terms of blockchain and distributed ledger technology, the European Union's actorness in this regard seems stronger than some of the other aspects. Member states would appear to be happy with letting the European Union draft higher level policies and policy guidelines on how to address the emerging new technology domain. However, in terms of an external perspective, the blockchain and distributed ledger technology space does not appear to have a strong international governance landscape. While China, like the EU, has shown significant ambition in promoting the development and application of blockchain and DLT technologies within its own economy, international governance leadership in terms of recognition remains an open question.

5.5.6. Attractiveness

Attractiveness, as a component in actorness, has to do with how interested other actors are in collaborating with the European Union in a given domain, and how worthwhile they consider such efforts. While perhaps difficult to evaluate at this point in the development of the technology space, what could be said that the vast range of different initiatives in which the European Union has engaged in can be considered to increase the actorness of the European Union in this regard. Europe has done well so far in fostering innovation ecosystems around blockchain and distributed ledgers, so on a finer scale of granularity, Europe does seem to be an attractive choice for blockchain innovators—but not the only attractive location to establish operations.

5.5.7. Opportunity and necessity to act

In order tor the actorness of the European Union to become strong, the external factors must be conducive to an *opportunity to act*. In the field of product data and global supply chains, there have efforts for a long time to move from the level of individual systems to higher stages of integration, but with little success, as discussed earlier in this report (see Figure 7). Additionally, according to the double helix model of Fine (1996, 2008, 2010), industry configurations tend to oscillate between high vertical integration, and high horizontal modularity. Lately, with the digital platform giants, *e.g*. Google, Apple, Facebook, and Amazon, there have been growing antitrust concerns regarding excessive vertical integration, and the lack of horizontal modularity, especially in the European discussions. implying that a shift from vertical integration to a more horizontal configuration of increased modularity may be imminent. Thus, an opportunity—even a necessity to act—seems to be present regarding finding more equilateral technical solutions which would facilitate more democratic division of market power in digital platforms. In this respect, the actorness of the European Union seems strong when it comes to blockchain development and distributed ledger technologies in general.

6. Concluding discussion

Despite the hype and the flow of capital investments into the blockchain technology scene over the years, blockchain applications producing genuine proven customer value have been few and far in between (Burg et al. 2018). It seems quite clear that public permissionless applications are not likely to become mainstream any time soon. Permissioned applications, however, may become more commonplace over time—but they are not likely to carry implications significantly different from digitalization in large.

Despite the lack of mainstream adoption, blockchain systems are an example of how the regulatory control mechanisms for digital platforms may not be fully efficient against the emerging new forms of multi-sided network collaboration in the future. While open-source and open-access blockchain applications are not likely to break into the mainstream at least in the foreseeable future, the emerging alternative paradigms for social constructs may require some increased adaptation and new strategic approaches to governance on a more global level. In a wider context, assuming a proactive, leading role in the collaborative global governance efforts regarding peer-to-peer technologies can improve European Union’s autonomy, authority, and attractiveness in the digital world stage.

In the age of digitalization and digital platforms, access to global markets is more of a rule than an exception for digital goods and services. Thus, in the supranational economy, global governance entities must recognize the fact that they are intricately involved in a global competition for digital innovation and digital innovation ecosystems. The important role of regulation in fostering such innovations is something which only recently has been properly acknowledged (Chander 2015).

Thus, in order to attract innovators, the regulator must be able to react appropriately and without delay to emerging new technology trends and to ensure regulatory clarity in applying said technologies. Thus, the challenge of determining the correct response becomes even more difficult due to the shortened regulatory cycle, and the significance of efficiently observing, monitoring and testing is heightened in importance.

On the other hand, *ex post* regulation should not be overlooked as a potential tool in the competition for innovations, especially in the efforts to prevent stifling emerging innovation ecosystems.

Naturally, in the global governance of emerging new technology trends, a thorough understanding of the technology in question is vital. In this regard, it is important that the regulator reaches out directly to the industry experts for information, rather than restricting itself to an industry discussion mediated by consultants and political lobbyists. The regulator should identify the regulatory needs on an industry-specific basis. Respectively, in drafting out policy principles, it is recommended that industry soft law arrangements already in place or in the works are acknowledged and encouraged.

Effective supply chain traceability can revolutionize resource management and efficiency across the economy. Information regarding the provenance of items is at the very core of enhanced sustainability, efficiency, and authenticity. Hence, data management and data sharing are vitally important, especially in closed-loop ecosystems. New supply chain practices call for novel approaches to governance in order to effectively manage product intelligence. Effective micro-level governance practices for managing product data across their lifecycles will accumulate macro-level benefits at the ecosystem level, thus enabling new modes of value creation throughout the entire ecosystem. Such modes of value creation could, for example, lead to sharing of the ownership of the goods throughout the life cycle, among all supply chain participants, based on their value-added contributions (Rajala et al. 2018).

While improving the resource efficiency and sustainability of global supply chains is important in its own right, from a global governance perspective, the most interesting area of focus with blockchain technology seems to be that which has to do with incentivization. For any global governance model to be truly sustainable and long-lasting, it needs to be *self-reinforcing*. This could perhaps be achieved by encapsulating positive feedback loops within the governance model itself. Given the growing importance of the issue of governance of technological platforms, the development of a more comprehensive understanding of the promises and perils of information sharing as a tool for global governance is a fertile area deserving of further study.

From the perspective of technological innovation, Europe should consider a dual approach. Enabling efficient development of open source software solutions should be fostered to its highest potential. In this regard, it is important that any technological approaches to facilitating social constructs are not thwarted with overly technology-oriented or otherwise non-applicable mandatory regulation.

So, what kinds of features should regulators seek to incorporate into the European manifestations of blockchain technology? One of the key issues is that while the technology itself does not necessarily conflict with values such as privacy, fairness, non-discrimination etc., it does seem to conflict in places with the European approach to and perception of some of those values. For example, some blockchain-based cryptocurrency systems can provide their users with an extremely high degree of anonymity and privacy—yet such systems cannot be GDPR-compliant, because due to the append-only nature of their databases, they cannot facilitate the right for data erasure.

Nonetheless, in principle, the incorporation of stronger European value perspective, such as digital trust and transparency would be possible through publicly provided modules and auxiliary services, such as blockchain APIs, and escrow services. In this respect, the interesting question for the future is, which one will prevail, the set tradition on how the European values are perceived and conceptualized, or technology innovation which may exhibit those same values but in a completely new form?

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D4.2 Taking stock of existing trends and forward- looking scenarios in the application and governance of distributed ledger technologies

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Trends In Global Governance and Europe's Role

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement nº 822735. This document reflects only the author's view and the Commission is not responsible for any use that may be made of the information it contains.