Chapter 6
Tokenomics: Decentralized Incentivization in the Context of Data Spaces

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Abstract A significant challenge in bootstrapping a jointly used infrastructure such as Data Spaces is to incentivize the participants to invest in setting up the infrastructure. In this chapter, we investigate this challenge and possible solutions, focusing on an approach called "Tokenomics."

The incentivization scheme should be utilized by governance frameworks, in which the participants of Data Spaces remain capable of action and independent through automated, effective, and fair decision-making processes. Also, potential participants should be motivated to participate in the establishment and further development of the system, while on the other hand, undesirable behavior should be penalized. In combination with distributed ledger technology (DLT) and machine-readable, legally compliant smart contracts, participant behavior can be affected in such a way that both data quality and quantity are improved for the whole Data Space.

To derive possible design options for Tokenomics approaches, we examine different token frameworks and their impact on participants. The investigation of the frameworks is carried out taking into account five significant domains: technical, behavior, inherent value, coordination, and pseudo-archetypes. Furthermore, we investigate which token designs provide smaller or larger incentives in order to join or maintain a DLT-based ecosystem.

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6.1 Tokenomics in the Context of Data Spaces

The last years have been characterized by data to become a significant value driver. In this context, the creation of secure data sharing ecosystems that ensure both data governance and traceability is of particular importance. By providing such ecosystems, potentials for new applications and services are unleashed [1]. Industry 4.0 and the related business process automation require ever-increasing amounts of data. Organizations can therefore no longer rely solely on internal and publicly available data sources to remain competitive. Instead, they also need information from external individuals and organizations. So far, most ecosystems are controlled and driven by central actors [2]. Trust is one of the most important prerequisites for successful cooperation in networks, since the extensive exchange of data between partners also means that sensitive internal information is passed on. In practice, there is a lack of trust between the actors. This lack of trust can lead to information being withheld [3, 4]. Network effects also cause them to evolve into monopolistic or at least oligopolistic structures. This dilemma has triggered a debate on data sovereignty, especially in Europe. The concept of data sovereignty is intended to give rise to alliance-driven data ecosystems with associated platforms. For this reason, the global alliance, International Data Spaces Association, which has been driven by companies and research institutions such as Fraunhofer since 2015, set its goal to develop standardized architectures for such platforms and test them in practice [5, 6].

A significant challenge in bootstrapping a jointly used infrastructure such as Data Spaces is to incentivize the future participants of this infrastructure to invest funds or effort in setting up the infrastructure in the first place. This challenge is closely related to the well-known "tragedy of the commons" [7] and its historic remedy to create cooperatives [8]. It is also closely related to the topic of open-source economics [9].

In this chapter, we investigate this challenge and possible solutions, focusing on an approach called "Tokenomics" which has the goal to address this challenge using a token-based incentivization scheme [10, 11].

Distributed ledger technology (DLT) in general and blockchain technology (BCT) in particular can be utilized and are highly relevant to consider in situations where data sharing is pursued in a decentralized manner. BCT received attention in 2008 when an individual or group under the pseudonym *Satoshi Nakamoto* introduced the technology in a white paper that also introduced the decentralized cryptocurrency Bitcoin [12, 13]. An important feature of BCT is the possibility of using tokens that can act as incentives in a decentralized network. Incentive systems can thus be created for actors to join the network and act in the interests of the ecosystem [14].

Therefore, in the following two sections, we present two use cases where the use of blockchain-empowered tokens makes it possible to address the described challenges. For this purpose, we investigate different token classifications depending on the use cases. In the second section, we turn to supply chain management and describe two projects that use token deployment to create incentive systems. The two projects are then compared in terms of similarities and differences. In the third section, we use a similar approach to examine the Personal Data Market (PDM) use case. For this reason, we present five different Tokenomics approaches and derive a suggestion for token archetypes of PDM token systems.

6.2 Token-Based Supply Chain Management

The use of distributed ledger technologies (DLTs) promises improvements of supply chain processes, especially with regard to the traceability of products along the entire value chain. DLT offers an ideal solution to reliably connect and manage IoT devices. In this context, supply chain management and logistics are two of the main application domains for linking blockchain technology (BCT) with new technologies such as Internet of Things (IoT) or artificial intelligence (AI) [15, 16]. DLT-based tokens play a key role in this context as they can be used to incentivize various actors in participating in such a value chain and establish a truly decentralized network. Consequently, we address the topics of DLT-based tokens for supply chain management in this chapter and present various token classifications. We then compare two blockchain projects in terms of token incentivization.

6.2.1 Supply Chain Traceability

Due to advancing globalization, traceability of goods in supply chains has gained importance. Also, consumers have a greater interest in consuming goods that meet certain sustainable and ethical standards [17, 18]. In this context, supply chains have become increasingly complex, complicating manufacturers' sourcing efforts [19]. In addition, regulations and international standardization are placing new demands on the supply chain management functions of companies. The European Parliament calls for food traceability and requires food suppliers as well as market participants to provide information on the origin of goods [20]. In order to trace the origin of a product, supply chain management ideally needs to be operated by multiple interconnected actors in the supply chain. However, traditional systems often miss cross-company interconnections and are operated in isolation—so-called data silos. Therefore, supply chain actors often are not able to trace relevant goods and receive information on their location or origin [21, 22]. In recent years, various methods have been developed to monitor processes and activities in the networked industry. The Industry 4.0 emerged and led to the digitization of processes, where supply chains provide real-time access to relevant products and production information for all stakeholders involved [23, 24]. The fourth industrial revolution is characterized by the emergence of various technologies, such as IoT and BCT, which conquer the boundaries between the physical and digital world and have a big potential in their combination. Such technologies can transform modern supply chain networks into complete digital ecosystems. The digitization of supply chains offers outstanding business speed, agility, and the development of traceability mechanisms that enable near-complete identification and recording of products and processes. It is worth noting that blockchain-enabled supply chain approaches coupled with IoT applications could improve communication and traceability data delivery, enabling additional data management and analytics benefits for the logistics industry [25]. In supply chain management, payment processes can also be automated using smart contracts and, in combination with cyber-physical systems, increasingly autonomized. By eliminating manual activities, the processes involved are accelerated considerably [16, 26].

6.2.2 Distributed Ledger Technology and Tokenomics

Before blockchain technology was developed, many attempts were made to fulfill the desire of passing an asset digitally from one party to another via a secure, peer-to-peer Internet connection [27]. To address this need, the Bitcoin white paper "A Peer-to-Peer Electronic Cash System," published by *Satoshi Nakamoto* in 2008, proposed a new way for transferring money within a digital peer-to-peer network [13]. Until then, peer-to-peer currencies faced the problem that it was impossible to avoid a single unit being spent twice without a central intermediary [28]. When executing a transaction digitally without a central intermediary, one party could use a digital asset that has already been used in another transaction and, hence, spend it twice [29, 30]. If a central intermediary should be avoided in a decentralized network, the goal is to overcome those risks with individuals not relying on only one central authority but several ones. BCT is a specific approach for storing and ordering information of transactions without a central intermediary [31]. It serves as a decentralized data backup system that enables all members of a transaction to manage the uncovered information carefully and, at the same time, ensure its validity. Based on BCT, several peer-to-peer transfer technologies were developed and later combined under the term distributed ledger technology. Although DLT and BCT are often used interchangeably, BCT represents a specific type of DLT [27].

Apart from the public ledger envisioned by *Nakamoto*, blockchain solutions today can generally be classified into one of three categories: public, private, and consortium blockchains [32]. One feature within blockchain technology is of particular importance: tokens. Tokens can provide incentive design optimization to induce honest behavior among actors in a competitive environment [14]. For each type of goods managed in the supply chain, a smart contract with tokens is set up. As a type of blockchain recordkeeping, these tokens digitally replicate physical assets in distributed ledgers [33]. The process of tokenization transforms tangible and intangible assets into digitally encoded tokens [34]. The owner's digital record can be transferred between parties through the DLT network without a central authority [35]. There are two significant types of blockchain recordkeeping mechanisms:

currencies and tokens. A currency is usually native to a blockchain. Since BCT builds upon cryptography, such a currency is also called a cryptocurrency. The primary example is Bitcoin, which is the native currency of the Bitcoin blockchain [13]. A token is not native to a blockchain but is created on top of a blockchain and governed by a smart contract. Smart contracts govern most tokens following the common standard [36].

According to *Weingärtner*, the categorization of tokens into fixed classes is more difficult because any variation or functional enhancements can be programmed using smart contracts [37]. Freni et al. [38] have analyzed eight different token classification approaches from the literature to derive a morphological token classification framework. A useful distinction of tokens can be made by using the following five domains: The *technical* domain includes all technical properties of the token. All native functional properties are gathered in the *behavior* domain. The *inherent value* domain describes the economic value of the token. Furthermore, the *inherent value* domain investigates how the value of the token is created and influenced. The coordination of stakeholders depends on certain characteristics of the token, which are summarized in the *coordination* domain. The last domain, *pseudo-archetypes*, gathers all combined token frameworks. The derived 16 dimensions of the morphological token framework are summarized in dependence of the domains in Table 6.1.

With the use of tokens that represent the ownership of scarce digital resources, actors can be coordinated in a network. A proper design of a token is achieved by

Table 6.1 Morphological token classification framework [38]

	Domain			
	Technical	Token behavior	Inherent value	Coordination
Dimension	Accessibility *(Permissioned, Permissionless)*	Burnability *(Burnable, Non-burnable)*	Underlying Value *(Asset-backed, Network Value, . . .)*	Economic Value Driver *(Demand, Supply,. . .)*
	Chain *(New Chain, Forked Chain,. . .)*	Expirability *(Expirable, Non-expirable)*	Value generated by *(Effort of others, Effort of holders)*	Role *(Store of Value, Voting right, Value Exchange,. . .)*
	Layer *(Blockchain, Protocol Application)*	Spendability *(Spendable, Non-spendable)*		Monetary Policy *(Schedule-based, Pre-mined, . . .)*
	Number of Blockchains *(Single Chain, Cross Chain)*	Token Type *(Fungible, Non-fungible, Hybrid)*		
	Representation Type *(Common, Unique)*	Token Unit *(Fractional, Whole, Singleton)*		
		Tradability *(Tradable, Non-tradable, Delegable)*		

aligning the different types of incentives within a token-built ecosystem. The token can then be used to orchestrate the creation and control the development of these protocols. The use of tokens can accelerate and improve the development of an incentive-based decentralized network. These incentives bring different stakeholders' interests to a common denominator. Thus, token-based networks can strengthen competitive collaboration in the long run in a digital age [11, 39, 40].

Hülsemann and Tumasjan [12] simulated the effects of different designs. The designs of cryptocurrencies, network tokens, and investment tokens were examined in the context of prediction markets. The research concluded that network tokens provide the largest incentives for actors to join and remain in the network ecosystem over the long term. For example, network tokens can provide services within a system. In addition, the authors found that investment tokens provide the smallest incentives [12].

6.2.3 DLT-Based Supply Chain Traceability

To strengthen supply chain management, various blockchain projects have been initiated that also aim to create incentives through the use of tokens. In this chapter, we briefly summarize two well-known projects and present the differences and similarities in the token design.

VeChainThor was developed as a public blockchain to simplify supply chain management. Originally, it was developed to determine whether a real product is a fake or not, so that fraud and counterfeiting can be eliminated. In the meantime, the blockchain is used by large companies for supply chain traceability. VeChainThor designed a bi-token system that includes VeChain Token (VET) and VeThor Token (VTHO). The function of VET is to serve as a value-transfer medium to enable rapid value circulation within the VeChainThor network. VTHO represents the underlying cost of using VeChainThor and is consumed, or in other words, burned by performing on-chain operations. Furthermore, VTHO is generated from holding VET, which is established to allow any user with VET to make transactions at no extra cost if the user holds the VET tokens for long enough. The goal of this token design is to prevent transaction fees from being directly exposed to the volatility of VET's price, making the VeChainThor blockchain more suitable for conducting business or financial activities for both individuals and companies. The demand for VTHO arises from the execution of smart contracts and payment transactions. To stabilize transaction costs and maintain the balance of supply and demand for VTHO, the Foundation closely monitors the market and estimates the demand for VTHO based on the activity of applications running on the VeChainThor blockchain and token transfers [41]. The token classification of VET and VTHO is summarized in Table 6.2.

Waltonchain is a supply chain solutions platform built on the blockchain. It offers decentralized product tracking that tracks QR and RFID codes on the blockchain. Waltonchain (WTC) is a cross-chain ecosystem where the parent chain and child

Table 6.2 Token classification VeChainThor

	Domain			
	Technical	Token behavior	Inherent value	Coordination
Dimension	Accessibility: *Permissionless*	Burnability: *Burnable (VTHO), Non-burnable (VET)*	Underlying Value: *Network Value*	Economic Value Driver: *Demand*
	New Chain, New Code	*Non-expirable*	Value generated by: *Effort of Holders*	Role: Value Exchange, Reward Potential (VET), Access to Service (VTHO)
	Layer: Blockchain	*Spendable*		Monetary Policy: Pre-mined *Schedule-based*
	Single Chain	*Fungible*		
	RepresentationType: *Common*	Token Unit: *Fractional*		
		Tradable		

chains serve as the framework. In this cross-chain ecosystem, data circulation and value transfer can be realized between child chains. Using the cross-chain mechanism, child chain tokens are exchanged for the WTC token and can be further exchanged for other child chain tokens; thus, value circulates on the blockchain [42]. The Waltonchain ecosystem is currently under steady development and in order to make WTC more stable in the cross-chain IoT ecosystem, Waltonchain Foundation issues the Waltonchain Autonomy token (WTA) on the Waltonchain mainnet. To incentivize the community members, the Foundation launches tasks which can be completed by the community. By completing tasks the community members can earn points, which can be converted to WTA at a certain ratio. Furthermore, the WTA token can be used to deduct service fees during the token exchange between WTC and child-chain tokens [43]. The token classification of WTC and WTA is summarized in Table 6.3.

The two blockchain projects investigated, VeChainThor and Waltonchain, show similar patterns in token design. Both projects use two different tokens each in an attempt to get actors to join the ecosystem and act in the interests of the network. Both projects use a second token (VTHO and WTA) to maintain stability in the system and avoid the volatility of market behavior. However, the difference between the designs lies in the incentivization. While the VTHO token is designed to eliminate the cost of transactions within the blockchain, the WTA token aims to ensure that actors act in the spirit of the ecosystem. Moreover, the introduction of these two tokens induces actors to hold VET and WTC tokens in order to receive VTHO or WTA. In this context, the VET and WTC tokens constitute the role of value exchange, while WTC can be used for cross-chain transactions. These

Table 6.3 Token classification Waltonchain

	Domain			
	Technical	Token behavior	Inherent value	Coordination
Dimension	Accessibility: *Permissionless*	Burnability: *Non-burnable*	Underlying Value: *Network Value*	Economic Value Driver: *Demand*
	New Chain, New Code	*Non-expirable*	Value generated by: *Effort of Holders*	Role: Value Exchange, Reward Potential (Staking)
	Layer: Blockchain	*Spendable*		Monetary Policy: Pre-mined, Schedule Distribution
	Cross Chain	*Fungible*		
	Representation Type: *Common*	Token Unit: *Fractional*		
		Tradable		

exemplary findings should be enriched by empirical data in future studies so that further token designs can be evaluated in terms of incentivization.

As the value creation process more and more often takes place in enterprise networks—rather than in individual enterprises—also the combination and enrichment of data takes place by various actors in data spaces. For this reason, we investigate the use of Tokenomics in the context of Data Spaces in the next section.

6.3 Tokenomics in the Context of Personal Data Markets

Tokenomics is commonly applied in the framework of Personal Data Markets. In order to shed light on the interplay of these related concepts, we investigate the motivational factors of market operators for using a Tokenomics approach when building Personal Data Markets (PDMs). Furthermore, we classify token design patterns with regard to PDMs and examine whether there are "specific token designs" commonly applied for Personal Data Market infrastructures.

6.3.1 Personal Data Markets

Nowadays, individuals create tremendous amounts of valuable data [44] while interacting in their lives using devices equipped with sensors such as mobile phones, tablets, smart home systems, or computers. Even though this personal data belongs to the individuals, data producers commonly give up all rights concerning their data by agreeing to terms and conditions, which are required of them before using certain services [45]. Thus, service providers can easily get access to such valuable personal data. Subsequently, they might use this personal data for further product and service development or even sell it to various third parties making substantial profits [46, 47]. The individuals from whom data were collected are left without any control or profit. Against this background, the concept of Personal Data Markets (PDM) has been raised in numerous discussions during the past years as an appropriate solution medium. PDMs are believed to lead to a fair(er) data economy and, hence, foster innovation in all areas of application through efficient and large-scale data sharing between private data owners and organizations of all kinds [48]. Consequently, the expectation is that they can contribute to societal benefit. Despite the potential benefit PDMs promise for the entire society, many marketplace providers are frequently forced to their knees as a variety of challenges for PDMs exist [49]. These challenges originate mainly from technological, legal, economic, or ethical domains [49], resulting in short life cycles of many marketplace providers, e.g., Data Fairplay, Datareum, Datatrade, Synapse AI, and MYBS. However, there are PDMs which seem to operate successfully as they have existed for some years now. When analyzing a sample of such "resistant" PDMs, it becomes clear that token systems play a major role in order to master the economic challenge of incentivizing market participants, especially the owners of personal data, for sharing their data.

6.3.2 Motivational Factors for Tokenomics Approach in Personal Data Markets

In the context of PDMs, tokens can be defined as units of value the market operator creates and emits in order to self-govern its business model, and to empower all participants of the marketplace to interact with each other, while facilitating the distribution of rewards and the sharing of benefits to all stakeholders. Thereby, the concept of Tokenomics has arisen from game theory, mechanism design, and monetary economics [50]. It is vital for a general understanding about the interplay between the concepts of Tokenomics and PDMs to examine the motivational factors convincing market operators for the application of token systems in the framework of their technical marketplace architectures. For this purpose, existing PDMs were analyzed giving special attention to technical architecture whitepapers of marketplace operators. The results of the sample examined are summarized below.

Airbloc relies on two kinds of tokens with distinct purposes. Firstly, this market operator offers the token ABL which is a tradable ERC20 token used as a means of participating in the network in order to settle payments for data exchange as well as staking register and maintaining certain services on nodes. Thus, ABL serves for payment, settlement, and participation. Secondly, Airbloc runs the virtual and non-tradable AIR token, primarily used for providing rewards to network participants. AIR tokens are one-way convertible into ABL only. Hence, AIR supports productive behavior within the network by assessing participant's reputation and contribution.

The *Datum Network* is built upon the DAT token as utility token in order to facilitate transactions, especially data sharing, among data owners and buyers by providing the medium for payment settlements. It is a smart token enabling users to buy and sell stored data while enforcing data usage policies set by the data owner. The latter is controlled by underlying smart contracts running on blockchain. Furthermore, the token grants access to certain privileges in the network such as data storage and participation in the data market.

Madana uses tokens based on the Lisk Blockchain in order to support consistency, transparency, and co-determination as the PAX token holder has the opportunity to vote for a global data model ensuring consistency across the entire ecosystem. In doing so, the token holder determines the way data must be offered in order to participate. Furthermore, the token system serves to handle rewards for contributions of participants to the Madana platform in terms of data or services functioning as a payment vehicle. Thus, Tokenomics incentivizes provision of analytical services and data sharing on the platform.

In the *OSA DC* network, participants receive tokens for offering services such as collecting, cleaning, and enriching data and offering data storage or analytical services. Furthermore, the OSA tokens function as a payment medium, buying and selling transactions among participants. Additionally, the token system is applied to provide a reward system where data providers receive token rewards for each action in the ecosystem and data consumers may also be rewarded for purchasing specific products and services. Thus, OSA assigns three main purposes to its OSA token system: facilitation of service offerings, payment medium in the ecosystem, and incentivization to contribute to the network.

VLD tokens are functional utility smart contracts within the *VETRI* platform where users are remunerated in VLD tokens based on the desirability of their data shared perceived by data consumers. Thereby, the tokens enable to buy and sell transactions on the marketplace. Furthermore, the tokens function as payment and settlement medium for secure data storage and services platform participants can purchase. Above all, Vetri's token system aims to provide an incentivization mechanism for all stakeholders and to support price stability.

Based on our findings summarized in Table 6.4, we derive the following main motivational factors for the application of token systems within Personal Data Market infrastructures: payment medium, incentivization mechanism, access and usage control, and facilitation of transactions on the marketplace (including services).

6.3.3 Token Design Principles for Personal Data Markets

With the insights gained from the analysis of motivational factors for applying Tokenomics in PDMs, the following section introduces common design patterns

Table 6.4 Motivational factors for Tokenomics approach in existing Personal Data Markets

Motivational factors	Token	PDM
ABL • Payment medium and settlement • Access to and participation in network *AIR* • Assessment of productive behavior and contribution to network	ABL AIR	Airbloc
• Facilitation of transactions • Payment medium • Enforcement of data usage rights • Access to privileges in network	DAT	Datum Network
• Support of consistency, transparency, and co-determination • Payment medium • Incentivization for contributions to network	PAX	Madana
• Facilitation of service offerings • Payment medium • Incentivization for contributions to network	OSA	OSA DC
• Access to data storage and services • Payment medium for data • Facilitation of transactions • Incentivization and compensation of all participants	VLD	Vetri

of tokens in literature [36]. Subsequently, we try to highlight overarching token design principles chosen by PDMs while relying on the taxonomy of token classification of Oliveira et al. [36]. In this taxonomy we suggest common token design principles, typically applied in Personal Data Markets based on our previously analyzed PDM sample.

The first token attribute is the *Class* of tokens which is commonly used for the distinction of tokens as it differentiates cryptocurrencies (digital money), digital shares including entitlements for profit sharing (tokenized security), and remaining crypto-assets based on tokens with attached utility (utility tokens) [36]. According to our sample, utility tokens are the dominant design of *Class* in PDMs. The *Purpose* of tokens distinguishes between tokens represented uniquely as an asset (asset-backed), tokens combined with an access permission (usage token), and tokens storing value to reward or incentivize behavior (work token) [51, 52]. In our sample, most PDMs rely on the design characteristics of usage token and work token as they are applied, for instance, as a right to access the marketplace or the entire platform as well as for incentivization of a certain behavior. Mougayar [53] classified tokens into *Roles*, representing a right for the owner (right), a unit of value exchange within a system (value exchange), a fee for access (toll), a tool to enrich user experience (function), a de facto payment method (currency), or a right for the data owner to receive a share of the profit (earnings). In our sample, the main *Roles* appeared to be rights, mediums for value exchange, access, and currency. Glatz [54] classified tokens according to their *Representation*. According to the author, they can be designed as pure digital assets (digital), bound to physical objects (physical), tied to objects from virtual reality (virtual), or state legal permissions and rights granted by law or the network (legal). The major *Representations* of token designs in PDMs we examined were digital assets. Furthermore, they were commonly combined with rights granted by the network. Chen [35] divided tokens into their *Supply* which can either be fixed and distributed once (fixed) or accorded to a certain schedule (schedule-based). Most tokens in PDMs are offered once and subsequently burned over time, meaning that supply is fixed. Another attribute refers to the behavior tokens aim to incentivize. Lena and Oxana [55] called this attribute *Incentive System* where the token design can incentivize to enter, to use, or to stay long term in a system or on a platform. Incentivization of behavior plays a key role in PDMs when designing tokens. However, according to the whitepapers we analyzed, the incentivization of usage is the most dominant design principle in terms of *Incentive System* applied by market operators. Lena and Oxana [55] also suggested the attribute *Transactions* distinguishing spendable and non-spendable tokens. In PDMs, tokens are usually spendable on a platform, e.g., when reception or execution of payment transactions is concerned. Yadav [56] considered *Ownership* as an attribute since a token can either be tradable or non-tradable. In PDMs, the former design principle is usually the case. Similar to *Supply*, Oliveira et al. [36] defined the attribute *Burnability* reflecting the possibility for purposely burning tokens in order to create artificial scarcity or to express the extinction of access rights bound to the token. According to the sample analyzed, burning tokens over time is a commonly applied technique in PDMs. Just like *Ownership*, Glatz [54] defined *Fungibility* of tokens which addresses either purely equal (fungible) tokens or non-fungible ones due to their distinct characteristics ensuring their uniqueness. The dominant design principle of PDMs in this regard are fungible tokens. Furthermore, the attribute *Layer* refers to the distinction based on the location of tokens. Thereby, Little [51] differentiates between tokens native to blockchain, issued on top of a protocol or placed on the application layer [51]. The PDMs of our sample under study mainly run on a blockchain as the first layer carrying a token system as a second layer. Finally, token design is also affected by the *Chain* the system relies on. Srinivasan [57] differentiated the design pattern of new chains on new code, new chains on forked code, forked chains on forked code, or issued on top of a protocol. We state that the latter appears as the dominant design principle for PDMs relying on the information from our whitepapers.

6.3.4 Derivation of Token Archetypes for PDMs

Oliveira et al. [36] defined eight token archetypes depending on their specific purposes where several tokens exhibit a multipurpose ability, that is to say they serve more than one purpose simultaneously (see Table 6.5). The archetypes are cryptocurrency token, equity token, funding token, consensus token, work token, voting token, asset token, and payment token. According to our previously defined motivational factors for the application of tokens in PDMs and some frequent PDM

Table 6.5 Taxonomy of tokens design characteristics from Oliveira et al. [36] applied to PDMs

Design Attribute	Design Characteristics					
Class	Cryptocurrency	*Utility Tokens*	Tokenized Security			
Purpose	Asset-backed Tokens	*Usage Tokens*	*Work Tokens*			
Role	*Right*	*Value Exchange*	*Toll*	Function	*Currency*	Earnings
Representation	*Digital*	Physical	Virtual	*Legal*		
Supply	*Fixed*	Schedule-based				
Incentive System	Enter Platform	*Use Platform*	Stay-long term			
Transactions	*Spendable*	Non-Spendable				
Ownership	*Tradable*	Non-Tradable				
Burnability	*Burnable*	Non-burnable				
Fungibility	*Fungible*	Non-Fungible				
Layer	Blockchain (Native)	*Product (Non-Native)*	Application (dApp)			
Chain	New chain, new code	New chain, forked code	Forked chain, forked code	*Issued on top of protocol*		

The highlighted characteristics of tokens in PDMs are based on our previous sample only

token designs analyzed, we suggest the following main corresponding archetypes for token design in PDMs.

As we assigned the archetype with the best thematically fit to the derived motivational factors, further adjustments to our work are possible and recommended. Furthermore, we emphasize that both Tables 6.2 and 6.6 present suggestions we give based on findings and assumptions derived from our analysis of PDMs in practice. We encourage future research to empirically examine design patterns of token systems in PDMs and to define more justified archetypes in order to extend the still limited (design) knowledge in research about the mutual relation of the domains Tokenomics and Personal Data Markets.

Table 6.6 Suggestions of token archetypes of PDM token systems relying on the archetypes defined by Oliveira et al. [36]

Motivational factor	Archetype	Main purpose	Token description
Payment medium	Payment token	Payment	Token used as internal payment method in the system/platform
Incentivization mechanism	Work token	Work reward	Token used as reward for users completing actions or exhibiting certain behavior
Access and usage control	Asset token	Asset ownership	Token representing asset ownership
Transaction and service facilitation	Consensus token	Validation reward, store of wealth	Token used as reward to nodes/participants ensuring certain services such as data validation or consensus

6.4 Conclusions

A significant challenge in bootstrapping a jointly used infrastructure such as Data Spaces is to incentivize the future participants of this infrastructure to invest funds or effort in setting up the infrastructure in the first place. In this chapter, we investigated this challenge and possible solutions, focusing on an approach called “Tokenomics” which has the goal to address this challenge using a token-based incentivization scheme.

To derive possible design options for Tokenomics approaches, we examined different token frameworks and their impact on participants. Furthermore, we investigated which token designs provide smaller or larger incentives in order to join or maintain a DLT-based ecosystem. This investigation was done in the context of two use cases where the use of blockchain-empowered tokens makes it possible to address the described challenges: As part of supply chain management we discussed two projects that use token deployment to create incentive systems. The two projects were then compared in terms of similarities and differences. In the last part of this chapter, we used a similar approach to examine the Personal Data Market (PDM) use case. Toward this, we presented five different Tokenomics approaches and derive a suggestion for token archetypes of PDM token systems.

Based on these investigations we can conclude that the Tokenomics approach appears suitable for use in addressing the challenge of incentivizing the future participants of this infrastructure to invest funds or effort in setting up the infrastructure. We therefore recommend that this approach be further elaborated at a technical level to be used for this purpose.

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