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Archetypes of blockchain-based business models in enterprise networks

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Abstract

Many enterprises are currently engaged in developing blockchain-based business models. Enterprise networks offer a variety of potential applications for blockchain solutions as they benefit from transparency and security as well as automation of handling data, material, and financial flows along their supply chains. Despite profound potentials, the indicated business models are still in their early stages and need further investigation. To provide an overview of existing blockchain-based business models in the context of enterprise networks, the underlying paper designs a multi-dimensional taxonomy and identifies several archetypes of blockchain-based businesses. For the taxonomy development, data from 101 blockchain start-ups serves as a basis for empirical validation. Using hierarchical clustering and the k-means method, seven archetypes that sharpen the understanding of how blockchain solutions affect business models in enterprise networks and enable new business models are derived. The proposed work results are intended to be applied in future research and practice to classify and assess the integration of blockchain solutions into existing business models and to support developing new ones that leverage emerging technological capabilities.

Keywords Blockchain technology · Business models · Enterprise networks · Taxonomy · Archetypes

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1 Introduction

In recent years, blockchain technology has experienced an increasing interest in research and practice. Although blockchain is a novel technology with largely unexplored effects, numerous use cases have already been discussed in industrial practice (Treiblmaier 2018). Blockchain solutions are prominently tested and implemented in various use cases in different industries ranging from automotive (Miehle et al. 2019) to food and beverage (Kamilaris et al. 2019) or logistics (Tijan et al. 2019). However, those use cases often remain in their isolated use case environments. Moreover, the adopted use cases focus primarily on process improvements (Farooq et al. 2021; Tijan et al. 2019). On the other hand, the concept of a fully-fledged blockchain business model still needs to be explored. Although blockchain technology has now passed the peak of the hype cycle (Gartner 2020), it is still mainly start-ups that are developing business models based on the blockchain and thus ensuring the spread of the technology (Böhmecke-Schwafert and García Moreno 2023; Gürpınar 2023; Subhiksha et al. 2020).

Business models applying blockchain and tokenization are widespread in the financial and gaming industries (Al-Jaroodi and Mohamed 2019; Oh and Shong 2017). Although logistics and supply chain management offer a broad application area for blockchain and tokenization business models, they seem much less represented than financial applications. However, due to its inherent characteristics, blockchain technology is particularly suitable for cross-enterprise use cases, e.g., in supply chain management, as it can enable more transparency and security, in addition to automatization of data, material, and financial flows in supply chains (Petersen et al. 2018; Pournader et al. 2020). Nevertheless, these applications and related business models are still in the early stage of development (Morkunas et al. 2019). The successful implementation of tested prototypes and their continuation in the active business process seems challenging for many companies (Akram et al. 2020).

Amongst others, blockchain solutions need to be implemented in a network to tap their full potential. Most companies nowadays operate in complex, cross-enterprise value creation networks. Enterprise networks are defined as a dynamic and cross-company configuration of resources and competencies (Thoben and Jagdev 2001). Consequently, the actions of one firm influence all network partners within the enterprise ecosystem. Thus, companies that wish to successfully implement blockchain solutions within their enterprise network need to take the interests, needs, and challenges of all relevant actors into consideration. Likewise, introducing a blockchain solution strongly and directly impacts the business model. Thereby, not only is the business model of the initiating company subject to transformation concerning its supply chain or the new value propositions it may offer its clients or network partners but also the business model of respective network partners is affected. Therefore, crucial success factors for the implementation of blockchain solutions are not only the technical feasibility but also the respective business model. Only if suitable business models can be developed the technological solution will deploy its full potential.

Lambert (2006, p. 2) points out the importance of appropriate classification schemes in business model research because “business models are abstract, complex concepts whose understanding can be improved by developing a general classification scheme.” Taxonomies help researchers disentangle a complex research domain and facilitate classifying a wide range of research objects (Nickerson et al. 2013). Classifying objects and distinguishing them from each other is fundamental to theory building in an emerging and dynamic field (Williams et al. 2008), exemplified in this case by blockchain based business models. Archetypes can be derived based on a taxonomic analysis of a field of interest. Archetypal representations are used in various domains, including economics and information systems (IS). Basic conceptual representations are derived from archetypes. Archetypes provide basic conceptual representations from which manifestations are derived (Möller et al. 2019). Johnson refers to archetypes as an “original pattern from which copies are made” original pattern from which copies are made” (Johnson 1994, p. 289). Visualizing the taxonomy as a morphological box creates patterns, of which the central ones form the basis for archetypes. Deriving archetypes from taxonomy is considered purposeful because archetypes are “a basic human mechanism for organizing, summarizing and generalizing information about the world” “a basic human mechanism for organizing, summarizing and generalizing information about the world” (Souza et al. 2007, p. 2). Therefore, the paper poses the following research questions:

Research Question 1 (RQ1) What are the characteristics of blockchain business models in enterprise networks?

Research Question 2 (RQ2) What are archetypal blockchain business model patterns in enterprise networks?

To answer these research questions, the paper is structured as follows: After the preceding introduction, the theoretical background of blockchain technology in enterprise networks and (digital) business model theory is outlined, as well as the state of the art in the context of start-ups and blockchain-based business models. The following section explains the research design. A systematic literature review will be conducted, and empirical data will be collected. Then, a taxonomy for blockchain-based business models in enterprise networks is developed based on the scientific literature and empirical data. A cluster analysis is used as a statistical method to identify business model patterns and derive archetypes. Finally, the archetypes are presented, discussed and conclusions are drawn.

2 Research background

2.1 Blockchain solutions in enterprise networks

Blockchain technology describes decentralized or distributed IT infrastructures as a subset of distributed ledger technologies (DLT) (Beck et al. 2017; Große et al.

2020). In these infrastructures, accounts are no longer managed centrally by one instance but in a peer-to-peer (P2P) network without a central authority (Morabito 2017). Blockchain technology uses cryptographic mechanisms to encrypt data sent to the network and utilizes “blocks” to store transactions sequentially “chained” together. In this way, the data is distributed among the network participants represented by nodes who all possess the same data (Beck et al. 2017). After a block is validated, it is appended to the previous blocks, creating a chain called the blockchain. A new block is connected to the previous blocks, so it becomes increasingly difficult to remove it from the entire chain (Nakamoto 2008). Due to this interconnectedness of the blocks, transactions on the blockchain cannot be subsequently changed or removed. The blockchain is thus tamper-proof and creates a single point of truth (Große et al. 2021).

In addition, blockchain solutions can be categorized into public, private, and consortium blockchain solutions. Public blockchains grant access rights to the broader public and offer complete data transparency, most commonly applied in cryptocurrencies (Nakamoto 2008). In contrast, private and consortium blockchain solutions have permissioned access, read, and write authorizations either for one or more selected network members (private blockchain) or the whole consortium of members (consortium blockchain) (Dib et al. 2018). In current enterprise blockchain projects, private and consortium variants are used more frequently than public ones (Gürpınar et al. 2021).

Most enterprise projects focus on integrating the technology in supply chains or even broader enterprise networks rather than choosing application areas within the boundaries of a single enterprise. Only in this way can blockchain technology’s potential be fully utilized (Gürpınar et al. 2020). Enterprise networks do not only realize vertical and horizontal information exchange as well as information sharing between enterprises but aim to improve the efficiency of collaboration and thus reduce respective costs (Chen et al. 2021). The hurdles enterprise networks typically face are already well researched and focus on transaction costs that arise when collaborating—the so-called “friction” (Sheaff 2000). Therefore, the support of information systems is conducive to the collaborative management of enterprises in such networks to save transaction costs or even zero “friction” (Chen et al. 2021; Große et al. 2021). Blockchain technology seems promising for reducing transaction costs and increasing efficiency in complex enterprise networks.

2.2 Digital business models

The business model terminology emerged in the 1990s, and since then, business models have become increasingly important in research and industrial practice (Veit et al. 2014). Business model analysis has been established as a strategic management tool to support start-ups and established companies in evaluating their business logic and innovation management (Möller et al. 2020; Veit et al. 2014). However, despite the numerous scientific publications that have been released on

this topic, there is no unitary approach defining what a business model is (Morris et al. 2005; Rückeshäuser and Ostern 2017; Teece 2018). As a result of the application of the concept in specific research areas of individual scholars, divergent definitions have emerged in “silos” (Teece 2018). These definitions differ in terms of length, derivation approach, and content (Burkhart et al. 2011). Nevertheless, a growing consensus is that business models should be understood as an overall description and architecture of how a company creates, delivers, and captures value (Osterwalder et al. 2005; Shafer et al. 2005; Teece 2010).

Digitalization, as the major trend transforming entire supply chains, is the main driver for new business model innovations. The distinction between traditional and digital business models is commonly described as the transition from non-digital mechanisms for creating value to digital mechanisms (Bärenfanger and Otto 2015; Bock and Wiener 2017; El Sawy and Pereira 2013; Veit et al. 2014). However, previous research has found no common understanding of the definition of a “digital” business model (Bock and Wiener 2017). In the scientific literature, digital business models are often addressed using different terminology, such as data-driven business models (Engelbrecht et al. 2016; Kühne and Böhmman 2018; Möller et al. 2020; Zolnowski and Christiansen 2016) or platform business models (Remane et al. 2017; Veit et al. 2014). A common consensus concerning the digital business model is using digital technologies as a core element of business logic and extracting value and revenue from data (Hartmann et al. 2016; Möller et al. 2020).

Implementing new technologies always impacts business models by challenging existing mechanisms and creating new opportunities for value creation (Amit and Zott 2001; Teece 2010). Therefore, the underlying paper focuses on blockchain-based business models as a special type of digital business model. Potentials for new, blockchain-based business models can be realized in various industries, such as the financial sector, supply chain management, insurance, digital knowledge management, e-business, e-commerce, and the public sector (Friedlmaier et al. 2018; Glaser 2017). The importance of the digital business model for blockchain companies should not be underestimated. Due to its inherent characteristics, blockchain offers companies a promising potential to challenge their existing business model and create new forms of value creation (Iansiti and Lakhani 2017; Lacity 2018). At the organizational level, the business logic of a company that uses blockchain to a broader extent differs significantly from that of traditional companies. For example, business processes are decentralized and automated (Underwood 2016). Thereby, blockchain enables new value propositions, especially for customized assets (Mayer et al. 2021), with new products and service offerings based on transparency and trust. The use of disruptive technologies also influences the resources required and activities that are carried out (Morkunas et al. 2019). While traditionally, the production and sale of physical goods is a company’s core business, the service industry also plays a significant role in the economy. Blockchain technology encourages the trade of non-physical goods such as data, certificates, or even machine capacities and delivers a reliable data basis for services (Mayer et al. 2021). Thus, companies can not only enter new markets but deploy new and efficient value creation strategies leading to new income streams (Beinke et al. 2018; Nowiński and Kozma 2017; Subramanian

2017). Decentralization also changes the relationship and interaction between contractual partners. However, companies whose current business model acts as a core element in the intermediation between two transaction parties need to question how blockchain technology will change their value proposition, competition, and ways of working in the future (Morkunas et al. 2019). Through blockchain technology, it is possible, for example, to ensure traceability and information transparency as well as to make existing processes more efficient by reducing the number of dominant intermediaries (Kumar et al. 2020). Therefore, intermediaries are no longer necessary to build transparency and trust. Instead, direct cooperation between the contractual partners is strengthened, and value is created jointly within co-creation (Mayer et al. 2021). This is especially challenging for companies that benefit from information asymmetries and central information processing.

The most common current applications of blockchain technology are cryptocurrencies and tokenization (Tasca and Tessone 2019). A token is defined as “a sequence of characters that serves as an identifier for a specific asset (e.g., personalized usage rights) or asset type (e.g., a cryptocurrency)” (Sunyaev et al. 2021, p. 457). Tokens provide a tool to digitize all kinds of assets (Dai and Vasarhelyi 2017; Heines et al. 2021). Tokenization enables, for the first time, a digital representation of goods, ownership, currencies, artworks, or even services in the form of tradable tokens. Therefore, tokens can clearly define ownership and property rights, thus making the asset tradable, sharable, and transferable (Dai and Vasarhelyi 2017; Heines and Gürpınar 2022; Sunyaev et al. 2021). This tradability with respect to digital assets is a truly new value proposition: On the one hand, they can be used to create new digital values for the first time, transfer values between business partners, or to store assets (Heines and Gürpınar 2022). On the other hand, using tokens can also serve as an incentive mechanism to use a service (Oliveira et al. 2018). Thus, tokens help to achieve network effects within an ecosystem (Tönnissen et al. 2020). In terms of business models, companies can increase their value by rewarding participants with tokens or accepting tokens from third parties (Subramanian 2017). Moreover, the issued tokens can be a financing instrument for the issuing company (Chen 2018).

In summary, blockchain technology and its applications influence business models in various ways by creating new and changing existing business models. A growing number of new business models that would have been inconceivable or not economically viable without the technology are emerging. The extent to which blockchain affects business models and which archetypal business model patterns can be identified in enterprise networks is part of the further investigation of the underlying paper.

2.3 Recent knowledge of designing blockchain-based systems

Xu et al. (2019) present a taxonomy that covers essential dimensions to guide through blockchain specific functionalities. Their framework captures core design parameters of blockchain systems and enables users to compare multiple blockchain configurations in terms of implementation of their fundamental properties, cost

efficiency, performance, and flexibility. Building upon Xu et al. (2019), Notheisen (2019) taxonomy outlines further design options for blockchain configurations. The five resulting dimensions include network features, data storage, scalability, architectural features, and a deployment model. Wieninger et al. (2019) also address the basic features of a blockchain in their morphology to contribute to a better understanding of the technology itself. In their publication, the derivation and description of features and characteristics of blockchain technology are evaluated based on a comprehensive literature review. Based on the morphology developed, it is possible to distinguish basic types of blockchain technology using participation, application, and technology characteristics. Table 1 gives an overview of existing taxonomies and general systemizations in the literature adjacent to the topic.

Rückeshäuser and Ostern (2017) were among the first authors who examined blockchain start-ups and companies to develop a typology of blockchain business models. They also advocate the simultaneous analysis of the distributed ledger technology and the business model in future research. In addition, Beinke et al. (2018) follow a similar approach and develop a taxonomy of blockchain start-ups with a particular focus on business models of start-ups in the finance sector. The authors identified a total of 63 companies. Based on a cluster analysis, the authors derive five archetypes to describe business models. The authors also call for further research involving other industries and the analysis of additional business model characteristics. Moreover, Tasca and Tessone (2019) published a comparative study across the most widely known blockchain technologies and deconstructed the respective technologies into their relevant building blocks. Then, they are hierarchically classified into main and subcomponents. A taxonomy was developed to visualize the outcome. The work follows a holistic approach, and business model aspects are only considered marginally, as more focus is placed on technical functionalities. Weking et al. (2020b) developed a taxonomy, particularly on blockchain business models based on 99 blockchain ventures, to explore the impact of the technology on business models. As a result, five archetypal patterns that enhance understanding of how blockchain technology affects existing business models are identified. However, in their work, it remains unclear how the emergence of new business models can be influenced. Tönnissen et al. (2020) developed a taxonomy for analyzing 195 blockchain start-ups and performed a cluster analysis to identify three different archetypes. While extracting new findings about token-based approaches mainly in the finance sector, the work presents future research needs regarding incentives to be placed on blockchain stakeholders in industry sectors. Other authors, such as Seebacher et al. (2020) and Morkunas et al. (2019), only indirectly examine blockchain business models in their work. Seebacher et al. (2020) analyze the role of blockchain in digital platforms in their conceptual taxonomy. On the other hand, Morkunas et al. (2019) explore the factors influencing blockchain technology on business models in their work based on the Business Model Canvas developed by Osterwalder and Pigneur (2010). Thus, the purpose underlying the paper can contribute a new perspective on this topic, as it plans to focus especially on enterprise networks and applications from supply chain management—contrary to only the partial aspect of finance.

Table 1 Examples of topic-related taxonomies and systemizations

Source	Type	Description
Xu et al. (2019)	General taxonomy	Taxonomy on the general design of blockchain systems
Notheisen (2019)	General taxonomy	Taxonomy on the general design of blockchain systems
Wieninger et al. (2019)	General taxonomy	Taxonomy on the general design of blockchain systems
Rückeshäuser and Ostern (2017)	General typology	Typology of distributed ledger-based business models
Beinke et al. (2018)	Domain-specific taxonomy	Business model taxonomy of start-ups in the finance sector using blockchain
Tasca and Tessone (2019)	General taxonomy	Taxonomic deconstruction of blockchain-based technologies
Weking et al. (2020b)	General taxonomy	Taxonomy of blockchain-based business models
Tönissen et al. (2020)	Domain-specific taxonomy	Taxonomy of blockchain-based business models of start-ups focusing on token
Seebacher et al. (2020)	Domain-specific taxonomy	Taxonomy of blockchain platforms
Morkunas et al. (2019)	Case-study	Impact of blockchain technology using the Business model Canvas

3 Research design

Due to the novelty of blockchain technology, there is a limited body of knowledge on the outlined issues and presented research questions. In this paper, a systematic literature review is conducted to provide a comprehensive overview of the existing findings on the current state of the research topic and to avoid redundant investigations (vom Brocke et al. 2009). The paper builds upon literature findings and ensures practical relevance by collecting further empirical data from a start-up case analysis (Yin 2018). The findings extend the existing knowledge base derived from the literature and are systematized through a multidimensional taxonomy (Nickerson et al. 2013). Finally, a cluster analysis is conducted as a recommended method for identifying patterns in theoretical and empirical findings to derive archetypes that help establish universal concepts (Jain et al. 1999). An overview of the research design is presented in Fig. 1, while all steps are explained in detail in the following.

3.1 Systematic literature review and empirical case analysis

Based on a systematic literature review process, findings on the current state of research are consolidated over autumn 2022. Therefore, the review follows established guidelines within the Information Systems community (vom Brocke et al. 2009; Webster and Watson 2002). First, databases are selected to cover the major IS research journals and conference proceedings (Ferratt et al. 2007; Peffers and Ya 2003). To ensure the inclusion of high-quality papers that address any aspects of the developed research questions, peer-reviewed journals, and conference proceedings are considered through a systematic literature review. The databases AISel, Scopus, and ScienceDirect were screened with the following initial search string (*Blockchain OR “Distributed Ledger”*) AND (*“Business Model” OR “Value” OR “Business Strategy” OR Transformation*) AND (*“Supply Chain” OR Logistic OR “Enterprise network”*) to also include supply chain management topics. The scope of the literature review includes only peer-reviewed articles (Webster and Watson 2002) that explicitly impact the taxonomy’s development, i.e., have identifiable methodological components (Cooper 1988). These include either articles that present business

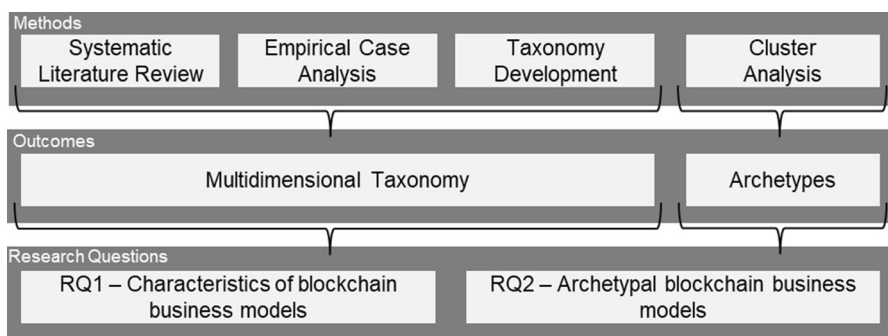


Fig. 1 Overview of the research design

model taxonomies in the mentioned topic as their contribution or are conceptual bases for the development of a taxonomy, as well as contributions that are useful for identifying characteristic features of blockchain business models. The latter destination requires a backward search, as this type of article is usually referenced in articles that present business model taxonomies. Since the initial search string did not reach the critical mass of literature, a second search string was defined. To expand the initial list of articles, the following search term was used to identify additional non-blockchain articles that have the potential to be applied to the research questions posed: “*Digital*” AND “*Business Model*” AND (“*Supply Chain Management*” OR “*Logistic*” OR “*SCM*” OR “*Enterprise network*”).

Figure 2 illustrates the summarized search process. In a manual final screening process, the individual articles’ titles, abstracts, and keywords were screened to remove irrelevant papers and duplicates. The full-text screening further reduced the results and formed the basis for the forward and backward search. In total, 52 relevant articles were identified through the literature search.

Empirical information is also collected and analyzed to incorporate practical implications into the development of the taxonomy. The method of data collection follows the approach of Täuscher and Laudien (2018), who based their method of data collection on Hartmann et al. (2016). As already outlined, blockchain technology is still a novel technology. Thus, the underlying paper focuses on start-ups to analyze emerging business models (Beinke et al. 2018; Weking et al. 2020b). The start-up database CrunchBase is used as the initial database for the empirical study to draw a sample of enterprise networks where blockchain technology is an integral part of their business model. CrunchBase is regarded as the world’s largest database for start-ups (Marra et al. 2015) (with over 70 million users and over 2 million registered companies), containing a wide range of business-related information about start-ups, such as investment and funding information, founding members, mergers and acquisitions, news, and various industry trends. The companies can be filtered according to various criteria, e.g., location, industry, and technologies. The subject of the data collection were all companies in the CrunchBase category “Blockchain” in the areas of “supply chain management,” “logistics,” and “enterprise networks” in autumn 2022. The inclusion of the search terms “supply chain management,” “logistics,” and “enterprise networks” is necessary because there is no clear distinction between these terms, especially in the English-speaking world (Cooper et al. 1997).

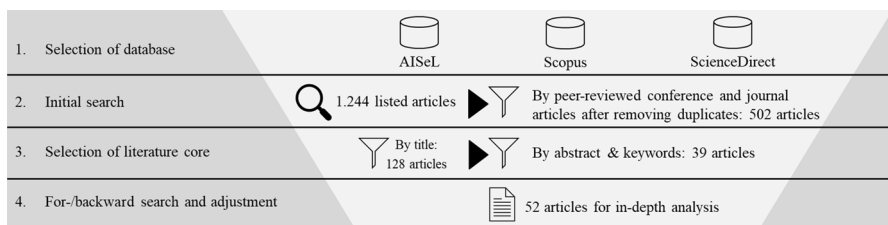


Fig. 2 Literature search process

The data collection resulted in a total of 1.024 hits after eliminating duplicates, a sample size of 990 companies could be selected.

To ensure that the sample contains only relevant companies, the following five criteria were used: First, only start-ups that have already received funding were admitted to ensure data quality and potential business success (Krishna et al. 2016). Second, no longer active companies were excluded (Möller et al. 2019). In other words, companies whose websites cannot be found are unavailable in English or German. Third, enterprises with no relation to supply chain management or enterprise networks were excluded. Fourth, companies' business models were analyzed to exclude those where blockchain technology is not an integral part of the business model (e.g., wallet providers or cryptocurrency exchanges) (Weking et al. 2020b). Fifth, the companies' business models were analyzed in more detail, and those companies that did not provide sufficient information about their business models were excluded (Täuscher and Laudien 2018). Following the approach of Tönnissen et al. (2020), primary sources, e.g., the company's website, interviews, and secondary sources, e.g., freely available articles, blog entries, and videos, were used to gather information. Some companies address a broad selection of use cases. An exemplary use case was selected according to the described criteria in this situation. Thus, multiple selections were excluded. In total, a list of 70 blockchain start-ups around supply chain management and enterprise networks could be compiled.

However, this initial sample from CrunchBase was too small to conduct a cluster analysis, so additional available data sources were added to the initial sample. The authors decided to use desk research to identify further companies. The main intention was to identify not only additional start-ups but also established companies, particularly ones already using blockchain technology, to achieve a heterogeneous and larger sample size. Even after using multiple databases, it was not easy to find suitable specimens. The existing textual and graphical data were coded and entered into a system of tables (in Microsoft Excel) and iteratively generalized (Möller et al. 2020). A code in this context is a "construct that symbolizes the individual data and thus assigns them interpreted meaning for subsequent pattern recognition, categorization, theory building, and other analytic processes" (Saldaña 2021, p. 4), making it an appropriate tool for this research. Since this type of research relies on publicly available data, filling in every company according to every dimension was impossible. Characteristics such as "unknown" or "unspecified" have been omitted from Table 2. The authors discussed each business's suitability against the selection criteria until a consensus was reached. The final sample consists of 101 companies that meet the selection criteria.

3.2 Taxonomy development

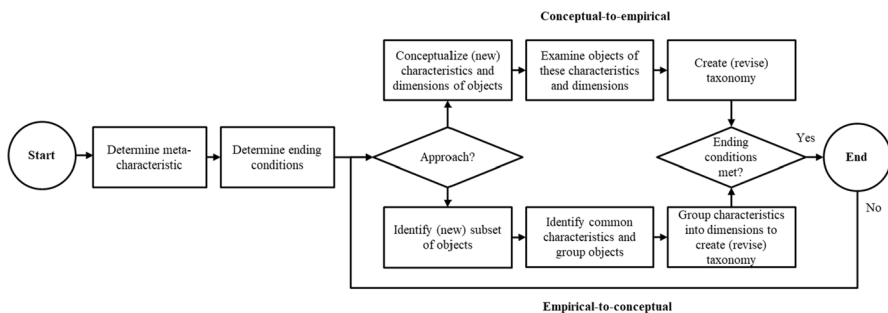
Taxonomies are an accepted method of classification in science that provides a systematic way of structuring the body of knowledge in a particular domain (Glass and Vessey 1995). Furthermore, taxonomies help to understand and explain complex phenomena (Nickerson et al. 2013). Their visualization as a morphology helps to draw empirical conclusions about the design of the phenomenon, i.e., its

Table 2 The data collection process of the case study enterprises

		Hits
Initial search	Blockchain AND “Logistics” OR “Supply Chain Management” OR “Enterprise Networks”	1.024
After check	After eliminating duplicates	990
	After the evaluation and adjustment process (Selection criteria: Only funded and active start-ups related to blockchain technology, business context logistics, or supply chain management, sufficient information is available)	70
Extended search	Extension of the search with additional databases	101

morphological configuration (Ritchey 2015). Thinking about patterns and configurations is valuable for business models because most business models are a recombination of existing patterns (Gassmann et al. 2016). In this paper, a taxonomy of design elements for blockchain-based business models in enterprise networks is developed based on the systematic literature review and the identified empirical data to achieve a systematic representation of blockchain-based business models to identify the impact factors of blockchain technology on business models. Therefore, the underlying taxonomy provides a structure to differentiate blockchain business models according to archetypal characteristics and reflects the extent of their current development, enabling the identification of gaps between research and practice. Developing the taxonomy “blockchain business models in enterprise networks” follows the established guideline in IS research by Nickerson et al. (2013). The methodology is based on the process model shown in Fig. 3, in which the taxonomy development steps are shown and discussed within the group of co-authors in structured peer debriefings (Lincoln et al. 1985).

At the beginning of the taxonomy development, a meta-characteristic must be defined, which represents the overall purpose of the taxonomy as well as the starting point from which all subordinate elements have to be derived. The second step is to define the ending conditions. These define the stage at which the taxonomy development is concluded. In this regard, Nickerson et al. (2013) list eight objective and five subjective ending conditions adapted to the present taxonomy development. The

**Fig. 3** Procedural model for taxonomy development (Nickerson et al. 2013)

third step is the conceptual design of the taxonomy. Here, one has to choose between an empirical-conceptual or a reverse approach. The taxonomy aims to link concepts widely used in the scientific literature with empirical data. Initially, the conceptual-empirical approach will be followed. Based on this, as many iterations as necessary using the empirical-conceptual approach. The approach is iteratively repeated until theoretical saturation is finally reached, i.e., until no further manipulation of dimensions and features is required.

3.3 Cluster analysis

Using cluster analysis to derive archetypes is seen as sensible, as archetypes represent basic patterns from which copies are derived (Johnson 1994). Cluster analysis is a statistical method for identifying similar structures in data sets (Jain et al. 1999). Archetypes represent these basic patterns. Performing a cluster analysis helps to categorize business models according to their similarities along the taxonomy's dimensions and characteristics (Möller et al. 2019). The statistical programming language R is used to conduct the cluster analysis. Software "packages" in R that provide functions for analysis, clustering, and visualization of data are provided by developers around the world (Gardener 2012). In this case, the "cluster" package, which contains various tools and functions for clustering, is used. Among others, the *Daisy* function (Dissimilarity Matrix Calculation) enables the evaluation of dissimilarities between datasets containing non-numerical values using the Gower coefficient (Gower 1971; Maechler et al. 2021).

According to the recommendations of Punj and Stewart (1983), some papers adopt two clustering algorithms to compare the results and increase the validity of the clustering. In this case, the authors use agglomerative hierarchical clustering and K-means. The agglomerative hierarchical clustering is performed in the first step according to Ward's method (Ward 1963). Agglomerative clustering aims to cluster objects based on their similarity. In contrast, other methods, such as complete, single, or average linkage, may result in less homogeneous clusters or tend to favor certain outliers. The Ward approach is iterative, analyzing each object individually and clustering all elements depending on their similarities (Eszergár-Kiss and Caesar 2017). Based on this, the K-means partitioning method is used. The K-means method is an iterative clustering method in which objects are clustered from a number of objects in several iterations based on an a priori-defined number of partitions (Jain 2010). The elbow method can be used to determine the optimal number of clusters. The elbow method is based on the assumption that no more added value is created for the data modeling beyond a certain number of clusters (Bholowalia and Kumar 2014). Following the approach of Weking et al. (2020b), the clusters were also analyzed qualitatively to ensure that they are separable (interheterogeneity) and that the individual clusters share common characteristics (intra-homogeneity). For this purpose, the solutions were discussed within the research group. The clustering solution's robustness is strengthened by comparing clustering results (Fred and Jain 2003; Wagner and Wagner 2007). Through this, the existence of the individual clusters can be confirmed.

4 Taxonomy design and result

4.1 Meta-characteristic and meta-dimensions

The meta-characteristic defines the goal and purpose of the taxonomy. This taxonomy reads as follows: “Key differentiating factors of blockchain-based business models in enterprise networks.” The meta-characteristic aims to identify the impact factors of blockchain technology on business models. It also enables identifying and describing underlying blockchain business model archetypes. Due to the comprehensive nature of some companies, the search is limited to key elements of business models.

A meta-dimension as a higher-level conceptual framework for dimensions, supports the targeted derivation of dimensions and characteristics (Remane et al. 2016). In this paper, the V^4 framework developed by Al-Debei et al. (2008) is used. The V^4 framework provides a high-level ontological structure for the business model concept, consisting of a four-part subdivision, that is already used especially in taxonomic analyses of digital business models (Bock and Wiener 2017; Möller et al. 2019). In addition to the V^4 framework, there are other frameworks, such as the VISOR-Framework by El Sawy and Pereira (2013). Publications such as Remane et al. (2016), Remane et al. (2017), and Möller et al. (2019) show that these frameworks seem to be more appropriate for specific taxonomies. According to Al-Debei et al.’s (2008) V^4 framework, the meta-dimensions taxonomy design parameters consist of the following four design variables: *Value Proposition*, *Value Architecture*, *Value Network*, *Value Finance*. The *Value Proposition* comprises a bundle of products and services that add value to a customer segment (Chesbrough 2010). The *Value Architecture* is the technological and organizational infrastructure to deliver products and services to customers (Al-Debei and Avison 2010). The *Value Network* comprises the actors creating the value proposition (Hamel 2002). The channels for value delivery and the roles and modalities of the network are also considered (Al-Debei and Avison 2010). The *Value Finance* provides a dimension that integrates both the revenue streams and the cost structure (Al-Debei et al. 2008).

4.2 Iteration overview

Four iterations were required to reach the final state in the underlying taxonomy development process. The first iteration provides a general frame of reference that serves as a conceptual starting point. Thus, the first iteration provides the conceptual meta-dimensions identified from the literature, specifically the V^4 framework by Al-Debei et al. (2008). In the second iteration, an initial conceptualization was conducted by identifying dimensions and characteristics through deductive reasoning and extraction from the results of the systematic literature review. Following Nickerson et al. (2013), this iteration is based on a conceptual-empirical development approach to derive an initial set of conceptually grounded dimensions and characteristics consistent with the meta-characteristics from the identified

academic literature on blockchain business models. Therefore, the first two iterations serve to identify initial dimensions and characteristics.

The subsequent iterations follow the empirical-conceptual approach (Nickerson et al. 2013). The authors chose an empirical approach to validate the conceptual taxonomic structure in the third iteration. The analysis of the blockchain business models was distributed among the authors. To this end, an initial sample size of 85 companies was classified. In this iteration, all dimensions that were important from a conceptual perspective but could not be validated by the empirical evaluation or required further adjustments due to their granularity were removed or revised. Following Janssen et al. (2020), with the revision, the conceptual taxonomy was systematically readjusted by (i) eliminating the characteristics that could not be empirically confirmed in any of the analyzed objects, (ii) merging similar characteristic expressions, (iii) splitting characteristics that proved to be too superficial or individual, (iv) as well as adding new ones that were identified during the research. To sum up, the third iteration validates the conceptually derived dimensions and characteristics and develops further dimensions and characteristics. The fourth iteration is also empirical-conceptual and has two functions: First, it completes the underlying analysis. Thus, it could be a source of dimensions and characteristics, and secondly, it serves to validate the results from the previous iterations. For this purpose, an additional subset of 16 blockchain start-ups has been chosen and analyzed for validation as they possessed business models with a stronger focus on supply chains. Each of the initial iterations resulted in a change to the existing composition of the dimensions, which led to the ending conditions not being met. This justified the further iterations until the taxonomy's refinement progressed to its fourth iteration, signifying the achievement of theoretical saturation. The analysis involved studying 101 companies, exhaustively exploring all characteristics and successfully addressed the research question, resulting in a robust taxonomy. Figure 4 summarizes the results of the iterations.

4.3 Final taxonomy

The final taxonomy with four meta-dimensions, 13 dimensions, and the associated characteristics is depicted in Table 3. Usually, taxonomies are based on mutually exclusive characteristics (Nickerson et al. 2013). Due to the nature of the identified characteristics, the authors have opted for non-exclusive characteristics in line with a morphological approach. This approach is suitable as it serves the purpose of the taxonomy as a visualization tool for blockchain business models. On the other hand, the additional creation of complexity requires a further generalization of the characteristic expressions, which creates an additional complexity driver. At the same time, it is not conducive to an unambiguous representation of the exemplars.

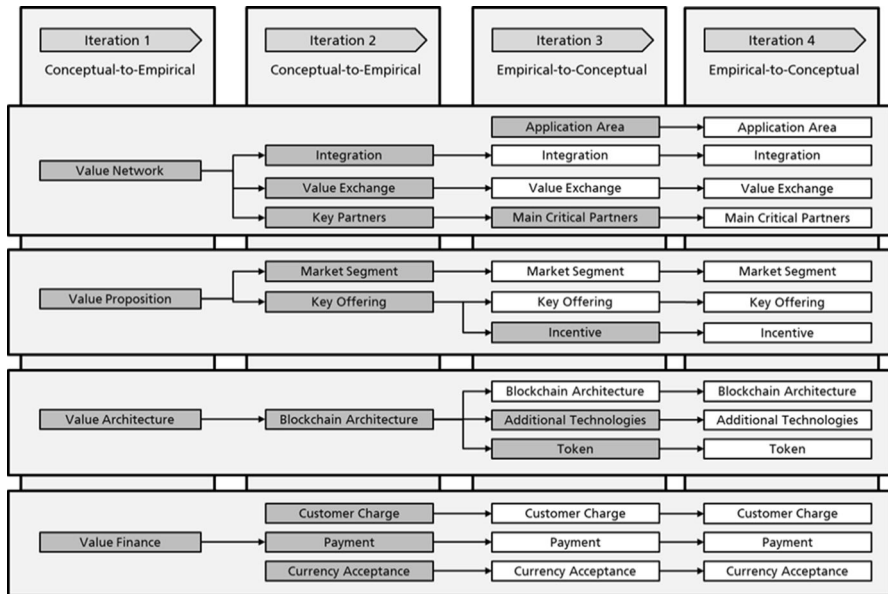


Fig. 4 Overview of the required iterations to design the dimensions of the taxonomy. *Light gray coloring = new or adapted dimension, Dark gray coloring = adopted dimension

Table 3 Taxonomy of blockchain business models

MD	Dimension	Characteristics						EX
Value Network	(1) Application Area	Servitization	Trading	Financing	Compliance Management	Cross-Company Exchange	Value Creation	Y
	(2) Integration	Stand-Alone	Horizontal		Vertical	Hybrid		Y
	(3) Main Critical Partners	Industry Partner	Regulators	Certifier & Verifier	Other	None		Y
	(4) Value Exchanges	Physical Assets		Digital Assets		Financial Assets		N
Value Proposition	(5) Market Segment	B2B		B2C		B2B & B2C		Y
	(6) Key Offering	Tracking & Tracing	Financial Transactions	Data Sharing	Marketplace	Tokenization	Fraud Prevention	Y
	(7) Incentive	Process Automation	End Customer Benefit	Transparency	Cost savings	Security Enhancement	Digitalization of Values	N
Value Architecture	(8) Blockchain Architecture (*)	Public	Consortium	Private	Hybrid	Not Given		Y
	(9) Additional Technologies (*)	IoT-Devices	Digital Twins	Artificial Intelligence	Other	None		N
	(10) Token	Utility Token	Payment Token	Asset Token		No Token		N
Value Finance	(11) Customer Charge	Free	One-Time Fee	Subscription	Pay-per-Use	Not Given		N
	(12) Payment	On-Chain Payment		Off-Chain Payment		Indirect Incomes		N
	(13) Currency Acceptance	Own Token		Crypto Currency		Fiat Currency		N

EX exclusivity, MD meta-dimension, Y yes, N no

*Dimensions are not considered in the following cluster analysis

4.3.1 Value network

The company's positioning within the value network is significant for describing a business model. A company has relationships with suppliers, partners, and customers through which it can achieve the provision of complementary goods, increase network effects, and add value to existing information systems (Rückeshäuser and Ostern 2017). The positioning of the business model in the value network shows where value is created for the customer in relation to the value chain (Chesbrough and Rosenbloom 2002). Therefore, the taxonomy takes a closer look at the dimensions of "Application Area," "Integration," "Critical Partners," and "Value Exchanges." The (1) *Application Area* describes which focus area the company's value proposition addresses. The underlying results indicate that the focus is either on *Servitization* (Weking et al. 2020a), *Trading* (Beinke et al. 2018), *Financing* (Beinke et al. 2018), *Compliance Management* (Wang et al. 2021), *Cross-Company Exchange* (Chong et al. 2019) or *Value Creation* (Chong et al. 2019). The dimension (2) *Integration* illustrates the way how products and services are integrated into the enterprise network. Blockchain solutions are often called networks, so more than one entity must be integrated (Gürpınar et al. 2020). A distinction is made between *Stand-Alone* (sole integration), *Horizontal* (integration on the same level), *Vertical* (integration of different levels), and *Hybrid* (integration on the same as well as on different levels) (Cui et al. 2020). The various entities needed to build the blockchain network can be characterized as (3) *Critical Partners*. These include the most important partnerships of the business model operator. Critical partners are partners without whom the business model cannot operate (Düdder et al. 2021; Rejeb et al. 2021). The evaluation of the empirical results reflects that *Industry Partners* (Weking et al. 2020b), *Regulators* (Martino 2021), *Certifiers and Verifiers* (Chang et al. 2018) can be critical partners; it is also possible that there is *no critical partner* in the corporate environment. Based on this, the dimension (4) *Value Exchanges* describes how values are exchanged (*Physical Assets*, *Digital Assets*, *Financial Assets*). Values can be exchanged physically as well as digitally and merely financially. The analysis of this study shows that a combination of individual characteristics is also possible (Corbet et al. 2018; Knezevic 2018).

4.3.2 Value proposition

A business model has to deliver a value proposition to the customer and hence solve an important problem or fulfill an essential need of a target customer by offering an appropriate product or service (Johnson et al. 2008). The value of a technology is reflected in the customer's willingness to pay for a product or service (Chesbrough and Rosenbloom 2002). Based on previous research and in line with the given definition and framework, the meta-dimension "Value Proposition" includes the dimensions "Market Segment," "Key Offering," and "Incentive." The dimension (5) *Market Segment* illustrates which customer group the product or the service is aimed at (Rückeshäuser and Ostern 2017). For meaningful inclusion in the taxonomy, an abstraction is necessary. Therefore, a three-part classification is used with B2B, B2C, or B2B & B2C (Beinke et al. 2018; Tönnissen et al. 2020). Due to the focus on

enterprise networks, market segments such as C2C are not part of the taxonomy. The dimension (6) *Key Offering* answers the question of what kind of value the company offers its customers. The evaluation of the empirical results and the academic literature indicate that the focus is either on *Tracking and Tracing* (Dujak and Sajter 2019), *Financial Transactions* (Morkunas et al. 2019), *Data Sharing* (Möller et al. 2019), *Marketplace* (Weking et al. 2020b), *Tokenization* (Weking et al. 2020b) or *Fraud Prevention* (Dujak and Sajter 2019) solutions. The dimension (7) *Incentive* reflects what motivates the customer or what the specific customer benefit is that the customer experiences from the product or service (Woodruff 1997). The customer benefits are *Process Automation* (Chang and Chen 2020), *End Customer Benefits* (Ali et al. 2021), *Transparency* (Ali et al. 2021), *Cost Savings* (Ko et al. 2018), *Security Enhancement* (Ali et al. 2021), and *Digitalization of Values* (Knezevic 2018).

4.3.3 Value architecture

The value architecture identifies a business model's technological and organizational infrastructure (Al-Debei and Avison 2010). This taxonomy includes the "Blockchain Architecture," "Additional Technologies," and the integration of "Tokens" into the business model. The (8) *Blockchain Architecture* determines the permissions. In the scientific literature and practice, the blockchain architecture is divided into the types *Public* (blockchain publicly accessible), *Consortium* (accessible to a certain group of users), and *Private* (blockchain available after registration) (Zheng et al. 2017). In addition, there are also cases where permissions can be ascribed to a *Hybrid* architecture (Desai et al. 2019). Blockchain solutions are usually versatile and complex. The evaluation of blockchain business models shows that limiting products and services solely to blockchain technology would often fall short. Rather, other technologies that complement each other and thus lead to a new value proposition are used in addition to blockchain (Gürpınar et al. 2022). For describing the business model infrastructure, combining blockchain with (9) *Additional Technologies* is of particular interest (Schlecht et al. 2021). Linking blockchain with the *Internet of Things (IoT)* is considered one of the "most popular applications of blockchain" (Choo et al. 2020, p. 983). Other technological combinations include the interaction of blockchain, *Digital Twins* (Yaqoob et al. 2020), and *Artificial Intelligence (AI)* (Salah et al. 2019). (10) *Tokens* represent a broad field of application within blockchain business models. Within a business model, blockchain tokens can represent a wide range of digital assets. Tokens can be used to transfer value between business partners or to store assets (Heines and Gürpınar 2022). They can also serve as an incentive mechanism to use a service (Oliveira et al. 2018) or help to achieve network effects within an ecosystem (Tönnissen et al. 2020). In the taxonomy, tokens are differentiated into *Utility Tokens* (similar to a voucher), *Payment Tokens* (focus on the payment function), and *Asset Tokens* (a kind of digital security) according to their use in the scientific literature (Oliveira et al. 2018).

4.3.4 Value finance

For the profitability of a business model, it is necessary to look at the financial perspective. A business model has to provide a consistent profit-making logic (Morris et al. 2005). This implies questions about what fee the customer pays, how payment is made, and what currencies are accepted. The (11) *Customer Charge* refers to the specific pattern of revenue generation, i.e., it explains how the company earns money or how the costs are incurred by the customer. Blockchain-based business models are considered a special type of digital business model. The evaluation of the company data proves that a distinction equivalent to digital business models in line with Möller et al. (2019) between *Free*, *One-Time Fee*, *Subscription*, and *Pay-per-Use* also applies to blockchain business models. The dimension (12) *Payment* describes how payment is processed. A distinction is made between traditional *On-Chain Payment*, *Off-Chain Payment* processed via the blockchain, and *Indirect Income* flows, which are usually attributable to open-source business models (Foulonneau and Martin 2014; Tasca and Tessone 2019). Based on the payment, the dimension (13) *Currency Acceptance* describes which currencies the operator accepts for payment. Often, implemented crypto tokens only deal with the transfer of ownership of their own tokens within a closed system. In this case, the transfer of value is based on its own underlying digital currency but may also have off-chain solutions to interact with other currencies (Tasca and Tessone 2019). Weking et al. (2020b) also use this dimension with a five-part subdivision. Within this taxonomy, the exclusivity of the characteristic expressions was dispensed with so that they could be condensed into three characteristics. A distinction is made between *Own Token*, established *Crypto-Currencies*, and traditional *Fiat-Currency*.

5 Derivation and discussion of archetypes

In scientific research, taxonomies are often used to generate clusters based on the taxonomy and then to generate archetypes from the clusters (Möller et al. 2022). Business model archetypes can be derived based on the analysis of the 101 blockchain companies, which were already used in developing the taxonomy. In line with the research design, the cluster analysis (see Sect. 3.3) is used as the foundation for archetypes (Csizér and Jamieson 2012).

Following Everitt et al. (2011) and Milligan (1996) several steps need to be utilized in a cluster analysis. First, relevant entities need to be selected and are already comprised of the described blockchain companies. Next, the authors describe the selection and standardization of variables. For this purpose, the company data was coded, entered into a table system (in Microsoft Excel), and iteratively generalized. The coding is based on a binary numbering scheme, which makes the characteristic properties shown in the taxonomy comparable for further analysis. In this context, the analysis of the empirical data showed a wide dispersion in the technical realization of the blockchain implementation framework. This is attributable to the dimensions of blockchain architecture and additional technologies. A comparison of the use cases within a cluster shows that although

they have the same intention, they can be technically realized differently. In addition to the wide range of possible implementations in the dimensions of blockchain architecture and additional technologies, there is also a high number of unknown characteristics in the dimension of blockchain architecture (54%). Due to this, the dimensions of blockchain architecture and additional technologies were excluded from the cluster analysis. Therefore, the database of all clusters is based on the similarities of the remaining variables of the individual objects. Furthermore, the author's advice is to select a specific clustering method. For this purpose, the Ward algorithm (Ward 1963) was applied to the data set. The Ward algorithm is often used for practical applications and is a hierarchical clustering algorithm that calculates the distances between all elements. In contrast to non-hierarchical partitioning algorithms such as the K-means algorithm, it has the advantage that it can be used without having to predefine a certain number of clusters. Combining hierarchical algorithms such as Ward's algorithm and the K-means algorithm is a recommended approach to take advantage of both types of algorithms (Balijepally et al. 2011). In the analysis, both hierarchical clustering using Ward's method as well as the K-means algorithm in R were applied.

The elbow method (Bholowalia and Kumar 2014) shows that the optimal number of clusters is between five and eight. To determine the partitioning results with the most comprehensive insight, the parameters are varied between five and eight partitions, and the results are compared based on the similarities between the patterns of each object across the dimensions and characteristics of the taxonomy. According to Möller et al. (2019) the following methods were chosen to assess the validity of the clustering result adequately:

- Manual verification of the clusters for meaningfulness (Rousseeuw 1987),
- and comparison of clustering results with different algorithms (Fred and Jain 2003).
- In the present case, hierarchical clustering and K-means results (Punj and Stewart 1983; Täuscher and Laudien 2018).
- In addition, outliers are identified and removed (Punj and Stewart 1983).

The matching of each clustering result with the dataset led to a consensus for the possible archetypes at $k=7$ clusters. The hierarchical clustering and K-means results proved comparable and indicated seven potential archetypes. Table 4 shows the distributions of the characteristics across the seven archetypes.

To evaluate the structural strength of the individual clusters, the silhouette width was also examined. The average silhouette width is used to determine the cluster validity for K-means. This method calculates the average length of the silhouette width. It thus provides a measure of cluster validity assessment, with strong cluster structures having a high average silhouette width, with a maximum numerical value of 1.00 (correct clustering) and a lowest of -1.00 (incorrect clustering) (Rousseeuw 1987). The first iteration of a sample of $n=101$ revealed seven clear outliers with a negative silhouette width value. By analyzing the dataset, the outliers were identified as exotic and comparable to the entire dataset. For example, outliers include companies that cannot be located exclusively in one use case. However, because

Table 4 Evaluation of the blockchain business model patterns

			Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7
			30	16	13	15	6	8	6
Value Network	Application Area	N							
		Servitization	0%	0%	23%	0%	0%	50%	0%
		Trading	0%	100%	8%	0%	0%	50%	0%
		Financing	0%	0%	0%	0%	100%	0%	0%
		Compliance Management	0%	0%	0%	33%	0%	0%	0%
		Cross-Company Exchange	100%	0%	69%	67%	0%	0%	0%
	Integration	Value Creation	0%	0%	0%	0%	0%	0%	100%
		Stand-Alone	3%	6%	8%	40%	17%	0%	100%
		Horizontal	3%	38%	85%	13%	17%	38%	0%
		Vertical	94%	44%	8%	47%	33%	38%	0%
	Value Exchanges	Hybride	0%	13%	0%	0%	33%	25%	0%
		Digital Assets	97%	100%	100%	100%	83%	100%	100%
		Financial Transactions	0%	75%	31%	0%	100%	88%	0%
	Main Critical Partner	Physical Assets	27%	13%	0%	0%	33%	50%	0%
		Industry Partner	76%	63%	8%	20%	67%	50%	0%
		Regulators	0%	0%	15%	20%	0%	25%	0%
		Certifier & Verifier	0%	0%	8%	33%	0%	0%	0%
		Other	0%	0%	8%	0%	0%	0%	0%
		None	21%	38%	62%	27%	33%	25%	100%
Value Proposition	Market Segment	B2B	97%	94%	69%	93%	83%	38%	100%
		B2C	0%	0%	23%	0%	0%	50%	0%
		B2B & B2C	3%	6%	8%	7%	17%	13%	0%
	Key Offering	Tracking & Tracing	79%	0%	8%	0%	0%	0%	0%
		Financial Transactions	0%	13%	0%	0%	100%	13%	0%
		Data Sharing	0%	0%	85%	27%	0%	0%	0%
		Marketplace	0%	88%	0%	0%	0%	88%	0%
		Tokenization	0%	0%	0%	0%	0%	0%	100%
		Fraud Prevention	21%	0%	8%	73%	0%	0%	0%
	Incentives	Process Automation	0%	50%	46%	0%	83%	0%	0%
		End Customer Benefit	36%	13%	15%	7%	0%	75%	0%
		Transparency	100%	75%	69%	20%	0%	50%	0%
		Cost Savings	0%	81%	31%	0%	100%	38%	0%
		Security Enhancement	0%	50%	69%	100%	67%	38%	0%
		Digitization of Values	0%	50%	69%	87%	17%	13%	100%
Value Architecture	Token	Utility-Token	0%	0%	0%	0%	0%	38%	67%
		Payment Token	0%	31%	0%	0%	0%	75%	67%
		Asset Token	12%	0%	23%	0%	0%	0%	100%
		No Token	88%	69%	77%	100%	100%	0%	0%
	Customer Charge	Free	9%	19%	46%	0%	0%	0%	0%
		One-Time Fee	9%	0%	0%	0%	17%	0%	67%
		Subscription	64%	38%	31%	33%	33%	13%	0%
		Pay-per-Use	3%	13%	31%	20%	67%	100%	0%
		Not Given	30%	31%	0%	47%	17%	0%	33%
		Off-Chain Payment	91%	81%	62%	100%	33%	13%	100%
	Payment	On-Chain Payment	3%	0%	8%	0%	67%	88%	0%
		Indirect Income	9%	19%	46%	0%	0%	0%	0%
		Own Token	0%	6%	0%	0%	0%	75%	0%
	Currency Acceptance	Crypto-Currency	0%	6%	0%	0%	33%	13%	0%
		Fiat-Currency	100%	100%	100%	100%	100%	100%	100%

Relative frequency of the characteristic expressions 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

N = sample size, the color scale represents the relative frequency of the characteristic expressions

their numbers are so small and their composition is unique compared to the others, they are identified as outliers. The goal is to identify archetypes as basic and representative patterns, so these outliers were excluded from further analysis. Thus, the final sample comprises a total of $n = 94$ companies. Table 5 provides an overview of the archetypes developed and a brief description of the underlying clusters.

The identified patterns show that business models around supply chain management and enterprise networks based on blockchain can be quite diverse. Business model pattern 1 “*Supply Chain Integration for Tracking and Tracing*” represents a

Table 5 Summary of the developed archetypes of blockchain business models in enterprise networks

#	Archetypes	Description
1	Supply chain integration for tracking and tracing	Providers of tracking and tracing solutions to increase transparency in supply chains. Practices include product traceability, product condition monitoring, and authenticity verification to combat counterfeit products. Some platforms also aim to integrate the end customer by providing access to product information and allowing for interaction with the manufacturer. Tokens can be used as payment or reward to intensify end-customer/supply chain partner interaction <i>Examples:</i> ChekkIt, PROVENANCE, Ownest
2	Decentralized B2B Trading Platforms	Decentralized marketplaces for the mediation of supply and demand. Contracts are processed using smart contracts, which are negotiated and paid for automatically. Error-prone manual processes are replaced by more efficient, transparent, and secure digital processes. Payment between actors can be token-based or traditional using fiat currency. Use cases include the mediation and organizational processing of transport services and the trade of goods and commodities <i>Examples:</i> dexFreight, Honeywell Aerospace, Grain Discovery
3	Supply chain data exchange	Digitalization of cross-company processes and services for more efficient and secure data exchange. Data such as freight documents, financial documents, or machine hours are digitized and automatically shared with designated partners along the supply chain. In addition, their ownership can be transferred in the form of asset token <i>Examples:</i> BitCargo, WAVE BL, CargoX
4	Secure and compliant digitalization of documents	Secure and compliant digitalization of certificates and identities to protect against fraud. Two fields of application can be distinguished. Digital credentials protect against fraud and create trust between trading partners, while digital certificates allow for immutable storage of documents or general data online. For example, certificates can be shared with third parties to provide proof to regulators or auditors. These business models are often used in highly regulated areas and require the involvement of issuers and verifiers <i>Examples:</i> TrustCerts, CertiCraft, Spherity
5	Facilitation and automation of financial transactions	Trade finance solutions that initiate transactions automatically and secure them via the blockchain. Some solutions also enable secure, everyday payment using cryptocurrencies. Especially in trade transactions, time-consuming paper-based processes can be automated and accelerated. Trade finance solutions often take a pay-per-use approach <i>Examples:</i> MarcoPolo, we.trade, OMC Group

Table 5 (continued)

#	Archetypes	Description
6	Service-oriented B2C marketplaces	<p>Platforms that promote the mediation between suppliers and consumers in the end customer sector. The fields of application are diverse and can be divided into the areas of trading user data, mediation and processing of services, and decentralized product marketplaces. Due to the end customer focus, utility or payment tokens are often applied as an incentive for participation and payment. The platforms aim to build an ecosystem for expanding new services</p> <p><i>Examples:</i> VINchain, QUASA, Farm2Kitchen</p>
7	Tokenization of assets	<p>Generation of new digital assets through tokenization. Tokens digitally represent tangible or intangible assets used in trading, payment, or reward processes. NFTs represent unique assets. As tokens are created using smart contracts, they cannot be duplicated and are therefore counterfeit-proof</p> <p><i>Examples:</i> ARXUM, Token Fabrik, Squire Mining</p>

traditional business model in supply chain management. Tracking and tracing solutions based on blockchain technology are offered here. In particular, the value proposition of transparency through blockchain technology and trustworthiness for all actors involved is focused on this business model. The services are often offered on a platform basis and thus contain intermediary elements despite the decentralized nature of blockchain technology. Business model pattern 2 “*Decentralized B2B Trading Platforms*” does not necessarily only represent logistics processes, it mainly enables the exchange and trade via decentralized marketplaces. In addition to conventional platforms, the focus is on automated, secure blockchain-based payments triggered by smart contracts. This increases security for all participants and reduces transaction costs because payment terms and modalities can be defined directly and with little effort by the participants. Business model 3 “*Supply Chain Data Exchange*” focuses primarily on secure data exchange along the supply chain. In contrast to business model pattern 1, it is primarily about business processes between specific companies that want to exchange data based on blockchain technology. This can be any form of information that is persistently recorded using blockchain technology. In addition to the secure exchange of data, the focus can also be on the exchange of documents, as in the case of business model 4 “*Secure and Compliant Digitization of Documents*.” In particular, certificates or documents can be exchanged between different parties in a trustworthy manner with the help of blockchain technology and often in conjunction with digital, decentralized identities. Blockchain technology, combined with digital, decentralized identities, enables the verification of the authenticity of information and the self-sovereign sharing of content. Next to the exchange of data or documents, blockchain-based payments are addressed in the context of business model pattern 5 “*Facilitation and Automation of Financial Transactions*.” Here, tokens can represent financial assets, automated payment processes can be triggered via smart contracts, or new revenue streams in pay-per-use business models can be enabled. Unlike the previous patterns, which focus on industrial customers, business model pattern 6 “*Service-Oriented B2C Marketplaces*” addresses end consumers. The goal of the platform providers is to create new service ecosystems and to enable new peer-to-peer experiences based on blockchain technology, for example, to connect producers with end-consumers directly. In this way, new distribution channels are realized, and intermediary structures are reduced. Finally, business model pattern 7 “*Tokenization of Assets*” offers the most far-reaching possibility of new forms of value creation. The tokenization of assets is less about supplementing an existing business model in process improvement but rather about new forms of value generation. Companies can tokenize machines and assets, company shares, or other forms of investment, thus exploring new ways of gaining capital.

Generally, it can be observed that business model patterns 1 to 6 mostly focus on easing existing processes. Blockchain technology allows the exchange of data and information and the integration and depiction of supply chain processes. Thereby, the technology is an enabler for digitalization as existing impediments such as lack of trust, asynchrony, and the problem of bottlenecks in central platform solutions are minimized. Thus, blockchain technology does not create entirely new business models per se but allows for the implementation of supply chain business models that

would otherwise not have been able to create the same value. However, unlike business model patterns 1 to 6, business model pattern 7 is not only an enabler for business models but goes one step further and can be seen as a creator and true business model innovation. Tokenization allows values to be mapped, provided with unambiguous authorship, and thus made tradable. Through tradability and divisibility, the possibility of value creation arises—which, in principle, is not limited. Especially in the art market, a real trend is emerging in NFT art—digital art in the form of non-fungible tokens (unique tokens) (Duisenov 2022). By overcoming costly actions that had to secure or demonstrate the validity or origin as well as the ownership, tokens create new markets and allow for direct trade through clarified ownership and possession rights. Consequently, new values emerging, especially from data and digital assets, can be realized for the first time. Especially for enterprise networks, the potential is huge: Supply chain and logistical processes monitor and create increasingly data-driven processes. The depiction through tokens could lead to entirely new business models and new ways of organizing existing market hierarchies.

6 Conclusion, limitations, and outlook

In this research, archetypes for blockchain-based business models were derived using a taxonomic analysis based on a sample of start-ups. RQ1 is addressed by constructing the taxonomy in Sect. 4, while RQ2 is addressed by deriving archetypes in Sect. 5.

Studies have highlighted the ability of blockchain solutions to change and disrupt existing business models and create entirely new business models (Casino et al. 2019; Weking et al. 2020b). Based on the scientific literature and an empirical set of 101 start-ups, a taxonomy on the topic of blockchain-based business models in enterprise networks was developed, which allows the classification of business models based on 13 dimensions and 48 characteristics. Although blockchain technology has been discussed in academic literature for several years, its implementation in industrial practice is still in its infancy. Therefore, there is a gap between the promises of science and the current business value (Gürpınar 2023). The extent to which blockchain technology encourages the emergence of new business models or impacts existing ones is part of the taxonomic analysis. Based on a subsequent cluster analysis using the initial sample of the 101 start-ups and enterprises, seven archetypes for blockchain-based business models could be identified in the context of enterprise networks.

In line with the research questions, the taxonomy shows how blockchain technology impacts business models: Based on the different value propositions, it became apparent which incentives and motivations exist to participate in blockchain-based enterprise networks. The first essential findings were obtained regarding the status quo of blockchain-based value creation in business models. The seven archetypes, respectively, and business model patterns show that blockchain technology is used in different but distinct ways. Both flows of goods, as well as information and data flows, and financial flows can be mapped. Blockchain technology is an integral part of all essential elements of supply chain management. Tremendous potential exists

for business models in improving processes and the possibility of entirely new ways of creating value. These new forms of value creation are enabled in connection with tokenization. New forms of payment and value generation are also emerging. Thus, the seven archetypes also characterize the technological impact on the design of business models and promote their understanding.

However, the taxonomy and subsequent cluster analysis are also limited by certain constraints (Nickerson et al. 2013). The processual procedure of taxonomy development is partly based on subjective assumptions (Möller et al. 2019). This includes the definition of meta-dimensions and suitable dimensions and characteristics. Another limitation relates to the collection of company data. The data collection is based on companies whose business model is blockchain-based in the context of enterprise networks. For this purpose, the start-up database CrunchBase and extended desk research were chosen. It cannot be ruled out that other relevant companies were not identified for developing and validating the taxonomy through this method. This contribution will be expanded by including further databases and companies to obtain a comprehensive understanding and identify emerging business models. Another aspect is the data basis of the coding process, which relies on publicly available information such as the companies' websites, existing technical or white papers, and the CrunchBase information. This approach strengthens the validity of the data set. Although the empirical data collection was done collectively within the research team and divergent assessments were discussed within the team, the data is sensitive to personal influences and preferences.

The investigations provide several research contributions. The scientific contribution relates to systematically analyzing blockchain-based business models in enterprise networks by identifying archetypes. In line with the scientific literature, an additional contribution to the body of scientific knowledge on blockchain business models can be made. For this purpose, this paper considers the development path of business model research with the three levels of business models (real-world cases, business model elements, and patterns) and the importance of taxonomy formation within research (Osterwalder et al. 2005). The taxonomy and its results serve to describe, classify, visualize, and analyze blockchain business models in the context of enterprise networks. In addition to the scientific contribution, the results also contribute to business practice. For practitioners, the results guide the assessment of opportunities and barriers to integrating blockchain into the prevailing business model. The results also inspire innovation to innovate existing business models and derive new business model innovations (Remane et al. 2016; Weking et al. 2018). Companies can use the archetypes in an ideation phase to identify the potential for using blockchain technology and realize their implementation in the corporate context.

As blockchain is still a young technology and not fully explored, this study grounds future research for various aspects. Most of the identified archetypes are found to be on the process level. The business potential of blockchain has not been exhausted so far and will continue to develop in the future. Therefore, future research can build on the taxonomy and the archetypal business model patterns. Additional research is needed on how the transformation from incremental process improvements to holistic business models can be realized based on blockchain technology.

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