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Blockchain-based connectivity within digital platforms and ecosystems in international business

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ABSTRACT

Digital globalization enabled by disruptive technologies has opened a myriad of ways to create value, warranting a cross-disciplinary research agenda on digital connectivity in international business (IB). Given the scarcity of understanding about the role of specific technologies enabling value creation through digital connectivity, we investigate how blockchain-based digital connectivity shapes value creation in international digital platforms and ecosystems (DPEs). Building on a comparative empirical analysis of international DPEs enabled by different types of blockchain technology, we develop a typology of blockchain-based connectivity in IB. The typology demonstrates how different blockchain technology types enable different kinds of connectivity, resulting in diverse approaches to value creation within newly emerging forms of DPEs. These findings contextualize the concept of digital connectivity, enabling more precise explanations of blockchain's adoption in DPEs, and expand the conceptualization of DPEs, with three new types emerging from the utilization of blockchain-based connectivity. Moreover, this interdisciplinary explanation reveals why certain features theoretically attributed to blockchain (e.g., decentralization, trust) do not always realize or support value creation in practice in IB based on the DPE business model.

1. Introduction

The fast-paced adoption of disruptive technologies in international business (IB) uplifts the importance of understanding "*a digital form of globalization*" or digital connectivity, in which markets, industries, companies, and individuals can become interconnected via digital means (Luo, 2022, p. 962–3). Thus, as multinational enterprises (MNEs) design their strategies and business models with digitalization in mind (Autio et al., 2021; Nambisan and Luo, 2021), scholarship's attention shifts to theorizing about value creation in business through digital connectivity enabled by *connectivity technologies* (Luo, 2022), such as blockchain, cloud services, artificial intelligence (AI), data analytics, and Internet-of-Things (IoT) (Ahi et al., 2022; Banalieva and Dhanaraj, 2019; Luo, 2022; Nambisan et al., 2019). The growing body of research on digital platforms and ecosystems (DPEs), i.e., a specific kind of MNE business model in which digital connectivity establishes the foundations for value creation through the interconnectedness of physical and/or digital assets, stakeholders, and their relationships across borders and industries, provides valuable insights on the general use of connectivity

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technologies to drive business (Khan et al., 2023; Nambisan et al., 2019; Stallkamp and Schotter, 2021). However, this body of research gives less attention to the specific features of each connectivity technology, and their influence on digital connectivity and value creation in DPEs.

This is especially true of studies exploring one specific kind of digital connectivity, blockchain-based connectivity enabled by blockchain technology. Blockchain technology – "*a type of Distributed Ledger Technology (DLT)…a database recording all the transactions or digital events that are executed and shared among the participants in the network*" (Yang et al., 2020, p. 2) – provides the supreme level of network connectivity when compared to other technologies (Ahi et al., 2022). In conceptual works within business studies, it is suggested to offer digital connectivity characterized by visibility, traceability (Ahi et al., 2022), decentralization, immutability, collective verification of information, code-based rules, and trust (Lumineau et al., 2021; Torres de Oliveira et al., 2020). In practice, however, these features of blockchain-based connectivity do not necessarily manifest or support value creation in DPEs. For instance, TradeLens – a blockchain-based platform ecosystem created by Maersk and IBM – was discontinued due to a lack of the expected trust and decentralization in the ecosystem's exchanges (see Jovanovic et al. (2022)). This and similar examples invite cross-disciplinary investigation aimed at explaining the incongruences observed between the extant theorization on the connectivity enabled by blockchain technology and empirical evidence. Thus, in this paper, we delve into particularities of blockchain technology, seeking to understand how they shape connectivity and value creation in various DPEs under specific conditions.

Utilizing secondary data, we zoom into the operations of five DPEs that adopt different types (*consortium private permissioned, consortium public permissioned, or public permissionless* (Sunyaev et al., 2021)) of blockchain technology in their operations. When comparing these cases, we first ask *what kind of connectivity different types of blockchains provide* and, second, *how blockchain type-specific connectivity changes our understanding of value creation enabled by digital connectivity within DPEs.* We benchmark these five cases with a dozen empirical equivalents, as well as a number of conceptualizations within the literature. When benchmarking, we explore how the five cases create value through the network advantage (Banalieva and Dhanaraj, 2019), and how they fit or do not into the extant conceptualization of DPEs (Nambisan et al., 2019). While our analysis focuses on connectivity enabled by blockchain technology, we acknowledge that none of the technology operates as a standalone driver of digital connectivity, and therefore we recognize the importance of related connectivity technologies (Ahi et al., 2022; Strange et al., 2022; Strange and Zucchella, 2017) in the studied cases.

We find that blockchain type-specific connectivity is different due to its socio-technological characteristics and has substantially different implications for value creation in international DPEs. The blockchain-based connectivity that is argued to be decentralized and providing default trust among the network participants (Lumineau et al., 2021; Torres de Oliveira et al., 2020) is, in fact, enabled only by one specific type of blockchain (*public permissionless blockchain*) and only when this type is adopted in specific kinds of DPEs: (1) those that create digital peer-to-peer ecosystems, e.g., Ethereum, or (2) those that develop the infrastructure needed to benefit from those ecosystems, e.g., SushiSwap. Moving beyond these two kinds of DPEs, the other blockchain technology types adopted in DPEs enable various forms of connectivity. Through further analysis of cases, we conclude that blockchain-based connectivity can be semi-centralized and distributed, combined, or decentralized. Each of the latter is adopted in a specific kind of emerging DPE to enable value creation.

Our study contributes to the growing literature on connectivity (Berman et al., 2020; Castellani et al., 2022; Goerzen, 2018; Lorenzen et al., 2020; Luo, 2022), blockchain (Davidson et al., 2018; Filippi and Hassan, 2016; Lumineau et al., 2021; Morkunas et al., 2019; Murray et al., 2021; Torres de Oliveira et al., 2020), and DPEs (Khan et al., 2023; Nambisan et al., 2019; Stallkamp and Schotter, 2021) by synthesizing scattered insights into an interdisciplinary explanation of how specific types of blockchain technology enable value creation within DPEs in IB. This integrative theorization allows us to explain why not all blockchains provide decentralized connectivity in practice (e.g., Jovanovic et al., 2022), contrasting with the many studies pointing to decentralization and trust as distinctive blockchain connectivity features that enable value creation in business (e.g., Lumineau et al., 2021; Morkunas et al., 2019; Torres de Oliveira et al., 2020). Moreover, our findings invite shifting away from the currently polarized discussions centering around either blockchain business applications, such as cryptocurrencies (Jalal et al., 2021), supply chain management solutions (Cole et al., 2019; Öz and Gören, 2019), or the utility of generic blockchain features (Du et al., 2023; Torres de Oliveira et al., 2020; Woodside Jr et al., 2017) that overemphasize blockchain's potential to enhance business operations, without a deeper exploration of the mechanisms enabling these enhancements. Finally, our study showcases the existence of five rather than two kinds of DPEs (Nambisan et al., 2019), enriching the DPE literature (Li et al., 2019; Nambisan et al., 2019; Stallkamp and Schotter, 2021) with the value creation approaches made available through blockchain-based connectivity.

2. The conceptual foundations of blockchain-based connectivity

2.1. Blockchain-based connectivity as a specific form of digital connectivity for value creation in DPEs

The changes in connectivity (interconnectedness of markets, industries, companies, and individuals) resulting from the development, adoption, and intelligent orchestration of connectivity technologies (Luo, 2022), such as cloud computing, IoT, blockchain, and AI (Ahi et al., 2022; Luo, 2022; Xu et al., 2018), disrupt MNE strategies and operations in multiple ways. Digital connectivity can transform the nature of MNEs' firm-specific advantages (FSAs) (Banalieva and Dhanaraj, 2019; Li et al., 2019) and internationalization patterns (Monaghan et al., 2020; Rong et al., 2022), and provide sophisticated ways to design and manage MNE operations (Ahi et al., 2022; Nambisan and Luo, 2021; Strange et al., 2022; Strange and Zucchella, 2017). Moreover, through digital connectivity, MNEs find new ways to manage their interactions with key stakeholders (e.g., suppliers, customers, partners), manage knowledge and innovations, and orchestrate subsidiary networks (Luo, 2022). Consequently, MNEs can drastically increase efficiency in cross-border operations, reduce information costs (Strange and Zucchella, 2017), and broaden their strategic resources due to the newly available network advantage, i.e., MNEs' ability to "*exchange information and enter foreign markets through digital networks*" (Banalieva and Dhanaraj, 2019, p. 1382; Stallkamp and Schotter, 2021). All the above drives significant interest in researching digital connectivity and its specific applications in IB management.

One of the fastest-growing bodies of research related to the applications of digital connectivity concerns DPEs. A DPE is a business model employing connectivity technologies to intelligently orchestrate various assets, stakeholders, and interactions across borders and sometimes industries (Nambisan et al., 2019; Stallkamp and Schotter, 2021). Nambisan et al. (2019) distinguish two types of digital platforms – *multisided marketplaces* (e.g., Uber, eBay, Youtube) and *venues for innovation* (e.g., Apple iOS, Google (Android), Ford (SYNC)). The former employ connectivity technologies to create value by orchestrating exchanges among platform participants (e.g., easing access to geographically dispersed customers or supporting interactions with the MNE's partners or suppliers). The latter utilize connectivity technologies to create value in multiple ways: co-creating related or complementary products within the ecosystem, innovatively reconnecting with customers or partners, or offering internationalization opportunities for other MNEs or born globals (Nambisan et al., 2019).

The MNEs adopting DPE as their primary or supplementary business model typically become DPE leaders. The DPE leader ought to orchestrate and align various partners globally and locally in the digital environment to ensure value creation through digital connectivity in the DPE (Li et al., 2019; Nambisan et al., 2019). This is because "*control of platform architecture – the very infrastructure upon which the platform is built – gives platform firms gate-keeping rights and a highly asymmetric level of power over a host of replaceable complementors*" (Li et al., 2019, p. 1452). Despite the control power that DPE leaders have, platforms are built on the assumption that value is created through the co-specialization of partners, and a DPE's longevity and success depends on the coordination among the partners, as well as the strength of the entire ecosystem, beyond the platform itself (Li et al., 2019). The DPE is based on a semi-centralized interdependent connectivity, enabled through applications and digital interfaces. The DPE partners can be global, but also local and embedded within local institutional environments (Rong et al., 2022). The value created in DPEs depends on whether the MNE is dependent on the scope of the local (e.g., food delivery DPEs) or cross-border (e.g., online travel booking platforms) network (Stallkamp and Schotter, 2021). In these networks, DPEs may co-specialize in creating digital offerings as well as bundling digital offerings with tangible products (Autio et al., 2021).

When exploring how digital connectivity enables value creation in DPEs through the orchestration of various assets, partnerships, and stakeholders, the scholarship bundles connectivity technologies together, assuming the connectivity these technologies provide can be generalized under one higher-order concept of digital connectivity. Therefore, whether the specific features of each connectivity technology influence the nature of digital connectivity and affect the ways of creating value in DPEs remains underexplored. However, several scholars have recognized that each technology is likely to offer specific implications for value creation in MNEs (Ahi et al., 2022; Strange et al., 2022; Strange and Zucchella, 2017), creating grounds for an extensive research agenda.

Exploring the effects of technological particularities on digital connectivity and on value creation in DPEs seems especially important for blockchain technology and the connectivity it enables. In the conceptual work on blockchain technology applications in business, blockchain is suggested to enable decentralization and automatically establish trust due to the code-based rules that effortlessly create peer-to-peer exchanges (e.g., Lumineau et al., 2021; Morkunas et al., 2019; Torres de Oliveira et al., 2020). However, emerging empirical studies point out that decentralization is not always achieved (Du et al., 2023), that trust in the blockchain-based business industry is negatively affected by social malpractices (Šilenskytė et al., 2022), and that in some cases blockchain-technology-enabled DPEs completely fail when the expected features of blockchain-based connectivity are not realized (e.g., Jovanovic et al., 2022). For example, the iconic project TradeLens mentioned earlier was discontinued due to unrealized commercial expectations (Maersk, 2022). Some of the primary challenges in making this ecosystem function effectively were related to a lack of trust and an inability to provide the level of decentralization the ecosystem's partners were expecting (Jovanovic et al., 2022).

These emerging empirical observations that are incongruent with the current conceptualization of blockchain-enabled value creation in business invite a deeper, cross-disciplinary analysis aimed at understanding the particularities of blockchain as technology, the influence of these particularities on the connectivity it enables, and the value it may or may not create in DPEs under different conditions.

2.2. Socio-technical foundations of blockchain-based connectivity

The particularities of blockchain technology can only be defined by going beyond its generalist conceptualizations in business studies and delving into technology-focused literature. While the general definition of blockchain mentioned earlier applies to all different types of blockchains, each type has distinct features, which offer diverse implications for connectivity. We now elaborate on these distinct features of each blockchain type, explaining how they are likely to shape blockchain-based connectivity among stakeholders using blockchain-enabled DPEs.

Technologically, blockchain refers to digitally recording information in a database by storing information pieces in 'blocks' and connecting these 'blocks' in an immutable, interconnected chain through specific encryptions (Zheng et al., 2017). This database, with the chain of blocks containing encrypted information, is then *distributed* on a *network of nodes*, i.e., several or many computers or servers (*not* a single computer or server as happens with regular databases), formed by various stakeholders (Zheng et al., 2017). Each node in the network is supposed to hold the entire information coded in the blockchain or a part of it (Zheng et al., 2017), i.e., information on the blockchain is *not* always accessible to everyone using it.

Depending on how the stakeholders creating the blockchain decide to govern the network of nodes in which the encrypted information will be hosted, the blockchain can be classified into one of four broad types (Sunyaev et al., 2021; Zheng et al., 2017): (a) (*consortium*) *private permissioned* (a closed distributed database used either by a single firm (e.g., an MNE and its units) or its consortium (i.e., several firms and their units from the same or different industries) to transfer and record information in a trustworthy way only among a clearly predefined number of stakeholders, with their access rights to the information on the blockchain strictly defined (e.g., Jovanovic et al., 2022)); (b) (*consortium*) *public permissioned* (a closed distributed *database infrastructure* created by a single firm or its consortium and partly opened to other stakeholders (by defining their access rights), who can use this infrastructure for their purposes (e.g., to record information or create products/services using the initial infrastructure provided to them), but without breaking the defined rules for using it); (c) (*consortium*) *private permissionless* (a private database based on blockchain that is provided as a cloud solution for a set of stakeholders who access the network on equal terms, enabling them to record information in a trustworthy way within the firm or the consortium, Blockchain-as-a-Service, e.g., "*a medical data storage system for a hospital*" in which doctors can add patient data (Grodzicka et al., 2021, p. 882)); and (d) *public permissionless* (a database distributed in an *open* network of nodes, i.e., accessible to anyone, that can be created and used by anybody (potentially even owning part of the infrastructure), with the economic and other gains from its usage and/or development shared (e.g., Zutshi et al., 2021)).

Because information on a blockchain is hosted in a *distributed* network of nodes owned by several stakeholders who have to agree on how information should be accessed, verified, and recorded, blockchain is a 'social' technology. The exchanges and verification of information among the nodes happen according to the predefined encoded blockchain rules. Permissioned blockchains can be tampered with, whereas public permissionless blockchain is nearly impossible to tamper (Zheng et al., 2017). The *motivation* to transact is ensured either by supplementary legal agreements regarding collaboration, signed among the stakeholders, e.g., organizations, using blockchain, or by predefined encoded rewards – cryptographical tokens – through which stakeholders earn benefits from transacting and/or using blockchain (Zheng et al., 2017). A cryptographical token – "*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) can also facilitate the distributing and sharing of rewards and benefits to all stakeholders on the network (Freni et al., 2022). In theory, all types of blockchains can have a token in one or another way, representing a unit of value. In practice, *private permissioned* and *private permissionless* blockchain networks tend to have no token and no token-supported connectivity of stakeholders; *public permissioned* blockchains seldom have them, and tokens are used primarily in *public permissionless* blockchains. As a result, *private* and *public permissioned* and *private permissionless* blockchains do *not* provide decentralized connectivity but enable semi-centralized and distributed connectivity, whereas *public permissionless* blockchain provides conceptually promised, decentralized connectivity, enabled by exclusively code-based rules (Zheng et al., 2017).

Creating a token as a digital encrypted representation of an asset that serves as a medium of exchange for the DPE participants (Freni et al., 2022), and pre-coded immutable rules on how the token can be gained or exchanged through interactions on the network, lays the foundations for building trust in the network exchanges, even when other social control mechanisms (i.e., legal agreements, MNE management system) are not in place. Thus, the use of various tokens in *public permissionless* blockchain-based DPEs to incentivize exchanges allows the creation of Web3 – decentralized connectivity enabled by crypto-economics and characterized by user-generated content and user-generated authority (Korpal and Scott, 2022).

The crypto-economics used to enable connectivity in public permissionless blockchain networks does not comply with capitalist economic principles. It utilizes blockchain as an institutional technology, i.e., considers it an institution that creates trust through code-based rules among network participants and therefore enables value exchanges and overall coordination of economic activity (Davidson et al., 2018; Sunyaev et al., 2021). The predetermined rules (code-based rules and protocol-level conditions, e.g., transaction fees, consensus mechanism, etc.) preempt stakeholder network manipulations in favor of some specific network participant, and

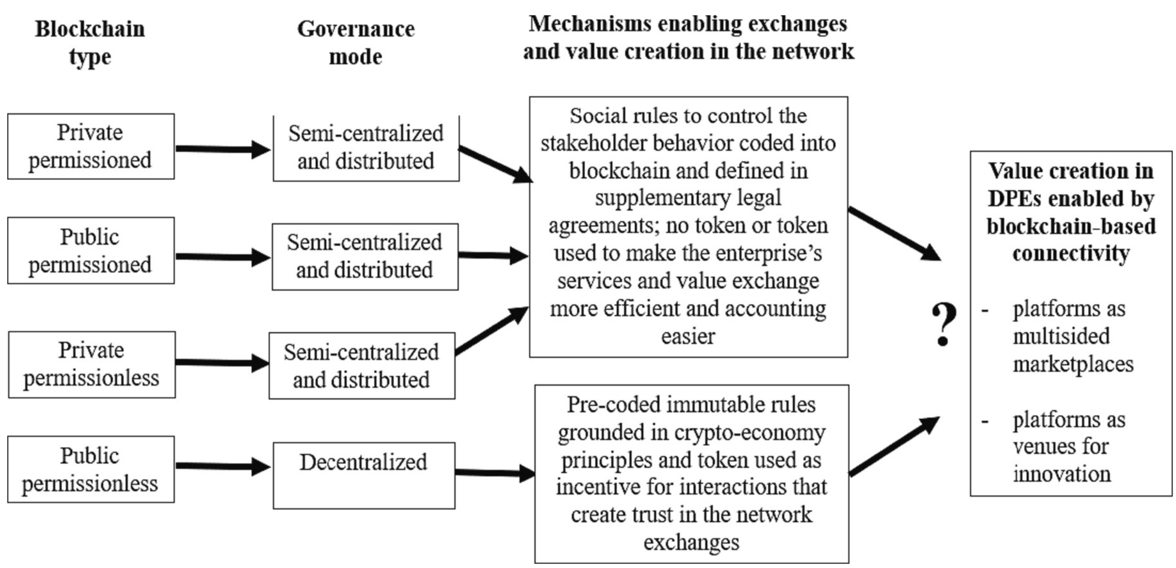

Fig. 1. Socio-technical foundations of blockchain-based connectivity.

incentivize individual autonomous stakeholders to act *in favor of the network* without misbehaving (Voshmgir and Zargham, 2020). In other words, the value created through decentralized connectivity enabled by public permissionless blockchain is entirely shared among *everyone* in the network.

Given the above, in Web3, tokens may provide not only economic but also social value: the right to work (e.g., by contributing to the DPE's development and receiving payment for it), the right to use services and content in the DPE, and the right to vote, through which decision making in, and the rules of, the DPE are created (Freni et al., 2022). The underlying value of the token is the representation of the level of trust towards the public permissionless blockchain network and the utility the token provides the token holders (Freni et al., 2022). To this end, public permissionless blockchain enables decentralized and codified governance mechanisms that oppose the semi-shared DPE coordination models.

The socio-technical features described above are summarized in Fig. 1, which serves as a heuristic framework for our empirical study.

We further conduct an empirical study to understand whether blockchain-based connectivity, as described in Fig. 1, manifests itself in international DPEs, and if it does, how the blockchain-type-specific connectivity changes our understanding of value creation in DPEs.

3. Research design: an abductive case study

Given the nature of our research question, we utilize a holistic rather than variable-specific case study approach (Piekkari and Welch, 2018) and compare representative cases (Siggelkow, 2007) to create a meaningful typology (Doty and Glick, 1994) of blockchain-based connectivity and its implications for value creation in DPEs. In line with suggestions by Snow and Ketchen Jr (2014), we utilize extant literature summarized in Fig. 1, as an initial framework for case analysis, to explore whether blockchain's existing technology typology makes sense when studying blockchain applications in international DPEs. We then explore more deeply how different blockchain types enable connectivity within the studied cases and how this connectivity is used to create value. The latter findings we juxtapose with insights on value creation within known forms of DPEs (Nambisan et al., 2019). Even if this analysis is guided with initial assumptions in mind (see Fig. 1), we allow our assumptions to be challenged by emerging empirical evidence (Dubois and Gadde, 2002): we iterate theoretical and empirical case analysis to distill those observations that meet the assumptions of extant theorization, and those that require additional conceptualization to capture an undertheorized phenomenon.

3.1. Case selection and analysis

To perform a holistic, in-depth analysis, we limit the number of cases and focus on several representative cases (Siggelkow, 2007), i.e., DPEs with distinctive success stories and long-lasting (in the highly volatile blockchain-based business industry) value creation pattern enabled by blockchain-based connectivity. To ensure our observations apply beyond the limited established sample, we compare the core cases with empirical equivalents, i.e., at least several other cases that utilize the same type of blockchain for value creation in DPEs. The study is holistic and we do not intend to 'test' identified variables across multiple cases (Piekkari and Welch, 2018). However, since we do intend to develop a conceptual typology that can be further quantified and tested (Doty and Glick, 1994), we apply the 'testing' logic in the case selection (Yin, 2009). The major underlying hypothesis behind our typology (Doty and Glick, 1994) is that a specific type of blockchain creates a different kind of connectivity that can be employed using a distinct approach for value creation in DPEs operating across borders.

Table 1
Cases that utilize blockchain-based connectivity to create value across borders.

Case and year of establishment	Brief description of case	Blockchain type adopted
IBM Food Trust (2017) (see Section 4.1)	The platform aims to address food safety and traceability challenges by providing a shared ledger that enables participants to track the journey of food products from farm to table.	Consortium private permissioned blockchain
Alastria (2017) (see Section 4.1)	Alastria is a non-profit association that promotes the development and adoption of blockchain technology. It aims to create a collaborative environment for businesses, institutions, and developers to leverage blockchain for various uses.	Consortium public permissioned blockchain
Animoca Brands (2014) (see Section 4.2)	Animoca Brands is a global digital entertainment company specializing in blockchain-based games and digital assets. The company develops and publishes various games, including popular titles based on renowned brands and intellectual property.	Public permissionless blockchain
SushiSwap (2020) (see Section 4.3)	SushiSwap is a decentralized cryptocurrency exchange (DEX) and automated market maker (AMM) protocol. It operates on the Ethereum blockchain and leverages smart contracts[a] to enable users to trade digital assets in a decentralized and permissionless manner.	Public permissionless blockchain
Ethereum (2013) (see Section 4.4)	Ethereum is a decentralized, open-source blockchain platform that enables the development and execution of smart contracts. It operates on a public permissionless blockchain, inviting anyone to participate in the network and build decentralized applications (dApps) on top of it.	Public permissionless blockchain

[a] Smart contracts are programmable self-executing code on the blockchain that automate processes, eliminating the need for intermediaries and providing secure and tamper-resistant execution: "*self-enforcing and self-executing programs which actuate the terms and conditions of a particular agreement using software codes and computational infrastructure. Smart contracts are decentralized programs that extend the use of the underlying blockchain network*" (Bashir, 2018).

Therefore, the cases are selected utilizing literal and theoretical replication logic (Yin, 2009). Literally, i.e., in line with the extant theorization, the cases are required to (a) be currently operating entities that adopt blockchain as a connectivity technology for value creation purposes; (b) be prominent in their area of operations for at least several years (Siggelkow, 2007); (c) have employed blockchain for value creation across borders rather than merely within local communities (i.e., qualify for an IB study); (d) utilize blockchain either as a main or a supplementary component of their DPE; and (e) provide a sufficient amount of secondary data to allow an understanding of how blockchain technology is used to create value in that specific DPE. Theoretically, i.e., expecting diversity in observations (Yin, 2009), the cases are required to adopt different types of blockchain, thus, a variety of blockchain-based connectivity is expected. Table 1 below briefly introduces the core cases.

The rich, publicly available data pool is analyzed holistically through comparison of cases and building of explanations (Yin, 2009) in an abductive manner (Dubois and Gadde, 2002), as described above. We do not perform detailed coding or create data structures, as this is irrelevant to this study's purpose and its holistic implementation approach. Instead, we identify organizations that can be meaningfully grouped (Doty and Glick, 1994) under a certain approach to value creation through blockchain-based connectivity, even if these cases are not identical. In the next section, we introduce the findings that directly feed into the development of the typology of blockchain-based connectivity and ways of creating value through such connectivity.

4. Value creation in DPEs through blockchain-based connectivity: the empirical evidence

When comparing the cases, we observe three types of blockchain-based connectivity: (1) semi-centralized and distributed connectivity without crypto-economics, (2) combined connectivity, and (3) decentralized connectivity with crypto-economics. Further, we provide details on each of these connectivity types manifesting in the cases.

4.1. Semi-centralized and distributed connectivity without crypto-economics: The cases of IBM Food Trust and Alastria

The IBM Food Trust, a DPE built on a *private permissioned* blockchain, links different stakeholders, i.e., organizations that are interconnected in a value chain (e.g., producers, "*feedlots, packers, processors, distribution centers and restaurants*"), to a consortium (IBM, n.d.). This DPE consists of the private permissioned blockchain hosted by several organizations in the value chain and linked to the add-on technologies, e.g., IoT, to monitor the food journey from the start to the end of the value chain (IBM, n.d.). IBM provides the technological framework built on Hyperledger Fabric for creating the blockchain-enabled DPE, and DPE-creating consortium members define who will use it, and how, for facilitating transparent and traceable exchanges in the food supply chain (IBM, 2020). Through the semi-centralized, partly distributed governance model defined by the consortium co-creators, stakeholders participating in the DPE can track the journey of food products (FoodTrust., 2018). The latter permits the creation of value because each stakeholder in the network can access information relevant to them, and real-time visibility optimizes inventory management and reduces waste, ensures compliance with regulations and certifications, facilitates international trade, and provides consumers with reliable product information (IBM, 2020). The IBM Food Trust case is from the food industry, but the blockchain-based connectivity and value creation approach in the DPE is very similar to that documented in the case of TradeLens (see Jovanovic et al. (2022)).

The IBM Food Trust can also be compared to Alastria. While the value creation path in Alastria's DPE is different from IBM Food Trust's (i.e., Alastria's DPE provides more opportunities for its stakeholders), the blockchain-based connectivity used to create value in the DPE is of the same kind – it is semi-centralized (i.e., stakeholders in the DPE can only do what the DPE's creators permit), distributed (several stakeholders hold 'block' validating nodes), and the exchanges in the DPE are enabled contractually rather than through exclusively code-based rules and crypto-economics. However, there are differences, too.

Alastria adopts *public permissioned blockchain* to create a platform for authorized and identified members, who can collaborate, share data, and develop blockchain-based solutions on the initially provided infrastructure. This means that Alastria utilizes public permissioned blockchain (Alastria, n.d.-a) as digital *infrastructure*, which can be *created* by selected member organizations (private or public) that are authorized to be in the network (Alastria, n.d.-c). The transactions on the network (public or private) are verified only by the network nodes (Alastria, n.d.-e), although anyone can view the network in the read-only mode since this information is publicly available. The members utilize this collectively created network to enrich their own operations: they can deploy applications on the network for commercial or public use (Alastria, n.d.-c); however, they cannot violate pre-defined rules, such as a ban on any activity related to the crypto-economics (Alastria, n.d.-d). Alastria creates value across borders using blockchain by enabling interoperability, facilitating trusted data exchange, addressing compliance challenges, promoting cross-border collaboration, and supporting business expansion and market access (Alastria, n.d.-e). For example, within Alastria, Altim Tecnologías de la Información has developed Biochain, a solution for certifying the states and documentation of the life cycle of the generation, transport, and production of biomass (Alastria, n.d.-b).

When juxtaposing these cases against the heuristic framework (see Fig. 1), we see that IBM Food Trust and Alastria adopt different kinds of blockchains with the same semi-centralized, distributed governance model, and benefit from the same kind of blockchain-based connectivity – semi-centralized and distributed without crypto-economics. However, the way the two cases create value in the DPEs is not the same as in currently known forms of DPEs. According to the value creation approach, IBM Food Trust and Alastria may be considered to be platforms used as venues for innovation, but they do not entirely comply with this conceptualization, since products/services in these DPEs are not always intended to be complementary or related, and the mission of the DPEs go beyond commercial benefits.

4.2. Combined connectivity: the case of Animoca Brands

Animoca Brands utilizes *public permissionless blockchain* technology with crypto-economics to facilitate community-driven initiatives, such as user-generated content, play-to-earn mechanics, and decentralized governance models (*EQUITY RESEARCH, n.d.*). The company fueled its operations with the famous *CryptoKitties* – the first game built on the Ethereum network, in which players collect, breed, and sell virtual cats (Ehrlich, 2022). Since then, the company has facilitated the trading or selling of digital assets across borders. Animoca Brands utilizes blockchain technology to ensure digital asset authenticity (i.e., non-fungible tokens - NFTs) and enhance the value of assets by allowing players to trade their assets peer-to-peer across various gaming experiences, regardless of geographical boundaries (Ehrlich, 2022; *EQUITY RESEARCH, n.d.*). The firm also utilizes security (i.e., investment) and utility (i.e., granting access to certain services or products) tokens to create additional network value for the firm, as well as a financial resource pool for growth (Top Animoca Brands Tokens by Market Capitalization, 2023). From the above, it may seem that Animoca Brands has adopted the decentralized governance model, as would be expected according to the initial assumptions illustrated in Fig. 1.

However, the firm operates within the traditional enterprise framework (it is a limited liability company); i.e., the distributed network does not entirely define how the MNE and its DPEs are governed or benefits shared. In addition to growing the MNE via crypto-economics principles and having various applications enriched by innovations based on public permissionless blockchain, the MNE has also grown in traditional ways through multiple acquisitions and through investing in firms experimenting with applications of public permissionless blockchain. Moreover, it has "*partnered with major brands such as Adidas, Atari, The Smurfs, and The Walking Dead for its virtual world game Sandbox*" (Animoca Brands, 2022).

In other words, Animoca Brands adopts public permissionless blockchain to innovate its business model and to enhance its products and services with decentralized, peer-to-peer interaction components. The MNE also uses DPEs with the decentralized governance mode, to benefit financially from new models of interacting with customers and investors. However, the governance model of the MNE and most of its DPEs is not entirely decentralized: Animoca Brands maintains some semi-centralized coordination through its DPE leadership and traditional enterprise format. The business model for value creation in this case is based on combining semi-centralized and decentralized blockchain-based connectivity grounded in crypto-economics. The value creation approach of Animoca Brands does not fit into the classification of currently known DPEs either (see Fig. 1).

4.3. Decentralized connectivity with crypto-economics: the cases of SushiSwap and Ethereum

The last two analyzed cases, however, have both decentralized governance among the 'shareholders' (token holders) and decentralized interconnectedness of all stakeholders. SushiSwap is a DPE built on *public permissionless blockchain* that extensively utilizes various kinds of tokens and principles of crypto-economics for decentralized peer-to-peer exchanges. Enabled by this blockchain, SushiSwap employs decentralized governance mechanisms, allowing token holders to participate in the decision-making processes of the DPE. Token holders from around the world can actively engage in voting and shaping the future direction of the DPE's protocol. This global participation ensures that decisions reflect the diverse perspectives and interests of the SushiSwap community across borders (SushiSwap, 2022b). Additionally, anyone from anywhere in the world can build smart contracts on the SushiSwap platform (Build on SushiSwap, 2023), further co-creating the platform.

In its market operations, SushiSwap empowers DPE users worldwide to participate in the decentralized cross-border finance ecosystem (Liu et al., n.d.; SushiSwap, 2022b) that has no leader coordinating the DPE activities. The use of smart contracts in the DPE ensures that transactions are executed as programmed, eliminating the need for intermediaries and reducing transaction costs. This transparency and efficiency benefits users engaging in cross-border trading by enabling faster settlement and reducing counterparty risks.

The decentralized governance mode without any DPE leader in the SushiSwap DPE allows it to maintain the financial well-being of the network, in which gains are shared collectively. For example, SushiSwap's liquidity pools ("*a place to pool tokens (otherwise known as liquidity)*") enable users to contribute their assets to the protocol, providing liquidity for various trading pairs (SushiSwap, 2023a). By aggregating liquidity across borders, SushiSwap enhances market depth, improves price stability, and facilitates seamless trading experiences. SushiSwap allows users to earn additional rewards by providing liquidity to the protocol. These rewards are distributed in the form of additional tokens, incentivizing users to contribute their assets to the network (SushiSwap, 2023a). Through blockchain-based yield farming (staking a specific kind of token whose value increases with every transaction in the network divided automatically *among all* holders of these special tokens), SushiSwap provides cross-border opportunities for users to earn passive income and participate in the decentralized finance (DeFi) ecosystem (SushiSwap, 2023b).

SushiSwap (Liu et al., n.d.; SushiSwap, 2022b), as a decentralized DPE consisting of several smart contracts and interfaces, connected to provide the service, is stored and executed on top of Ethereum (SushiSwap, 2022a). Ethereum – a decentralized open-source first-layer ecosystem based on *public permissionless blockchain* – enables developers to write code in multiple programming languages and deploy it on the Ethereum network, creating second-layer applications (Ethereum, 2022), such as SushiSwap and beyond. The decentralized nature of Ethereum ensures that transactions and computations are executed and verified by a network of nodes *distributed globally* (Tikhomirov, 2018).

To enable seamless transactions and a fuel for running smart contracts in an open, global network, Ethereum introduced its native cryptocurrency (a specific digital asset type) called Ether (ETH). Additionally, Ethereum supports the creation of other digital assets, i.e., many cryptocurrencies are linked with ETH (Ethereum, 2022). Ethereum's flexibility, programmability, and vast ecosystem of dApps have made it a popular platform for DeFi, NFTs, and various other applications that require trust, transparency, immutability, and the elimination of intermediaries. The programmability of the Ethereum network has made a significant impact on the development of decentralized technologies as, through smart contracts and digital asset issuance (tokenization), it has fueled initial coin offerings (ICOs) that have revolutionized the peer-to-peer capital-raising process for start-ups developing dApps and other projects in the blockchain ecosystem. Ethereum's blockchain fosters a global community of developers, entrepreneurs, and users who collaborate on open-source projects and contribute to the ecosystem (*Ethereum community,* n.d.). It also allows individuals from different countries to participate in shaping the future of decentralized technologies.

Therefore, both SushiSwap and Ethereum, while providing different opportunities for stakeholders in the DPE, utilize blockchain to enable an entirely decentralized governance mode for decentralized interconnectedness among all stakeholders, enacted by code-based transactions and token incentives, as illustrated in Fig. 1. However, based on the value-creating approach in the DPE, these cases do not fit under any currently known form of DPE.

4.4. Comparative analysis of cases that utilize blockchain-based connectivity

Table 2 summarizes the comparative analysis of all five cases analyzed above and indicates empirical equivalents to which these cases were additionally compared in the development of meaningful groups representing different kinds of blockchain-based connectivity.

Table 2 show that different kinds of blockchains create different kinds of connectivity that firms utilize to create value in DPEs spanning across borders. The primary differences in the blockchain-type-specific connectivity lie in the interconnectedness of network creators, contributors, and customers that it enables. Some blockchain types create similar connectivity but different approaches to creating value in DPEs. We also find three forms of DPEs that utilize blockchain-based connectivity to create value, but do not fit under the currently conceptualized forms of DPEs. In the next section, we further discuss these findings in the light of the literature, offering insights for its enhancement.

5. Discussion: creating value with blockchain-based connectivity in international DPEs

Digital connectivity (Luo, 2022), enabled by connectivity technologies (Ahi et al., 2022; Luo, 2022; Xu et al., 2018), opens many new avenues for creating value in DPEs that are partly integrated into MNEs' business models or become the main business model for the MNE, creating value across broders (Banalieva and Dhanaraj, 2019; Nambisan et al., 2019). This is because digital connectivity allows firms to benefit from network effects in addition to traditionally available resources (Banalieva and Dhanaraj, 2019; Li et al., 2019; Nambisan et al., 2019; Stallkamp and Schotter, 2021). Our study further contributes to this debate by exploring how digital

Table 2
Blockchain-based connectivity types and value creation in international DPEs they enable.

Type of connectivity	Semi-centralized, distributed connectivity	Combined: Semi-centralized and decentralized connectivity with crypto-economics	Decentralized connectivity with crypto-economics	
Blockchain and other connectivity technologies that enable each connectivity type	Blockchain *without* crypto-economics (potentially (consortium) private permissioned or public permissioned) in the applications and digital interfaces, potentially combined with other technologies, such as AI, IoT, cloud computing, and big data	Blockchain *with* crypto-economics (public permissionless blockchain) *combined* with the applications and digital interfaces and potentially supported by AI, cloud computing, big data, applications, and digital interfaces	Blockchain *with* crypto-economics (*always* public permissionless blockchain), which is potentially supported by AI, cloud computing, big data, applications, and digital interfaces	
Basic principles for creating value through blockchain as connectivity technology	Two-way connectivity, enhanced with some peer-to-peer exchanges, capitalist economics	Two-way connectivity in capitalist economics enhanced with peer-to-peer and decentralized connectivity enabled by crypto-economics	Peer-to-peer, decentralized connectivity enabled by crypto-economics	
Value created through blockchain-based connectivity	Enhances efficiency and effectiveness of MNE's internal and external operations; simplifies interactions among stakeholders in DPE; supports related business and product development within the DPE; enhances business models	Diversifies interactions among stakeholders in the DPE; innovates business model; diversifies MNE's and its DPE's funding schemes; creates additional monetary value for the DPE, its investors, and customers	Provides solutions for the first-layer ecosystem's (e.g., Ethereum's) users; creates additional monetary and other kinds of value for the solution-creating community, its investors, customers, and the DPE participants	Promotes related and unrelated business and product development; creates monetary and other kinds of value for both the ecosystem's users and co-creators
Case examples in the sample	IBM Food Trust, Alastria	Animoca Brands	SushiSwap	Ethereum
Empirical equivalents to the analyzed cases	TradeLens, Hyperledger	OpenSea, Binance, CoinBase, HyFi	AAVE, Uniswap, Balancer	Solana, Cardano, NEAR

connectivity, enabled by a specific blockchain technology type, affects interconnectedness and how this interconnectedness further shapes value creation in DPEs.

Based on our empirical findings, we suggest that, to understand value creation in DPEs that utilize blockchain for value creation, we need to explore three blockchain-based connectivity types: (1) semi-centralized and distributed connectivity without crypto-economics, (2) combined, and (3) decentralized with crypto-economic connectivity. These blockchain-based connectivity types are created through the use of specific types of blockchain. Some types of blockchain technology lead to similar blockchain-based connectivity types, but different approaches to creating value in the DPE. We elaborate on each blockchain connectivity type, explaining how it is utilized in emerging forms of DPEs.

5.1. Semi-centralized and distributed blockchain-based connectivity without crypto-economics, and platforms as venues for co-opetition

As illustrated by the cases of IBM Food Trust and Alastria, the connectivity that *permissioned blockchains* provide is conditional. The creators of the DPE clearly define who will access and record information in the blockchain-enabled network, and how, who will host and validate the nodes storing the information in the distributed network, and who is allowed to further co-create or enhance the technological infrastructure. Thus, the connectivity such blockchains provide is semi-centralized, yet (partly) distributed (Zheng et al., 2017).

Even if the transactions among the stakeholders are encoded and executed by programmed commands, they are initially defined by contractual agreements among the participating firms, or by an established management system within the firm. These social agreements, and not the motivators embedded in crypto-economics, are the foundations of control used to monitor the behavior of the permissioned blockchain-enabled network. As a result, trust among the DPE participants is not automatically given (it needs to be negotiated), even if the technology itself allows information to be secured and supports trustworthy transactions. The lack of trust upon entering the *conditioned* network is due to the possibility that permissioned blockchain can be tampered (Zheng et al., 2017), existing social mistrust, and other social barriers present among the consortium members, especially when they are competing or semi-competing firms within the value or supply chain (see Jovanovic et al., 2022).

The creators of such DPEs, just like in the currently conceptualized DPEs (Nambisan et al., 2019), have power over other stakeholders and can decide who enters the network, since the technology supports conditional access. If access to the network is granted, the stakeholders also have a copy of the stored network data (part or all of it, depending on the conditions regarding who can become a node for which information) (Zheng et al., 2017). Moreover, unlike in the currently conceptualized DPEs (Nambisan et al., 2019), the permissioned blockchain-enabled network is typically created to address a shared issue across the stakeholders, such as reducing unnecessary or untrustworthy intermediaries, ensuring the quality of product certification, reducing mistakes in multilayered transactions, or speeding up payments, among others. For example, in the studied cases, the issues concerned enhancing transparency in the food supply chain (IBM Food Trust) and the need for an infrastructure for creating solutions that would benefit multiple stakeholders in multiple industries (Alastria). Due to the shared nature of the issue to be solved via permissioned blockchain-based connectivity in such DPEs, the DPE leadership may be transferred to a third party representing consortium members, e.g., to an established association (see details in Jovanovic et al. (2022) or Alastria).

Given all the above, we conceptualize the DPEs that use semi-centralized and distributed blockchain-based connectivity without crypto-economics (such as IBM Food Trust or Alastria) as *platforms as venues for co-opetition.*

5.2. Combined blockchain-based connectivity, and platforms as venues for boundary-spanning

Public permissionless blockchain is based on the decentralized governance mode and provides connectivity for anyone anywhere on the open network (Sunyaev et al., 2021). To make such interconnectedness function, it employs crypto-economics embedded into the programmable code of the blockchain to motivate stakeholders to transact and trust the network (Davidson et al., 2018; Freni et al., 2022; Voshmgir and Zargham, 2020). The adoption of crypto-economics and tokens of different kinds to enable public, peer-to-peer connectivity, which happens beyond the control of the third party, has prompted a significant number of regulatory questions (Yano et al., 2020), since its principles fall beyond the currently used policy framework (Šilenskytė et al., 2022). Most importantly, decentralized blockchain-based connectivity with crypto-economics also introduces an entirely new mindset for defining and exchanging value through digital connectivity (Davidson et al., 2018), thereby resulting in many successful and not-so-successful applications in DPEs, as well as good and bad practices in the industry (Šilenskytė et al., 2022).

Under such conditions, many firms, such as Animoca Brands that we analyzed, try to combine the old way of defining and exchanging value in the networks (captured in capitalist principles), and the new way (captured in crypto-economics). As a result, a number of firms *combine* semi-centralized connectivity in DPEs with the new, decentralized, peer-to-peer connectivity incentivized by the use of diverse tokens. When MNEs create value in DPEs by utilizing various constellations of two-sided (semi-centralized) and peer-to-peer (decentralized) connectivity, we call them *platforms as venues for boundary-spanning.*

Combining the two economic logics, platforms used as venues for boundary-spanning (e.g., Animoca Brands, OpenSea, Binance, CoinBase, HyFi) enable inexperienced users to become familiar with decentralized connectivity. For example, in addition to the offerings of Animoca Brands discussed above, OpenSea allows the purchasing of NFTs, i.e., unique digital assets, in the platform, which acts as a multisided marketplace (Nambisan et al., 2019). CoinBase and Binance, as intermediaries, allow the exchange of fiat and cryptocurrencies in the semi-centralized DPE without direct participation in DeFi platforms, enabling boundary-spanning for users unfamiliar with peer-to-peer currency exchanges.

Thus, platforms as venues for boundary-spanning simultaneously have both (a) the legal entity that is meant to enable known DPE forms (Nambisan et al., 2019) and manage core and peripheral technologies (Banalieva and Dhanaraj, 2019) and (b) the decentralized DPEs for fund-raising and/or consumer engagement (e.g., through the issuing of their own tokens), or decentralized interaction elements based on crypto-economics embedded in their offerings for customers (e.g., the possibility to trade assets in the game, peer-to-peer, using tokens). By operating traditional DPEs (Nambisan et al., 2019) governed as limited companies, MNEs can hire and manage employees, create, purchase, and manage tangible and intangible assets, thus stabilizing DPE operations under turbulent crypto-market conditions, and manage and record fiat transactions, complying with existing institutional expectations for the business (Šilenskytė et al., forthcoming 2024). Simultaneously, by having decentralized governance enabled by public permissionless blockchain (i.e., decentralized authority organizations (DAO)) and a token of some kind, DPEs expand their offerings, funding sources, and customer pool globally.

The combined blockchain-based connectivity allows DPEs to combine physical and digital assets, too, like in some traditional DPEs (Rong et al., 2022; Stallkamp and Schotter, 2021). For example, HyFi – a publicly traded fintech company – utilizes peer-to-peer public permissionless blockchain-enabled connectivity to provide a funding platform for green initiatives. This means that sustainability-driven projects (e.g., solar power plants, wind farms, green hydrogen plants) developed by individuals or firms can be financed through the CeDeFi – centralized, decentralized financing mechanism – thereby merging classical regulated financing with the decentralized crypto-economy.

5.3. Decentralized blockchain-based connectivity with crypto-economics, and platforms as venues for virtual co-creation

The public permissionless blockchain enables the decentralized connectivity described above and therefore the creation of DPEs in which none of the intermediaries or leaders, including the MNE itself, is needed to produce value in economic activities, because technology and crypto-economics solve the issues of distrust and market inefficiencies (Freni et al., 2022; Zutshi et al., 2021). For example, Ethereum is global by nature DPE, which is *shared* among its co-creators and participants (Tönnissen et al., 2020). Empirical equivalents of such DPEs are, e.g., Solana, Cardano, NEAR. The socio-technical economic interactions on the public permissionless blockchain network allow the creation of DPEs that are entirely decentralized but have a trusted value creation and exchange mechanism (a native token or programmable money, e.g., Ether). In addition, these DPEs have a socio-technological infrastructure in which any other individual or firm in the world can innovate by building dApps (Ethereum, 2022; Tikhomirov, 2018). These DPEs promote related and unrelated virtual business and product development, create virtual monetary and other value for DPE co-creators and stakeholders (e.g., suppliers and customers), foster virtual relationships (e.g., market exchanges), and contain virtual assets and identities. This is why we call them *platforms as venues for virtual co-creation*.

These DPEs adhere to the changing global market needs, in which consumption is also exclusively virtual – the newly emerging consumer highly values digital rather than physical assets and products (Baranowski and Pandari, 2021) and the possibility to secure their personal data when consuming digitally (Banotra et al., 2021). Different tokens incentivize participation in the interactions within the DPE (Freni et al., 2022; Tönnissen et al., 2020), some of which serve as digital currency: "*digital assets designed to work as a medium of exchange using cryptography to secure the transactions and to control the creation of additional units of the currency*" (Osterrieder et al., 2017, p. 58). For example, the users of Ethereum's DPE are charged "gas" fees that make transactions in the network economically feasible (Tikhomirov, 2018). Since these DPEs have a unit of value for exchanges among the DPE participants, they do not need to be related to any fiat currencies existing in the current markets. Participation in the DPE exchanges happens exclusively virtually.

The co-creation is central to the success of this type of DPE, because these DPEs create value only when widely used and adopted (Voshmgir and Zargham, 2020). Those like Ethereum can be used in multiple ways, as they do not define or limit how they can be used. Thus, on top of the infrastructure providing DPEs like Ethereum, second-layer protocol solutions (Web3Foundation, n.d.), such as SushiSwap, or empirical equivalents such as Balancer, Uniswap, or AAVE, are developed. Co-creation between the first and second-layer protocol solutions is symbiotic, i.e., they enhance the value and usability of the DPE when co-existing. They do not create value in exactly the same way, but can still be meaningfully grouped under DPEs that aim for virtual co-creation enabled through decentralized blockchain-based connectivity with crypto-economics. This is because, crypto-economics is adopted together with the technology, and features in programmable assets, trust, ownership, money, identity, and contracts (Pouwelse et al., 2017; Weber and Staples, 2022), along with socio-economic incentive mechanisms that oppose market internalization ideas (Davidson et al., 2018). In other words, when public permissionless blockchain is adopted in DPEs as a venue for virtual co-creation, this technology becomes an institution (Davidson et al., 2018), eliminating institutions that regulate the market in a capitalist economy. The trust that no misbehavior, misjudgment, operational error, or uncertainty will happen in the DPE is further reassured through smart contracts (Bashir, 2018). All these technological mechanisms become feasible because the DPE is open to anyone on equal, pre-programmed terms, without any conditions.

This means that decentralized connectivity enabled by public permissionless blockchains with crypto-economics shifts away from the idea of value creation through resource orchestration led by the DPE's leader (Banalieva and Dhanaraj, 2019; Nambisan et al., 2019), and instead advocates economic entities that are capable of co-creating value for the *entire* network. This co-creation is enabled through tokens of a specific kind that may allow network participants to simultaneously be a 'shareholder,' 'rightsholder,' stakeholder, customer, and co-creator of the ecosystem if they wish. Consequently, if a DPE-based MNE were to *entirely* embrace such connectivity, it would cease to exist in the form we theorize in the extant IB literature. Instead, a new techno-socio-economic entity would emerge, which could be referred to as a *digital community enterprise* – a virtual, decentralized MNE co-creating and co-sharing value with all DPE users and participants through the trusted technological institution.

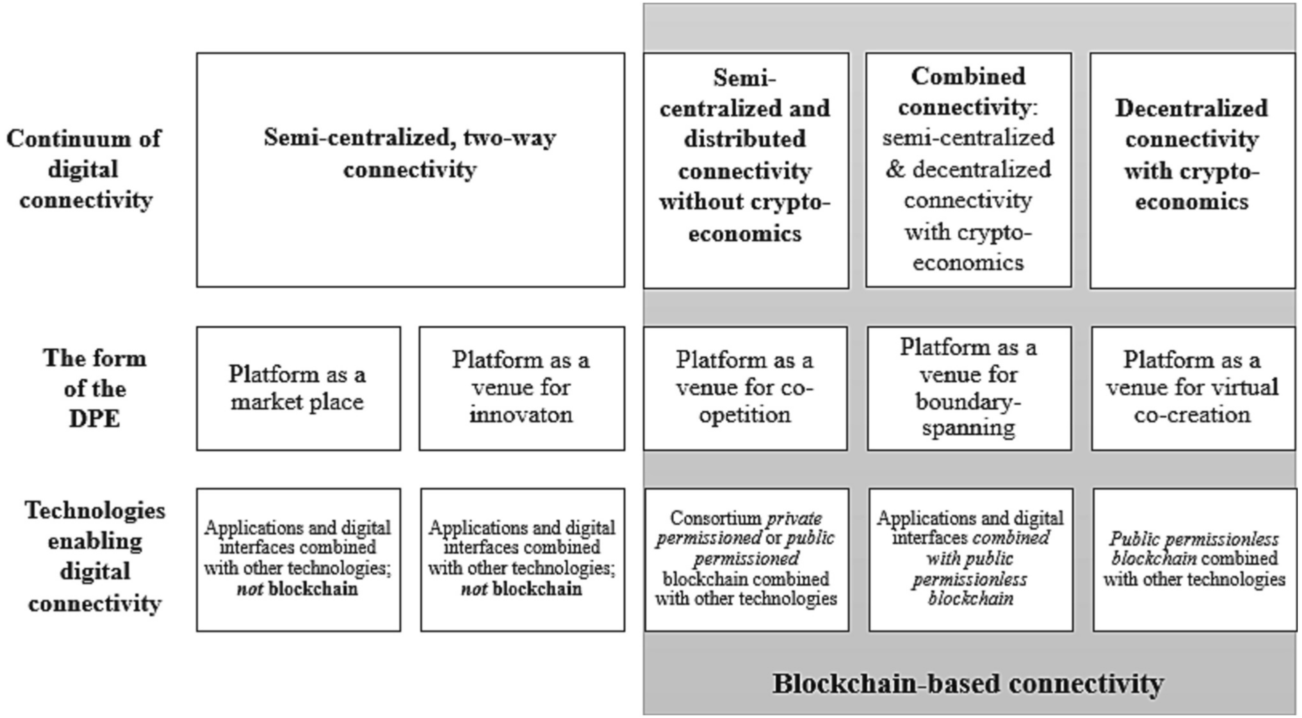

Fig. 2. Typology of blockchain-based connectivity to create value in international DPEs.

5.4. Typology of blockchain-based connectivity

The theoretical implications above are summarized in Fig. 2, representing a typology of blockchain-based connectivity that can be utilized for value creation in newly emerging forms of DPEs.

These new types of connectivity and DPEs have remained undiscovered before now because blockchain technology has usually been discussed without any exploration of its technological particularities (e.g., Lumineau et al., 2021; Morkunas et al., 2019; Murray et al., 2021; Torres de Oliveira et al., 2020). We demonstrate that exploring each connectivity technology on a separate basis can produce significant improvements in our understanding of digital connectivity, leading to a more precise theorization on how it is used to create value in DPEs. For example, our findings explain why emerging empirical evidence (e.g., Du et al., 2023; Jovanovic et al., 2022; Šilenskytė et al., 2022) sometimes counters the theoretical blockchain promise of decentralized, code-based interconnectedness in which trust is automatically given (Lumineau et al., 2021; Morkunas et al., 2019; Torres de Oliveira et al., 2020). These findings further reinforce the calls to explore implications of particular technologies on value creation in IB (Ahi et al., 2022; Strange and Zucchella, 2017).

Our findings and interdisciplinary typology synthesize and enrich the literature on connectivity (Berman et al., 2020; Castellani et al., 2022; Lorenzen et al., 2020; Luo, 2022), blockchain (Davidson et al., 2018; Filippi and Hassan, 2016; Lumineau et al., 2021; Morkunas et al., 2019; Murray et al., 2021; Torres de Oliveira et al., 2020), and DPEs (Nambisan et al., 2019; Stallkamp and Schotter, 2021), inviting scholars to further explore and test the relationships we have identified when studying blockchain technology's particularities.

5.5. Limitations and suggestions for future research

While making considerable contributions, this paper is not without limitations that highlight further research directions. First, we analyze a limited number of cases in an industry developing at the speed of light. It is very likely that, while we selected representative cases of each blockchain type and its connectivity, more constellations have emerged. Moreover, we do not broadly explore the diversity within token economics (Freni et al., 2022; Sunyaev et al., 2021) and various consensus mechanisms (Zheng et al., 2017) to completely shed light on peer-to-peer connectivity implications in DPEs. Thus, the typology we provide should be tested and further refined by expanding the case analysis and considering other potential types of connectivity and the DPEs in which they are applied.

Second, we do not elaborate on smart contracts (De Filippi et al., 2021; Herian, 2021), their standards and mechanisms, or their influence on blockchain-enabled peer-to-peer connectivity. Researchers should further explore whether the bundling of blockchain technology groups we provide is sufficient, or if it is necessary to delve deeper into technical aspects of protocol-level solutions to give an accurate representation of the connectivity that specific types of technology, such as blockchain, create. This would likely deepen the insights on various governance models and their applications. Overall, peer-to-peer connectivity enabled by public permissionless blockchain and crypto-economics is an exciting and novel direction for IB scholars to explore.

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Declaration of competing interest

None.

Data availability

Data will be made available on request.

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