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Coordinating Activity Interdependencies in the Contemporary Economy: The Principle of Distributed Control

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This study addresses the lack of knowledge about inter-organizational activity coordination in the contemporary economy. Existing understanding of economic coordination within inter-organizational research is based on the three modes of organization, market, and cooperative relationship. We extend the framework of Richardson that analyses specialization and complementarity within the industrial division of labour in terms of these three coordination modes. We propose a novel mode of coordinating economic activity, namely multi-actor arrangements, which is based on the coordination of very dissimilar yet complementary activities, grounded in the principle of distributed control. This fourth mode is necessary to explain contemporary phenomena such as the circular economy and blockchain because these involve interdependencies that were previously framed as too different or unrelated to coordinate. The extension is important because it changes our understanding of mixed-mode coordination. Our proposed fourth mode enables the conceptualization of how activity interdependencies are coordinated within inter-organizational relationships and networks undergoing transformation.

Introduction

It is well established that co-specialization in value-creation processes highlights the importance of coordinating inter-organizational activity interdependencies (Gulati and Singh, 1998; Hoetker and Mellewigt, 2009; Loasby, 1998; Porter and Kramer, 2011). Recent research suggests that increased connectivity is leading to interdependencies being reconfigured as boundaries between industries blur (Park, Ritala and Velu, 2021). We observe a contemporary economy characterized by the long-predicted *extreme connectivity* (Castells, 1996). It suggests that the industrial division of labour is both more complex and changing faster than previously.

Disruption and changes to industry dynamics increase uncertainty and complexity (Ahlstrom *et al.*, 2020), influencing existing industry boundaries. The challenge of coordinating reconfigured interdependencies impacts how inter-organizational activities are organized within and across industries. The challenge of coordinating highlights the importance of reshaping inter-organizational interaction (He *et al.*, 2020), resulting in changes to how, when, and where coordination takes place, and by and with whom (Hadida, Heide and Bell, 2019). Our point of departure is that contemporary phenomena such as the circular economy are expected to result in changes in how industries are organized (Yadav, 2018).

For example, materializing a circular economy requires activities within previously unconnected industries to be linked (Ghiselini, Cialani and Ulgiati, 2016), such as between materials recovery and core manufacturing in the automotive industry. This creates a need to coordinate new interdependencies in circular activity flows because technological and institutional developments imply associated changes in organizing (Langlois, 2003).

As a result, there is a need for new knowledge about how activities and processes are organized within inter-organizational relationship (IOR) research (Gulati, Puranam and Tushman, 2012; Lahiri, Cormican and Sampaio, 2021) because novel ways to coordinate are required (Hettich and Kreutzer, 2021; Schreyögg and Sydow, 2010; Srikanth and Puranam, 2011). The purpose of this paper is to address the lack of knowledge about inter-organizational activity coordination in the contemporary economy. Specifically, there is a gap in IOR research regarding inter-organizational activities formerly considered too different to coordinate, such as previously unrelated activities across industries. Such developments are transforming industries because they reshape human and organizational interaction (He *et al.*, 2020; Orlikowski and Scott, 2008).

This gap complements recent calls for novel directions in IOR research (Castañer and Oliveira, 2020; Lahiri, Cormican and Sampaio, 2021; Lumineau and Oliveira, 2018). It is significant for considering how to coordinate inter-organizational activity interdependencies within a variety of IOR arrangements, for example alliances (Das and Teng, 2001), aligned supply chains (Christopher, 2005), and business networks (Dubois, Hulthén and Sundquist, 2019; Håkansson *et al.*, 2009). This is, in particular, because the activity interdependencies observable have no obvious hierarchical control as in extended networks (Nakano, 2003), no dominant hub actor (Gray *et al.*, 1996), and no requirement of a common system-level goal as in a meta-organization (Gulati, Puranam and Tushman, 2012).

As such, this study addresses the following research question: '*What are the relevant modes that explain inter-organizational coordination in the contemporary economy?*' We answer this question by proposing an extension of Richardson (1972). His framework explains the industrial division of labour in terms of three modes of coordinating economic activity, namely the organization, market, and cooperative relationship. Similarity and complementarity underpin the activity types and coordination principles within these three modes. We posit that Richardson (1972) is the seminal paper when investigating inter-organizational coordination modes. We break new ground by proposing a new coordination mode, namely multi-actor arrangements. It is based on new activity types (very dissimilar) and a new coordination principle (distributed control).

The paper proceeds as follows. In the section 'Coordinating inter-organizational activities in relationships and networks', we provide a brief overview of coordination as a core theme within IOR (Castañer and Oliveira, 2020). Next, we outline Richardson's (1972) framework of three modes of coordinating economic activity in industries, and then provide a 50-year timeline of how the framework has been applied in terms of inter-organizational relationships, capabilities, and mixed modes. In the section 'Two illustrations of activity coordination in the contemporary economy', we provide two illustrations, namely circular economy and blockchain. The two illustrations share the requirement to coordinate previously unrelated activities across industries, thereby creating new activity interdependencies.

In the section 'A fourth coordination mode', we propose our extension. This has been developed by relating Richardson (1972) to Langlois (2003) regarding how changes in technology, institutions and organizing practices are closely related, along with the two illustrations. The fourth coordination mode is multi-actor arrangements, underpinned by the coordination of very dissimilar, complementary activities, based on the principle of distributed control. The contribution of the paper is therefore to propose a fourth coordination mode. The extension is important because it changes our understanding of mixed-mode coordination (Bradach and Eccles, 1989; Håkansson and Lind, 2004; Humphrey and Schmitz, 2001; Patrucco, 2014; Ritter, 2007; Sacchetti and Sugden, 2003) as based on four coordination modes. The new mode is essential for explaining the coordination of inter-organizational interdependencies in the contemporary economy.

Coordinating inter-organizational activities in relationships and networks

The need for intra-organizational coordination is a long-standing theme within organizational design, and indeed the reason for the existence of the firm (Thompson, 1967). Coordination, along with collaboration and cooperation, is one of three key themes within IOR research (Castañer and Oliveira, 2020). Inter-organizational coordination is necessitated by interdependencies from specialization (Loasby, 2012; Smith, 1976, 1776), requiring tasks/activities to be linked across firms (Briscoe and Rogan, 2016; Van de Ven, 1976). Institutionalization and technology drive specialization into specific configurations, ranging from the Smithian invisible hand, to the visible hand (Chandler, 1977), and the vanishing hand of Langlois (2003). Interdependencies result from the different intra-organizational knowledge bases underpinning the distributed capabilities needed to perform activities (Loasby, 1998; Richardson, 1972).

Coordination costs arise as tasks are separated across boundaries (Gulati and Singh, 1998), or in the '*division of labour across partners*' (Hoetker and Mellewigt, 2009, p. 1026). Debate centres on the bundles of formal and informal coordination mechanisms needed to handle Thompson's (1967) three types of interdependencies (Bygballe, Swärd and Vaagaasar, 2016; Gulati and Singh, 1998; Grandori, 1997; Van de Ven and Walker, 1984). Coordination mechanisms include '*routines*, *meetings*, *and plans*' (Okhuysen and Bechky, 2009, p. 46, Parmigiani and Mitchell, 2009). Other work focuses on coordinating, that is, on the work involved in creating coordination mechanisms (Jarzabkowski, Lê and Feldman, 2012) and the role of relational capabilities (Gittell, 2016).

The theme of complementarities within and across organizations also emphasizes activity coordination and interdependencies (Grandori and Soda, 2006; Lee and Kapoor, 2017; Teece, 1984; Whittington, Mayer and Curto, 1999). For example, value chains and activity designs such as value constellations (Normann and Ramírez, 1993) and value networks (Aarikka-Stenroos and Ritala, 2017).

Various frameworks for analysing inter-organizational coordination have been operationalized empirically in IOR research. Thompson's (1967) three types of interdependencies have been applied to inter-organizational activity analysis (Dubois, Hulthén and Pedersen, 2004; Fredriksson, 2006). For example, Fjeldstad *et al.* (2012) discuss alternative forms of organizing that are less reliant on hierarchy in their 'actor-oriented scheme' when describing architectures of collaboration, while Bankvall *et al.* (2010) delineate how different types of interdependencies co-exist within construction projects.

The activity–resource–actor model (Håkansson and Snehota, 1995; Håkansson *et al.*, 2009) within the industrial marketing and purchasing (IMP) approach conceptualizes activity coordination in business networks. The design and reconfiguration of activity interdependencies (Gadde, Hakansson and Persson, 2010) has been investigated along various themes, including network efficiency (Bayne, Schepis and Purchase, 2017). Some authors have adopted combinations of these coordination frameworks (Bankvall, 2014).

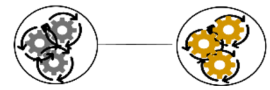
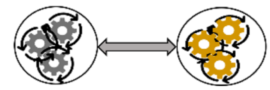
We have selected Richardson's (1972) framework to analyse inter-organizational coordination in the contemporary economy. It is the foundational paper for explaining the coordination of activity interdependencies because it explains the industrial division of labour using three coordination modes, with corresponding activity types and coordination principles. In the section 'Three modes of coordinating economic activity' below, we provide an overview of Richardson (1972).

Three modes of coordinating economic activity

Richardson (1972) theorized the industrial division of labour in terms of three modes of coordinating economic activity, namely organization, market transactions, and cooperative relationships. The three modes in which coordination occurs in industries are a continuum ('*we must not imagine that reality exhibits a sharp line of distinction*' (p. 887)). The conditions in which a coordination mode is suitable are based on the extent of similarity and complementarity of activities (see Table 1). That is, the specialization of activities within an industry varies by the mode of coordination, the type of activity to be performed (similar, complementary, and closely complementary), and the associated coordination principle (control, aggregate demands, and the matching of plans). Capabilities underpin each of the activity types.

The first coordination mode, organization, is when activities are to be coordinated '*jointly by one organisation*' (p. 890). The activities are 'directed' or coordinated within the organization by being '*…subject to a single control fitted into one coherent plan…*' (p. 890). The relevant coordination principle is that of control/internal consolidation. Activities can be either (i) complementary and similar or (ii) closely complementary and similar.

Table 1. Three modes of coordination in industries

Coordination modes	Activity types	Coordination principles	Graphical illustration
Organization (direction)	Complementary/Closely complementary & similar	Control/consolidation with one plan	Organisation A 
Market transactions	Complementary & dissimilar	Aggregate demands	Organisation A Organisation B 
Cooperative relationships	Closely complementary & dissimilar	Matching of plans	Organisation A Organisation B 

Note: (1) The fourth column provides a graphical representation for each row. (2) The circles indicate organizations that are performing activities (shown by the cogwheels). The thin lines identify market transactions, and the bidirectional arrows show the 'matching of plans' by two organizations in a cooperative relationship. (3) The size and colour of the cogwheels are significant as they denote the heterogeneity of activities. Activities of the same size and colour are similar, and cogwheels of different colours and sizes are increasingly dissimilar.

Similar activities '*require the same capability for their undertaking…the appropriate knowledge, experience and skill of an organisation*' (p. 888). In other words, similar activities are based on intra-organizational specialization. Activities that are sequentially dependent are termed complementary activities, or '*activities that represent different phases of a process of production requiring to be coordinated*' (p. 889). If two complementary activities require '*matching of plans*' (p. 890) or coordinating in advance within a large organization performing many activities, they are termed closely complementary activities.

The second mode of coordinating economic activity is market transactions. That is, '*the indirect consequence of successive interactive decisions*' (p. 890). The associated coordination principle is that of aggregate demand, or '*changing profit opportunities*' (p. 890). Activities are complementary (phases in a process) but dissimilar. They require different capabilities, or firms with different specializations that are complementary, but do not require prior matching of plans.

Richardson's contribution was to propose the cooperative relationship as the third mode of coordinating economic activity. That is, '*firms are not islands but are linked together in patterns of co-operation and affiliation*' (p. 895). The cooperative relationship is required to coordinate closely complementary and dissimilar activities. Two organizations with different capabilities coordinate through '*matching their plans in advance*' (p. 890) via '*the matching of particular activities…that are unique to the organisations involved*' (p. 891).

Cooperative relationships, capabilities and mixed coordination modes

Figure 1 provides a summary of how Richardson's framework has been applied from 1972 to 2022. A more extensive table is included in the Appendix.

In brief, within 10 years of their inception, Richardson's ideas were part of the debates around the nature of hybrid forms in the field of industrial organization. That is, Williamson (1975, 1981, 1983) and Richardson represented two different ways of governing hybrids (contractual transactions, cooperative relationships) when organizing vertically integrated production in industrial structures (Mariti and Smiley, 1983). Subsequently, researchers have applied Richardson's framework in three general overlapping ways: (i) cooperative relationships and networks, (ii) capabilities, and (iii) mixed coordination modes, which emphasize different arguments within the 1972 article.

Time period:	**1972-1985**	**1986-1990**	**1991-1995**	**1996-2000**	**2001-2005**	**2006-2010**	**2011-2015**	**2016-2022**
Theme 1: Cooperative relationships	*Nature of hybrid forms*	*Forms of cooperative relationships and networks*	*Frameworks for analysing network forms*	*Ways of organising division of labour*	*Modular production*	*Franchising*	*Cluster characteristics*	*Ecosystems*
Example papers	Williamson (1975, 1981, 1983) and Richardson (1972) are two different ways of coordinating hybrid forms. See also Langlois and Foss (1999).	Cooperative relationships as forms within networks (Powell, 1987; Bradach and Eccles, 1989).	Cooperation for inter-organisational technological development (Foray, 1991; Garud, 1994). Cooperative networks integrating closely complementary activities (Richardson, 1995).	Coordination mechanism (Grandori, 1997). Internationalisation of research and development and proximity (Blanc and Sierra, 1999)	Strategic networks (Gulati, Nohria and Zaheer, 2000). Global Value Chains (Humphrey and Schmitz, 2001). Coordination demands (Frederiksson and Gadde, 2005).	Entrepreneurship and firm boundaries (Loasby, 2007; Langlois, 2007). The dynamics of boundary choice in value chains (Jacobides and Winter, 2007). Technology and organising influencing vertical scope (Ciarli, Leoncini, Montresor and Valente, 2008).	Governance in the entrepreneurial theory of clusters (Pitelis, 2012). Cluster characteristics impact the types and extents of partner cooperation (Eigenhuller, Litzel and Fuchs, 2015).	Relocation of global production networks and new clusters (Gao, Dunford, Norcliffe and Lui, 2017). Foreign market network entry (Johanson and Johanson, 2021)
Theme 2: Capabilities	*N/A*	*Capabilities explain the boundary of the firm*	*Processes of capability acquisition based on similarity*	*Expansion of capabilities as a distinct theory of economic organisation*	*Small firms and modular production*	*Varying understandings of dynamic capabilities*	*Capability development in servitization*	*Capability development and activity interdependencies in ecosystems*
Example papers	- / -	Capabilities underpin the boundaries of the firm due to specialisation (Langlois, 1988). Assets as bundles of resources activities (Amit and Shoemaker, 1993).	Capabilities in strategic management theories (Mahoney and Pandian, 1992), and global strategy (Nohria and Garciapont, 1991). Capabilities' role in alliances (Gulati, 1995, 1998). Capability acquisition (Langlois and Robertson, 1995).	Difference between competences and capabilities (Foss, 1996). Efforts to combine parts of Transaction Cost Economics and Resource Based View to explain value creation through managing IOR (Madhok and Tallman, 1998).	Laosby (2000, p. 306): "*Penrose and Richardson link activities to capabilities".* Activity analysis of customisation and modular production (Frederiksson and Gadde, 2005).	System integration capability (Hobday, Davies and Prencipe, 2005). Capabilities are dynamic because they are in use (Loasby, 2010). Chandler's myriad contribution to 'capabilities theory' (Teece, 2010).	Evolutionary capabilities perspective (Andersen, 2011). Teece's (2014) review of dynamic and ordinary capabilities. Differences in the rate and potential of firm capability development (Rockart and Dutt, 2015).	The dynamics of project capabilities has multiple layers (Davies and Brady, 2016). Configurational activity interdependencies (Dubois, Hulthén and Sundquist, 2019).
Theme 3: Mixed modes	*N/A*	*Complementary coordination modes*	*N/A*	*N/A*	*Global value chains, subcontracting networks, and business relationships*	*Shifting complementarities among the three modes over time*	*Platforms combining coordination modes*	*N/A*
Example papers	- / -	Three control mechanisms are complementary and can be combined (Bradach and Eccles, 1989).	- / -	- / -	Different parts of a global value chain can be governed in different ways (Humphrey and Schmitz, 2001). Multiple coordination coexists in a complex relationship (Håkansson and Lind, 2004).	A 'nodularity theory of the firm' (Langlois, 2002, 2006). The drivers of vertical scope over time incorporate capability distribution at the industry level (Jacobides, 2008).	Platforms are hybrid modes combining coordination within both hierarchy and network modes (Patrucco, 2014)	- / -

Figure 1. Summary timeline of how Richardson's framework has been applied from 1972 to 2022

From the late 1980s onwards, there was a '*noticeable shift*' (Duguid, 2005, p. 453) to understanding cooperative relationships and networks as '*distinct organizational forms…rather than as mere hybrids*' (Blundel, 2002, p. 3). The existence of multiple forms of cooperative relationships and networks was highlighted (Bradach and Eccles, 1989; Powell, 1987, 1990), something that Richardson (1972, p. 883) also pointed to. The issue of vertical disaggregation (Child and Smith, 1987) was underlined in relation to geographical location (Blanc and Sierra, 1999; Scott, 1986) and technological development (Foray, 1991; Garud, 1994).

Various typologies of network forms (Garud and Kumaraswamy, 1995) and multi-layered frameworks for analysing business networks (Grandori and Soda, 1995; Håkansson and Snehota, 1995) expanded the scope in which specialization and complementarity were considered. In a later paper, Richardson (1995) discussed multiple relationships in '*cooperative networks*' (p. 1489) when '*integrating closely complementary activities*' (p. 1491). The resulting *systematic close complementarity* was said to require direction, but he did not elaborate on the design involved.

Empirical applications of network forms include strategic alliance and network formation (Chung, Singh and Lee, 2000; Gimeno, 2004), clusters (Lazzeretti, Sedita and Caloffi, 2014; Maskell and Malmberg, 2007; Pitelis, 2012; Steinle and Schiele, 2002), and supply chains and networks, such as global value chains (GVCs) (Humphrey and Schmitz, 2001), franchising (De Castro, Mota and Marnoto, 2009), projects (Davies and Brady, 2016), and, more recently, ecosystems (Andreoni, 2018; Wurth, Stam and Spigel, 2021).

Shifts in the forms of organizing production, such as modularity (Brusoni, Prencipe and Pavitt, 2001; Sturgeon, 2002, 2003), systems integration (Davies, 2004), subcontracting (Sacchetti and Sugden, 2003), delocalization/relocalization (Bellandi and Caloffi, 2008; Gao *et al.*, 2017), servitization (Spring and Araujo, 2013) and systemic innovation (Belussi, Sammarra and Sedita, 2010), have implications for specialization and complementarities because they change the division of labour in industries. For example, Davies (2004, p. 727) noted how integrated solutions for specific customers requires '*novel combinations of service capabilities*'.

Second, Richardson relied on Penrose (1959) to highlight differing '*organisation, knowledge, experience and skills*' (p. 888), or distributed capabilities. Hence, '*Penrose and Richardson link activities to capabilities*' (Loasby, 2000, p. 306). Initially, '*the idea of firm-specific capabilities did not fully catch on in management research…until the end of the 1980s*' (Argyres *et al.*, 2012). Capabilities were then employed to explain the boundaries of the firm due to specialization (Foss, 1999; Langlois, 1988; Langlois and Foss, 1999). For example, Langlois (1992) and Langlois and Robertson (1995) outlined how processes of capability acquisition are based on similarities to the existing capabilities of a firm, and that dissimilarity requires the utilization of the capabilities of other firms.

The distribution of capabilities underpins the heterogeneity of firms (Argyres and Zenger, 2012; Jacobides and Winter, 2005) and makes boundary choice in value chains a dynamic process (Jacobides and Winter, 2007). In '*a blurring of the boundary between production and exchange*' (Langlois and Foss, 1997, p. 15), both technological and coordinating capabilities are distributed across firms (Loasby, 1998). This incorporates strategic coordination capabilities, for resource utilization (Majumdar, 1998), for the ability to transact (Williamson, 1999), for managing strategic business nets (Möller, Rajala and Svahn, 2005), and in terms of system integration (Hobday, Davies and Prencipe, 2005). The distribution of capabilities can also be viewed as both direct (dyads) and indirect (network) (Araujo, Dubois and Gadde, 2003; Loasby, 1998; Spring and Araujo, 2014).

Richardson's (and Penrose's) ideas about capabilities were also incorporated within strategic management theories such as the resource-based view (RBV) (Holcomb and Hitt, 2007; Lockett and Thompson, 2001; Mahoney and Pandian, 1992), global strategy (Nohria and Garciapont, 1991), strategic alliances (Gulati, 1995, 1998), and stakeholder theory (Pitelis and Wahl, 1998). Richardson (1972) is also acknowledged as one of the foundational works underpinning 'the capabilities view' (Argyres *et al.*, 2012). For reviews explicating capabilities, competences, and the knowledge-based view, see Langlois and Foss (1997), Foss (1996, 2003). For reviews of dynamic capabilities, see Teece (2014, 2017).

Empirical analyses of business networks using Richardson's (1972) framework have investigated how to organize inter-organizational activity interdependencies in terms of outsourcing, customization, and modularity (Baraldi *et al.*, 2014; Dubois, 1998; Dubois, Hulthén and Pedersen, 2004; von Corswant and Fredriksson, 2002), which impacts capability development (Finch, 2003, Mota and de Castro, 2004). For example, von Corswant, Dubois and Fredriksson (2003) analysed the distribution of activities between a key customer and their suppliers in the auto industry. Coordination was based on similar activities being performed by both customers and suppliers, leading to the conceptualization of *similar and closely complementary activities* (the same capability/resources located in two different firms performing the same activities). Fredriksson and Gadde (2005) investigated how customized mass production increases coordination demands owing to increased complementarity. Recent contributions have assessed activity interdependencies in product recovery networks (Insanic and Gadde, 2014), and efficiency within 'coordinated configurations' across construction sites and supply chains (Dubois, Hulthén and Sundquist, 2019).

Third, in terms of the mixed nature of the three modes, Sacchetti and Sugden (2003, p. 672) point to the two-fold nature of Richardson's contribution: '*when looking at real industry, there may be mixed situations for which the triple distinction needs to be applied "with discretion"*' (Richardson, 1972, p. 896). The complementary nature of the three coordination modes was also discussed by Bradach and Eccles (1989, p. 98), in arguing how multiple control mechanisms are '*mixed together empirically*' rather than being substitutes.

The messy empirical reality was later emphasized in supply settings, for example in the varying modes co-existing within a GVC (Humphrey and Schmitz, 2001) and impacting power dynamics within the governance of subcontracting networks (Sacchetti and Sugden, 2003). Relationship governance also involves the co-existence of the three modes within a single relationship (Håkansson and Lind, 2004; Ritter, 2007). Furthermore, industry evolution and governance modes interface (Cacciatori and Jacobides, 2005), such as in terms of how coordination within both hierarchy and cooperative relationships is combined through platforms (Patrucco, 2014). 'Mixed governance' therefore varies over time as well as space (Jacobides, 2008), for example via the dynamics of mundane transaction costs (Langlois, 2002, 2006).

Coordinating previously unrelated activities

We are extending Richardson's (1972) framework to conceptualize the coordination of inter-organizational activity interdependencies within contemporary 'complex, uncertain business environments' (Ahlstrom *et al.*, 2020). Such business environments change competitive dynamics by impacting existing industry structures. This influences how inter-organizational activities are organized both within and across industries (Hagedoorn, Lokshin and Zobel, 2018). Richardson points towards the division of labour within and across industries being both (i) more complex and (ii) changing faster, than previously.

We can consider the implications for activity coordination by relating Richardson's framework to Langlois' (2003) characterization of disruption and other change drivers via technology, institutions and organizing. Technologies are the entire collection of '*devices and engineering practices available*' (Arthur, 2009, p. 28). Institutions are governance structures that facilitate coordination, which help organizations form expectations (Granovetter, 1992).

Technology, institutions, and organizing are said to change at different rates, with the latter lagging developments in the former. As such, technological and institutional changes can impact the way industries are organized and how coordination occurs (Langlois, 2003). Technology and organizing also interplay in the shaping of industry dynamics and evolution (Ciarli *et al.*, 2009).

To return to Richardson's (1972) framework, Langlois' ideas imply that different activity interdependencies could result from changing technologies and institutions. Activities might become less closely complementary but still require cooperative relationships. Alternatively, they may become more complementary yet more dissimilar, for example when activities from previously unconnected organizations are reconfigured and the composition of industries changes.

In the next section, we outline two illustrations of contemporary phenomena, those of circular economy and blockchain. The illustrations show new activity interdependencies, underpinned by changing technologies and institutions, in situations previously framed as being too different and/or unrelated for it to be economically feasible for the activities to be coordinated.

Two illustrations of activity coordination in the contemporary economy

We have utilized multiple secondary data sources to underpin the two empirical illustrations, circular economy and blockchain. We adopted a two-step snowballing technique, resembling the sampling strategies recommended for qualitative studies (Biernacki and Waldorf, 1981). First, web searches in Google scholar were undertaken to identify technological developments and shifts in institutional configurations discussed in frequently cited peer-reviewed articles. This resulted in examples of radical changes in activity coordination that were of interest for further exploration.

Second, the articles identified, published in high-ranked journals such as *Harvard Business Review*, acted as a starting point for snowballing additional empirical material. Our two illustrations are not intended to be representative or exhaustive, but instead serve to underscore our conceptual argument by recognition and acquaintance (Siggelkow, 2007). They also provide variety in business sector (automotive and food) and geography (Europe and Australia).

Circular activity coordination

Sustainability concerns and material scarcity have created institutional pressure for the increased circularity of activities within industries (Atasu, Ciocan and Désir, 2021; Goworek *et al.*, 2018). Core to the creation of circular economies is minimizing the waste generated in a product lifecycle (Murray, Skene and Haynes, 2017).

Specifically, efforts towards circularity in the automotive industry have resulted in models being designed for remanufacturing. This impacts product development and the production of new parts and subassemblies (Spring and Araujo, 2017). Groupe Renault has worked to refurbish components ranging from water pumps to turbos (Groupe Renault, 2020). Refurbished parts undergo the same quality control tests as new parts but sell at half the price. The recovery of large volumes of subassemblies for repair involves the 'upcycling' of deliveries of replacement parts to dealers. This implies that the 'sorting' of which components to transform must be achieved across multiple organizations (Insanic and Gadde, 2014).

Groupe Renault has recently established 'Re-Factory', a dedicated plant based on circularity, which combines activities within the plant and makes connections to other organizations (Groupe Renault, 2020, p. 15). It has created a need to manage new interdependencies in reverse and circular flows. Moreover, additional coordination is necessitated by new activity linkages across industries, for example producers of recycling technologies and waste management firms (The Ellen MacArthur Foundation, 2017a, 2017b) or by the original value chain being affected by new links in the designs for remanufacturing.

For example, Boone Comenor Metalimpex is a joint venture between Renault and Suez, which specializes in the recovery of scrap metal from production sites. Boone's metal recovery activities are very different from those of car manufacturing, but these activities are now tightly linked. As such, Groupe Renault needed to 'repurpose' and reconfigure their existing supply networks (Spring and Araujo, 2017) and establish new relationships.

The changes involved in the move towards circularity impact how activities are coordinated. The different reuses of various products change the division of labour across existing relationships and introduce new ones. Furthermore, a circular flow cannot be coordinated solely by any one hub firm (Ibid.). As such, companies with waste reduction goals are required to coordinate both within and outside their industry (Murray, Skene and Haynes, 2017). We posit that new interdependencies are created that require coordination of very dissimilar but closely complementary activities.

Activity coordination through blockchain

Blockchain technology ensures reliable and trustworthy transactions by coordinating among loosely coupled agents, organizations, and systems within networks. A blockchain is a digital ledger that cannot be tampered with, in which all transactions are recorded, stored, and validated. Blockchain is a distributed-consensus technology that allows networks to perform large numbers of transactions that are verified securely and stored without any centralized authority (Lacity and Van Hoek, 2021; Scott, Loonam and Kumar, 2017).

Specifically, in the food industry, blockchain is used for verification, traceability, and data sharing (Kamilaris, Fonts and Prenafeta-Boldύ, 2019). Austral Fisheries has partnered with World Wildlife Fund (WWF)-Australia and others in a supply chain based on this technology to achieve sustainable fishing (OpenSC, 2019). Each fish is given a radio frequency identification (RFID) tag that is linked to a unique identification (ID) created in the blockchain. This ID contains data on the fishing zone, water temperature, etc. A quick response (QR) code linked to the RFID tag is used to trace each fish as those involved in the supply chain process, transport, store, prepare, and sell it (WWF, 2018).

The blockchain coordinates and controls the entire activity flow, creating traceability and transparency, but also significant interdependencies across the organizations involved (Gaur and Gaiha, 2020; Iansiti and Lakhani, 2017). Producers, processors, handlers, retailers, chefs and consumers can access information to instantly track and check products because all the relevant

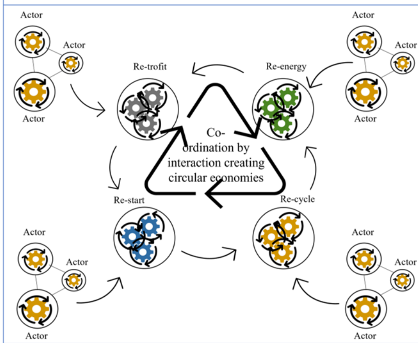
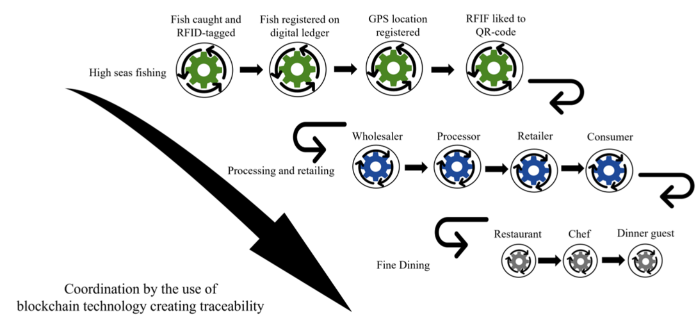
Coordination across sectors and industries	**Coordination among dispersed and loosely coupled entities**
Circular Economy (Groupe Renault)	Block chain (Austral Fisheries)
	
Inspired by Groupe Renault (2020, p. 15)	Inspired by Open SC (2021)
Characteristics	
• Links previously unconnected industries • Transforms the vertical and horizontal organising • Simultaneous vertical and horizontal coordination	• Coordination is core to and embedded in the technology • Interlinks loosely coupled actors for effortless transactions • Technology-facilitated trust

Figure 2. Exemplifying very dissimilar activity coordination [Colour figure can be viewed at wileyonlinelibrary.com]

transactions are stored and validated (Kamilaris, Fonts and Prenafeta-Boldύ, 2019).

Reliable information is exchanged instantly across many contexts, including coordination with regulators and non-governmental organizations (NGOs) (WWF, 2018). The blockchain also provides accurate and verified information regarding how products are processed in a way that respects social justice and sustainability (Garcia-Torres *et al.*, 2019).

Blockchain has the capacity to transform how widely dispersed activities can be linked as flows of goods are coordinated and managed across multiple organizations (Kamilaris, Fonts and Prenafeta-Boldύ, 2019). The linking capacity of blockchain creates interdependencies among organizations that have until recently been only very loosely linked (Scott, Loonam and Kumar, 2017). The newly created links become institutionalized as they are the result of algorithms that produce trust among connected organizations (Tapscott and Tapscott, 2017).

In sum, Figure 2 exemplifies diverse changes in technologies and institutions, shown in various ways in the two illustrations, which result in new ways of organizing (Langlois, 2003). In the Groupe Renault illustration (section 'Circular activity coordination'), activities are coordinated to create circular flows to meet waste reduction goals. In the Austral Fisheries illustration (section 'Activity coordination through blockchain'), activity coordination is underpinned by distributed, institutionalized trust and interaction. In both illustrations there is the need to coordinate very different activities. The organizations involved attempt to link industries that were previously unconnected or very dispersed. From their efforts follow new vertical and horizontal interdependencies, which cannot be coordinated by one organization.

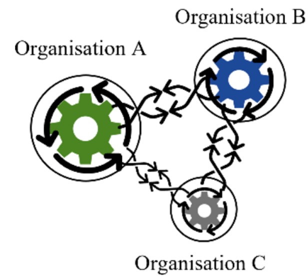
A fourth coordination mode

Our extension of Richardson's (1972) framework adds a new row (see Table 2). It encompasses (i) a new coordination mode, (ii) two new activity types, and (iii) a new coordination principle. These are (i) multi-actor arrangements, (ii) complementary, very dissimilar, and closely complementary, very dissimilar, and (iii) distributed control, respectively. Taken together, this is a fourth coordination mode. We now define and explain the new row, relating back to our two illustrations.

A new coordination mode

Multi-actor arrangements are necessitated by the increase in the extent of activity dissimilarity

Table 2. A fourth coordination mode added to Richardson (1972)

Coordination mode	Activity types	Coordination principle	Graphical illustration
Multi-actor arrangement	Complementary/ Closely complementary & very dissimilar	Distributed control	

Note (1) Crossing, interlinked arrows ( ) in the graphical illustration indicates coordination by the principle of distributed control. (2) The varying sizes and colours of the cogwheels illustrate that they are very dissimilar (see also note to Table 1).

in inter-organizational coordination. This new coordination mode is formed by *'coordinated links in networks of expanded scope'*. The change in scope occurs as a result of the inclusion of different types of organizations in the coordination of activities, for example public agencies and consumers. Multi-actor arrangements thereby involve a variety of organizations interacting to coordinate activities. This has similarities to extensive networks (Aarikka-Stenroos *et al.*, 2017), and involves non-business actors (Crespin-Mazet and Dontenwill, 2012; Mota and de Castro, 2004; Powell, 1987) for example within regional clusters (Eigenhüller, Litzel and Fuchs, 2015) and systems (Hobday, Davies and Prencipe, 2005).

The multi-actor arrangements in both illustrations concern how previously unrelated organizations from different industries become connected, as well as how organizations within an industry boundary coordinate in new ways. The change in scope of the division of labour (Cacciatori and Jacobides, 2005; Langlois, 2003) occurs because different, widely dispersed capabilities need to be connected.

For example, the blockchain technology connects organizations that are unalike, such as chefs and fishing vessels. This is done without the organizations interacting to ensure trust, because those involved only need to trust the blockchain itself. Transacting takes place through access to the digital ledger (Scott, Loonam and Kumar, 2017). Moreover, in the Renault example, a circular economy requires a reorganizing of activities, sometimes based on previous interactions, but not always. This implies the need to coordinate very dissimilar activities across existing and new suppliers. Cooperation across multiple types of organizations is imperative in the circular economy (Geissdoerfer *et al.*, 2017), precisely because of the new interdependencies being created.

Furthermore, there is a dynamic aspect to the new coordination mode. Multi-actor arrangements require the linking of very dissimilar activities that were previously considered to be too costly to coordinate. However, there are costs involved in materializing very dissimilar activity interdependencies. For example, the blockchain illustration is underpinned by the need to establish the blockchain technology. A thicker type of interaction amongst the organizations involved is required at initiation to align the very dissimilar activities with associated direct and indirect capabilities (Loasby, 1998), in creating a multi-actor arrangement. Once the blockchain is running, the need for such interactions diminishes and it is possible to utilize scale effects from the system of distributed trust built into the technology. The blockchain thereby enables the sustained coordination previously associated with tightly connected networks of organizations with high levels of mutual trust.

In the circular economy illustration, a multi-actor arrangement emerges as new activity interdependencies are established. Managers need to envision possible connections and incur costs in attempting to connect previously unrelated activities; that is, there is a need to invest in ascertaining which indirect capabilities are required and where these are distributed (Ibid.). The newly created circular activity interdependencies cannot be coordinated solely by any one of the organizations involved (Spring and Araujo, 2017).

Two new activity types

The need to coordinate 'very dissimilar' activities results in two new activity types: (i) complementary, very dissimilar and (ii) closely complementary, very dissimilar. We define very dissimilar activities as '*the type of activities that are enabled by the existence of very different capabilities located in two or more organizations*'. Such activities can be either complementary or closely complementary, but because of their extent of dissimilarity, costs are incurred in creating links for changed inter-organizational coordination.

These two new types of activity contrast with the focus on similarity in empirical research in supply chain management. For example, von Corswant, Dubois and Fredriksson (2003) argue that customer–supplier relationships can involve the coordination of similar yet closely complementary activities. This has parallels to the activity interdependencies in 'concurrent sourcing' (Parmigiani and Mitchell, 2009). Dubois, Hulthén and Sundquist (2019) recognize that the coordination of similar activities is achieved not only in one supply chain but through activity interdependencies across supply chains.

The two new activity types are central to our new coordination mode, multi-actor arrangements, based on the principle of distributed control. For example, in the circular economy illustration, very dissimilar activities from previously unconnected industries need to be coordinated to transform waste into new products. The joint venture between Renault and Suez, specializing in the recovery of scrap metal from the group's plants, requires establishing closely complementary, very dissimilar activities.

Furthermore, there are examples of complementary, very dissimilar activities in the blockchain illustration. The technology enables the coordination of very dissimilar activities, such as industrialized fishing and NGO-based activities, with consumer behaviour. While this core ability is designed into the technology, it needs to be implemented amongst the organizations involved, which requires extensive thick interactions, as we outlined above in the section entitled 'A new coordination mode'. Such thick interactions are a central way in which the coordination of very dissimilar yet (closely) complementary activities occurs, also manifesting the principle of distributed control.

A new coordination principle

The coordination of very dissimilar activities within multi-actor arrangements is underpinned by the principle of distributed control. We define it as '*a principle that enables multi-actor coordination amongst diverse organizations to achieve a level of coordination that aligns activities. It is characterized by the lack of a single, central organization and requires only the partial fulfilment of local goals and purposes*'.

The principle of distributed control is distinct from the other principles of coordination within Richardson's (1972) framework. This is because it permits coordination among a set of varied organizations without a central coordinator and links very dissimilar activities. Coordination is achieved by interaction among organizations in ways that allow for emergence and feedback, which creates a complex dynamic. It is decentralized but not random, and it does not rely on a common goal, but rather on the partial fulfilment of the local interconnected goals of those involved.

Briefly, 'distributed control' as a term originates from linear algebra, where it was used to optimize linear systems and subsequently nonlinear systems as a first-order approximation of optimization problems. It has been applied in engineering fields such as communication networks and transportation systems (Marden and Shamma, 2015), and has continued to develop within the control theory field (Murray, 2003). Modern control theory relies on systems science (Simon, 1965) and the developments in distributed artificial intelligence to design networked control systems. Here, distributed control is used to describe the global control effect that emerges from the application of local rules to agents that interact (recognized also in the early days of cybernetics (El-Fattah, 1980) and game theory (Schelling, 1978)).

We use the principle of distributed control to refer to the global control effect that emerges from various local interaction patterns in multi-actor arrangements characterized by decentralized coordination and very dissimilar activities. Such coordination cannot be achieved by direction, as this would require complementary activities to be similar, or by way of market transactions, as this would not allow for very dissimilar yet complementary activities to be coordinated. Moreover, cooperative relationships relying on the matching of plans cannot be used either, once more owing to the need to coordinate very dissimilar activities.

In the circular economy illustration, coordination is achieved by the principle of distributed control by way of new patterns of interactions across multiple organizations across several industry sectors. Being able to coordinate very dissimilar yet complementary activities such as in the Re-Factory example, in which research and development activities to develop new energy systems and propulsion techniques are connected to core automotive manufacturing operations, requires a new coordination principle. This is because the existing three coordination principles cannot explain how activities that are very different yet complementary can be coordinated. The principle of distributed control thus underscores that the development of the circular economy '*is part of a trend towards intelligent decentralization*' (Stahel, 2016, p. 437).

The new coordination principle also underlines the blockchain illustration. It enables patterns of coordination connecting and integrating very dissimilar yet complementary activities. It is visible in that scripts and algorithms across organizations and entities such as fish, vessels and consumers enable the coordination of such activities. The principle of distributed control is achieving coordination by way of technology that impacts on the coordination patterns among those involved.

There is a dynamic aspect to the principle of distributed control. For example, once a blockchain is established and agreed upon, there is no 'real' interaction among the loosely coupled organizations involved except the ones mediated by the technology. The investment in thicker, costly and time-consuming interactions during a set-up phase underpins the future economizing of thinner interactions requiring fewer coordination costs. Interaction becomes a digitally mediated multi-actor arrangement that does not rely on interaction-based trust, because trust is built into the functioning of the blockchain. As such, the principle of distributed control can manifest both by way of thick interactions among multiple organizations and in terms of technology.

Discussion and conclusions

The purpose of this paper was to address the lack of knowledge about inter-organizational activity coordination in the contemporary economy. We asked the following question: '*What are the relevant modes that explain inter-organizational coordination in the contemporary economy?*' The contribution of the paper is to propose a novel fourth coordination mode: multi-actor arrangements based on the coordination of very dissimilar activities, underpinned by the principle of distributed control. Our extension of Richardson's (1972) framework is significant because it changes our understanding of mixed-mode coordination (Bradach and Eccles, 1989; Håkansson and Lind, 2004; Humphrey and Schmitz, 2001; Patrucco, 2014; Ritter, 2007; Sacchetti and Sugden, 2003) in explaining the coordination of inter-organizational interdependencies.

The section 'Mixing four coordination modes' relates the new coordination mode to the existing three modes, before we consider how the now four mixed modes might interact over time (section 'Four coordination modes over time'). We consider the implications of the principle of distributed control in the section 'Implications of the principle of distributed control for coordinating activities' before concluding the paper with managerial implications and suggestions for further research.

Mixing four coordination modes

Our proposed extension of Richardson (1972) has implications for how we understand mixed coordination modes. As we established in the section 'Cooperative relationships, capabilities, and mixed coordination modes', the existing three coordination modes are complementary when coordinating activities within a relational or network form, such as within a GVC (Humphrey and Schmitz, 2001). The fourth coordination mode, multi-actor arrangements, can be related to the existing three modes by using the two empirical illustrations, circular economy and blockchain.

Our two illustrations are contemporary phenomena that require the proposed novel mode. Coordination within a circular economy incorporates very dissimilar activities and depends on the principle of distributed control, as does a blockchain. However, coordinating circular flows also requires collaboration in cooperative relationships (the third mode) to link inter-organizational activities and the associated capabilities. Thus, for circular economies, we expect the third and the fourth mode to be closely related. Market transactions, the second mode, may also occur as the outcome of the formation of circular economies. The first mode (organization) is also present, because intra-firm coordination links the activities within the organizations forming the circular economy, but not across them.

A blockchain is also underpinned by the fourth coordination mode and complemented by the third (cooperative relationships). This is because the coordination across a chain of organizations utilizing a blockchain also depends on cooperative relationships, at least when the blockchain is being established (see section 'Four coordination modes over time', below). The second mode, market transactions, may also arise as a result of this organizing because when a blockchain is operational, it governs the interdependencies across the organizations involved. For example, when restaurants are able to cater to new groups of clients who value traceability and sustainable seafood. We can expect that coordination modes one, three, and four can potentially be related. The first mode (organization) is indirectly associated to the extent that a blockchain is formed by organizations that are coordinated by direction, but the coordination across the blockchain itself does not comprise this coordination mode.

Overall, how, when, and to what extent the four coordination modes mix in contemporary economic phenomena is an empirical issue, warranting further research to determine the myriad ways in which the now four complementary coordination modes may mix.

We can also consider how our novel mode could be complementary to the three existing coordination modes when investigating relationship and network forms in the IOR literature. Both GVC (Humphrey and Schmitz, 2001) and modular production systems/networks (Langlois, 2003; Lombardi, 2003; Sturgeon, 2002, 2003; von Corswant and Fredriksson, 2002) could be partially coordinated by the principle of distributed control. For example, a blockchain could take part of the role of a 'lead firm' in a GVC, or have an impact on the certification function of 'external agents' (Humphrey and Schmitz, 2001), depending on the existence of very dissimilar yet complementary activities. The co-existence of four complementary modes could therefore expand our understanding of governance in a GVC.

The principle of distributed control could also be relevant to modular production networks, if the interfaces between the modular parts of the production systems can be specified (Lombardi, 2003, p. 1444) for very dissimilar activities. The novel fourth coordination mode may also complement the three current modes in platform organizations. For example, Patrucco (2014) argues shows how coordination within the first and third modes (organization and cooperative relationships) is combined through platforms. In a context in which very dissimilar activities require coordination, for example as a result of industry evolution (Cacciatori and Jacobides, 2005), the platform organization could be a hybrid containing elements of organization, cooperative relationships, and multi-actor arrangements.

Furthermore, the co-existence of the current three coordination modes within relationship and network governance has been established (Håkansson and Lind, 2004; Ritter, 2007). The fourth coordination mode could be complementary with the third when the coordination of very dissimilar activity interdependencies is necessitated within a single relationship and across multiple relationships in a business network or ecosystem. The newly proposed mode may also be relevant in strategic alliance (Chung, Singh and Lee, 2000; Gimeno, 2004) and alliance portfolio (Hagedoorn, Lokshin and Zobel, 2018) research when the types of activities underpinning the rationale for the alliance are very dissimilar in nature. The principle of distributed control can therefore coordinate across different types of multi-actor arrangements and be complementary with the third coordination mode.

Lastly, as Dubois (1998) and Finch (2003) note, the division of labour across industries changes over time as activity interdependencies are reconfigured. Jacobides and Winter (2007) make a similar point in terms of boundary choice in value chains being a dynamic process. While these authors are only discussing mixed modes in general terms, we outline how the mixing of four coordination modes might vary over time in the next section.

Four coordination modes over time

Alongside the co-existence of four modes of coordination at a point in time, the mix of coordination modes will vary over time (cf. Jacobides, 2008; Langlois, 2002, 2006) as changes in industry evolution occur (Cacciatori and Jacobides, 2005; Consoli, 2008). This is particularly the case across modes three and four in the extended Richardson framework.

In the section 'A new coordination mode', we outlined the dynamics of how the need to establish a blockchain technology requires closer collaboration than what is required when later utilizing it. The third mode of coordination is therefore dominant in the early phase of setting up a blockchain, because coordinating activities by matching of plans is needed as organizations interact via coordination mechanisms, such as '*meetings and plans*' (Okhuysen and Bechky, 2009, p. 46), to agree on how to fill the digital ledger with content. Once the blockchain is enabled, the same organizations can coordinate their activities by the principle of distributed control, within the fourth mode of coordination. If a new organization was to become a part of the blockchain, this would again necessitate more of the third coordination mode. This suggests that coordination costs are dynamic over time (akin to dynamic transaction costs; Langlois, 2006), as a blockchain reduces the '*costs of organizing*' in a distributed form of modularity (Gomes and Dahab, 2010, p. 58).

A similar evolution is in play within the circular economy illustration. The need to change from linear to circular flows requires close cooperation among multiple organizations. For example, Renault was required to locate the indirect capabilities of other organizations (Loasby, 1998) currently situated outside the linear supply chain. The coordination capabilities needed are thereby altered by the new coordination mode, because of the relational work required to form very dissimilar activity interdependencies.

However, once established, a circular economy can rely more on activity coordination by the principle of distributed control, assuming that the organizations involved follow the now-established structure. If they do, activity coordination of dissimilar and complementary activities by market transaction (mode two) could also be performed, for example through selling waste material from automobile recycling into other supply chains, such as the manufacturing of residential flooring, etc.

Linking very dissimilar activities therefore requires working towards developing coordination mechanisms (Jarzabkowski, Lê and Feldman, 2012), which could be mixtures of relational and contracting forms (Parmigiani and Mitchell, 2009). This is costly and requires thick interactions in cooperative relationships involving both business and non-business organizations (traversing modes three and our new mode). These are coordination costs, not to separate tasks (Gulati and Singh, 1998), but rather to link previously too-different activity interdependencies across boundaries, which are underpinned by very different, and widely distributed, capabilities. Linking very dissimilar activities is a different order of magnitude than acquiring dissimilar capabilities within an industry (Andreoni, Frattini and Prodi, 2017).

Implications of the principle of distributed control for coordinating activities

We have used the principle of distributed control to describe the global control effect that emerges from the application of local rules to agents that interact. Specifically, the new coordination principle refers to the coordination of very dissimilar activity interdependencies within multi-actor arrangements, characterized by the lack of a single, central coordinating organization.

Drawing on Thompson (1967), Fjeldstad *et al.* (2012, p. 740) suggests an '*actor-oriented scheme*' to investigate the multi-party actor-oriented organization. Similar discussions are raised by Filatotchev and Nakajima (2010), when arguing for integrating internal and external corporate governance approaches, and by Eriksson and Hellström (2021), when outlining multi-actor resource integration as a coordination mechanism. Taking Richardson (1972) as our starting point, we suggest that the principle of distributed control can be used to explain both the coordination of multi-actor arrangements and such actor-oriented schemes.

However, the locus of the principle of distributed control is not a single organization, such as a dominant hub actor (Gray *et al.*, 1996). Rather, it is *in-between* organizations in a distributed manner, thereby constituting a coordination principle similar to a collective network mechanism (Bunge, 1997; Wilkinson, 2008). We expect the new principle to be most likely to manifest in terms of thick interactions among organizations creating multi-actor arrangements. However, it can also be designed into technologies such as blockchain.

The new coordination principle can contribute to significant accumulations of power. Dominance may occur because it potentially organizes very dissimilar activities in a way that favours one or a few organizations. At the same time, it provides little ethical guidance as to any preferred type of organization, and we make no assumption that the resulting distribution of resources is balanced. Parrilli and Sacchetti (2008) view power as a mixture of control and trust in the governance of production networks. The principle of distributed control may be used to systematically enhance the control aspects of this power dimension.

Furthermore, within a multi-actor arrangement coordinated by the new principle, goals need not be shared (or even known), and in fact not even all the organizations need be known to one another. This resonates with discussions of 'complex organizing' (Blackler, Crump and McDonald, 2000; Holt and Morris, 1993), although these works do not explicitly identify any underlying coordination principle. In sum, the principle of distributed control shapes the patterns of interactions involved in coordinating very dissimilar activities across multiple organizations in different sectors.

Managerial implications and suggestions for further research

For managers, understanding and utilizing the principle of distributed control is essential when attempting to mobilize others towards goals, such as designing in different interdependencies through exercising a relational capability (Gittell, 2016). This is because it enhances and partly changes the control dimension of power (Parrilli and Sacchetti, 2008). The power aspect can also be negative, which makes it necessary to recognize the organizing attempts from others, which can be malicious, for example as in hacker attacks. Understanding the principle of distributed control will assist managers, leaders and policy-makers to counteract the power of algorithms, which is becoming ubiquitous (Burrell and Fourcade, 2021).

Furthermore, the pressures to move from linear to circular flows has consequences for how to achieve coordination. Managers need to recognize that boundaries within industries (Jacobides and Winter, 2007) and also across industries are dynamic. The formation of activity interdependencies across previously unconnected linear chains requires recognizing the very different capabilities of other organizations and learning how to coordinate these. For example, an organization needs to consider its role within a circular economy when very dissimilar activities from previously unconnected industries are linked, and currently optimized supply chains are transformed, as waste reduction goals become paramount.

Turning to suggestions for further research, given that one limitation of this paper is a lack of empirical material, we call for more research to test out our extension of Richardson (1972) with a variety of research designs. For example, a multiple case study approach could be adopted to build theory about the ways in which the principle of distributed control plays out across different types of multi-actor arrangements in various contemporary economic settings in diverse business-to-business industry sectors as well as in public sectors such as healthcare.

Moreover, as sustainability has implications for the theory of the firm (Ventura, 2021), and there are other relevant technologies besides blockchain, the scope of the empirical settings can be further expanded. Other possible avenues could be to investigate which bundles of coordination mechanisms underpin the proposed novel coordination mode in a variety of industry settings. Finally, further empirical research could investigate the dynamics of four mixed modes over time, for example in different network and ecosystem forms.

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Supporting Information

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Supporting Information